Summary Report
and Proceedings

Conference on Low Back X-rays In Pre-employment Physical Examinations

PREFACE

The overtones of an aching back are so strong in our society, in psychological, physical, sociological and economic terms, that it has seemed an embarassment that the medical profession knows so little and can do so little to relieve significant spinal problems.

The problem is particularly acute in occupational health because a worker's own spinal problems can be complicated by job demands and further confused by obligations of workmen's compensation programs. With the advent of the Occupational Safety and Health Act of 1970, this became one of the many expanded federal areas of concern for the Department of Labor and the National Institute for Occupational Safety and Health of the Department of Health, Education and Welfare.

The radiographic examination of the lumbar spine is often the most objective evidence that a physician can obtain on the status of a patient's lower back. Over the years, many major industries have elected to require radiographic examinations of the lower spine as a part of pre-employment physical examinations given to persons considered for various categories of jobs. There has been considerable disagreement within the medical profession as to the value of such radiographic examinations, particularly in the prediction of future spinal injury or disability.

Thus, the American College of Radiology obtained from NIOSH a contract to conduct an exploratory discussion of the status of lumbar spinal x-ray examinations in industrial practice at present. The ACR enlisted the aid of the American Academy of Orthopedic Surgeons and the Industrial Medical Associationiin the planning and conduct of a weekend seminar January 12-1 at Tucson, Arizona. The proceedings which follow, with slight editorial improvements, reflect the substance of the discussions of some 50 physici and other scientists from involved disciplines.

Arthur J. Present, M.D.
Chairman, American College of
Radiology Ad Hoc Committee on
Low Back X-rays

Conference on Low Back X-rays in Pre-employment Physical Examinations

Tucson, Arizona

January 11 - 14, 1973

Sponsored by

THE AMERICAN COLLEGE OF RADIOLOGY
THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS
THE INDUSTRIAL MEDICAL ASSOCIATION

In cooperation with

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)*
HEALTH SERVICES AND MENTAL HEALTH ADMINISTRATION
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Supported in part by
PUBLIC HEALTH SERVICE
CONTRACT HSM-99-72-153

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CONCLUSIONS

1. Radiologic examinations of the lumbar spine may be an appropriate part of pre-employment or preplacement physical examinations for prospective employees where company policy or experience indicate their value. Such x-ray studies should be made in conjunction with proper histories, physical examinations and other appropriate diagnostic procedures. They should not be utilized as a sole screening method in the absence of other clinical modalities.

2. The incorporation of an x-ray examination of the lumbar spine in a pre-employment assessment of an individual is valuable in assessing the current status of the individual's spine but less positively valuable in predicting the possible trauma or disability which might result from that individual engaging in a physically stressful occupation.

3. The feelings by many physicians that lumbar spinal x-ray examinations can have a predictive value in assessing the reaction of an individual to physical stress are based primarily upon clinical observation, rather than statistical or other documentation. There is a need for the development of appropriate clinical and statistical studies to demonstrate the presence or absence of correlations between x-ray findings and subsequent development of spinal disabilities.

4. On the basis of clinical judgment and experience, it is possible for an industrial organization to devise protocols for its own use in determining the physical characteristics of prospective employees which appear to be useful both to the prospective employee and to the organization. However, there is little in the literature to indicate that x-ray findings should be given more prominence than other basic procedures in such assessments. There is need for much further study of the entire problem.

5. While parameters of the extent of lumbar spinal x-ray examinations can be suggested by physicians seeking consultative assistance, the final determination of the optimum execution of the procedure should be left to the radiologist or other physician responsible. In no case should the x-ray examination involve fewer than antero-posterior and lateral projections.

6. The physician responsible for the performance of lumbar spinal x-ray examinations should be cognizant of the imperative need for good radiation protection practice. Gonadal shielding should be used, particularly for male patients.

7. The extent of the problem of low back ailments, injuries and disabilities in various types of occupations and industries is sufficient to warrant the continuing attention of the medical profession and of responsible public agencies, particularly those charged with public health responsibilities for occupational programs.

SUMMARY

by John P. Connors

"It is most unusual to see a group of persons come together to address a problem, the nature of which is a mystery or an enigma."

With those words, Dr. Merlin K. DuVal, until recently assistant secretary of the Department of Health, Education and Welfare in Washington, and now returned to his post as vice-president for health affairs at the University of Arizona, welcomed an unusual group of 56 scientists to Tucson. They were, medically, polyglot.

Fourteen radiologists, 15 industrial physicians and 14 orthopedic surgeons formed the core of the group meeting for three days of intensive discussions at Tucson's Ramada Inn. With them were individual representatives from the disciplines of anatomy, neuropsychiatry, neurosurgery, pathophysiology, physics, preventive medicine and statistics, and physicians from government and labor.

And the problem that had brought them there is, indeed, an enigma — a puzzle with significant ramifications for medicine, for tens of thousands of American workers, for industry, and perhaps for generations still unborn. The question for the conference: Should low back x-rays be used in pre-employment physical examinations?

On the one hand, such examinations might save thousands of potential laborers from disabling injuries, and save industry tens of millions of dollars in settlements. On the other, the examinations are costly in themselves, and may constitute both an individual and genetic radiation hazard, and they may have little predictive value.

The literature on the subject is scanty and inconclusive. Studies have generally been limited to one company or industry, controls were lacking, and design of the research sometimes poor.

In the face of such uncertainties the American College of Radiology proposed the Tucson conference. Joining in sponsorship were the American Academy of Orthopedic Surgeons and the Industrial Medical Association. Supporting the conference was the National Institute for Occupational Safety and Health (NIOSH), Health Services and Mental Health Administration, Department of Health, Education and Welfare.

Chairman of the meeting was Arthur J. Present, M.D. of the department of radiology, University of Arizona Medical Center. He directed a tight schedule that kept conferees working from breakfast into the evenings.

The meeting began with didactic lectures on the anatomy of the spine, the nature of various types of low back pain and disability, psychiatric implications, epidemiology and industrial loss. Later, the conferees split into small, interdisciplinary groups for discussions and to begin to form conclusions. Later still, these groups reorganized along disciplinary lines. They brought their recommendations to a final, general session where conferees debated, amended and finally adopted position statements on the issue.

What is the cause of low back pain? The answers are several, and some are obscure.

As the sessions opened, Brown University anatomist G. E. Erikson, Ph.D., reviewed the comparative morphology of the back. He reminded the audience that the back as it exists in other mammals is more suited to strain than in primates that stand erect. And S. Henry LaRocca, M.D., New Orleans orthopedist, outlined those things which lead to the production of low back pain, and those which affect the patient's reaction to the pain. In tune with much of the rest of the meeting, he said of the causes of pain: "There are a number of them that we know about, and a number of them that we think we know something about, and a number of them which, I am sure, will develop in the future and of which, at present, we are totally ignorant."

Through x-rays, Dr. LaRocca pointed out congenital anomalies, such as spondylolysis and spondylolisthesis, and described arthritic problems.

"There seems to be an hereditary predisposition toward back disease," he

said. "The genetics of the problem have in no way been worked out, however."

Dr. LaRocca also showed x-ray evidence of disk disease and noted that immunologic mechanisms or biochemical reactions may be the ignition. But he acknowledged that disk degeneration may exist without symptoms.

The following speaker, Bernard Epstein, M.D., also led the conference through a review of spinal abnormalities demonstrated by x-ray. But the Long Island radiologist, too, called attention to negative x-ray findings in patients without symptoms.

"Here we have," he told the darkened room of conferees, "a man of 55 who came in for an intravenous pyelogram. After seeing this spine I expected to get a history of horrible back pain . . .He has every one of the things that we would look for: spurring, narrowing, atypical articulo facets, a narrow canal . . . slippages, narrowing bony overgrowth. And, yet, no pain."

The patient has been a laborer all his life, works hard, and has never taken a day off because of backache, Dr. Epstein said.

"So," he concluded, "I came back to the original question. What is a normal spine?"

"I think that possibly the answer will have to take into consideration the patient to a greater extent than the x-ray."

Delivering the same message in a different way was St. Louis orthopedic surgeon Lee T. Ford, M.D., the next speaker. Dr. Ford also made it clear, through numerous slides, that spinal abnormalities are frequently demonstrated by x-ray. But he added that in one series of over 1600 x-ray examinations he found only 7.3 percent that he interpreted as "perfectly normal". These were not pre-employment examinations, but were of patients "with some symptoms that might have been related to the low back."

Dr. Ford noted that radiologists at the Missouri-Pacific Hospital studied over 20,000 prospective employees of the Missouri-Pacific Railroad over the years and rejected 37 to 40 percent. That percentage increased to 43 when oblique views were taken in addition to the more standard AP and lateral views. But, he said, follow up — the incidence of low back disability — was unknown for rejected applicants and uncertain for those passed by the radiologist.



Dr. Ford urged a careful history and an adequate physical examination in addition to x-rays. And he concluded: "The present status of pre-employment x-rays of the lumbosacral spine certainly is that they are of interest and probably of help to the treating physician if and when a back injury does occur. On the other hand, we have all seen retired farmers and other workers with spondylolisthesis or with a very marked degenerative arthritis who have done heavy work for many years wihout symptoms . . ."

As the opening session of the conference moved toward a close, speakers remained ambiguous as to the essentiality of low back x-rays in pre-employment examinations, and their predictive value.

Benjamin Boshes, M.D., neuropsychiatrist from Northwestern University School of Medicine, stressed the psychologic implications of the back to the laborer. It represents, he said, not only his major tool in earning income, but can have meaning in terms of the worker's self image of virility.

Dr. Boshes asked: "When we begin to question how do we examine a patient with a question of a back that will stand up under stress, can we solve it with only a pre-employment x-ray?"

"The answer is, of course, it may add some exceedingly important information, but it is only information in part, as has already been suggested by the other speakers.

"The life history of the individual, his pattern of living, his successes and frustrations, the meaning of the back to him, all have to be taken into consideration."

The final speaker of the morning was E. Dale Trout, Sc.D., of Oregon State University at Corvallis, a radiation physicist concerned with safety.

"I am just like the rooster showing the hens the ostrich egg here this morning," he said. "I am not advocating anything. I just want to be sure that you know what can be done."

Dr. Trout warned of excess radiation hazard from improper procedures and urged greater protection for the patient. "If there is anything that this august body should do at this meeting," he said, "it is to say that some kind of gonadal shielding should be used on all of these patients where the gonads are in the useful beam — that collimation should remove them from the useful beam wherever possible."

A different view of the problem came during luncheon from Stover Snook,

Ph.D., specialist in human engineering from the Hopkinton (Massachusetts) Research Center of Liberty Mutual Life Insurance Company. Dr. Snook described his field as the study of man's capacity to do various types of work, and said it draws primarily upon the disciplines of psychology, physiology and engineering. The goal, he said, is "much the same as it is for industrial medicine, and that is a good match between the worker and his job. But the approach is quite different.

"Generally speaking, the industrial physician tries to match the individual to the job, whereas we try to design the job to match the individual."

In practice, low back x-rays are used to assign workers to various types of tasks based upon the degree of physical activity or physical stress. This is generally based on criteria published by the Industrial Medical Association in 1964 which divides work assignments into four categories ranging from administrative work, through light activity, and moderate physical activity, to heavy labor.

But, Dr. Snook asked, even if the individual who is likely to develop lower back pain can be identified, can medical officers prevent injury from occurring by placing that individual in a specific type of job?

Numerous studies indicate that back injuries in industry account for about 15 percent of all injuries, Dr. Snook said. Among them was a study by the Pennsylvania Department of Labor and Industry which reported 16.7 percent.

But, he added, when one examines the industries in Pennsylvania from which the highest and lowest number of back injuries were reported, one finds curious results.

Heading the list of high injury industries was stone, clay and glass works where materials handling is common. But also in the top ten were local transportation, communications and state government.

At the same time, among the lowest ten industries for back injury were anthracite mining, lumber and agriculture.

"We have no really clear-cut relationship between the heaviness of the task and the incidence of lower back pain," Dr. Snook said.

He also cited several studies which compared the incidence of low back pain among sedentary and nonsedentary workers. Among a sample of 2000 workers at Eastman Kodak followed over a 10 year period, 35 percent of the

sedentary workers complained of lower back pain compared to 47 percent of those involved in heavy labor, a difference of about 12 percent. In a survey at the New England Bell Telephone Company the figures were 43 and 57 percent. Moreover, another recent industrial study showed that 85 percent of employees with low back pain were performing jobs with little or no physical stress involved.

Sedentary jobs can contain stressing elements, Dr. Snook said. Even a secretary may occasionally pick up a 50-pound package of paper.

In addition, he pointed out, the studies indicate that approximately half the instances of lower back pain are not triggered by the task at all. He suggested that industry may be understressing, as well as overstressing, individual workers.

"I think one of the important questions for this symposium to consider," Dr. Snook said, "is whether these relatively small benefits of job placement based upon lower back x-rays are sufficient enough to justify the considerable cost in time and in money and in radiation."

When the group reconvened after lunch, much of what had been said by Dr. Snook was echoed in a paper presented by Laurens Rowe, M.D., of the Kodak Park Division of Eastman Kodak Company.

Citing studies of 2000 Kodak employees and another, more searching look at 250 unselected preretirees, Dr. Rowe concluded: "We are convinced that the syndrome of discogenic backache accounts for about 70 percent of

low back disability in industry."

In attempting to discover why disk degeneration occurs in some men and not in others, Dr. Rowe said it would be reasonable to guess that laborers would show more wear and tear on disks than would desk workers. "Actually," he said, "there was no significant difference in the incidence of disk degeneration as determined by x-rays between the heavy workers and the sedentary people."

Another theory is that structural abnormalities in the low back produce distortions of stress that lead to disk degeneration. "Actually," he said, "degeneration of the lower lumbar disks was seen in 37 percent of the men with one or more structural abnormalities, . . . while in men with none of these commonly interpreted structural abnormalities, disk degeneration occurred in 55 percent."

"We are thus unable to preselect the future disk degenerator at the usual age of hiring (late teens or early twenties) by any examination technique presently available," Dr. Rowe concluded. "Our current feeling is that the occurence of disk degeneration in a given individual depends more upon his genetic inheritance of basic connective tissue stuff than it does upon the environmental factors to which he may be exposed."

Dr. Rowe then introduced a panel of four physicians from industry, two of whom later sparked new discussion of the legal implications of low back injury in industry and the tremendous costs of disability payments.

The first to speak was Carl Zenz, M.D., medical director and a veteran of 17 years with Allis-Chalmers Corporation. He suggested that psychological adjustment of the worker to his assigned task and better design of tasks that produce stress are keys to prevention of injury. In one series of 2200 employees at Allis-Chalmers, he said 460 received low back x-rays. The average age of the group was 24 years. The overall rejection rate was about 17 percent.

The lumber industry, when faced with rapid turnover of employees and a need for more workers, provided another look at the problem. John Redfield, M.D., now with Kodak but for many years with Weyerhaeuser Company, reported that at one point 209 men were hired despite low back x-ray indicating high risk. At the same time, 664 so-called normal or low-risk subjects were employed. Both groups were assigned to similar duties.

Because of short term of employment, back injuries were reported in terms of injury rate per thousand person-years. In the high-risk group the injury rate was 32.5, while in the low-risk, or control group, the injury rate was 62.3.

"My conclusion at the end of the study," said Dr. Redfield, "was that for this population, given the conditions imposed, the back x-ray taken at the time of employment did not identify or predict the employee with the highest risk of injury."

In part because of the study, the current practice at the lumber plant is to x-ray the lumbosacral spines of only those applicants 40 years old or over, and any younger subjects whose history or physical findings suggest such investigation.

F. J. Kelly, M.D., medical director of the Mason and Hanger Corporation, Amarillo, Texas, reported on a recent survey of the records of that company's 1800 employees. He found 437 who had back problems. But, when he referred back to their pre-employment low back x-rays, he found that 82 percent had "normal" films and 13.7 percent showed significant high risk. He also noted that their figures indicate that if an employee is going to demonstrate back problems it will probably be during the first 3 years of his employment.

But Dr. Kelly also pointed out that legal responsibilities and the need for legal protection may necessitate the low back x-ray. He cited a California court decision in the early 1960's in which the court said: "It appears that both employee and employer in relationship, subject to the Workmen's Compensation Act, will be well advised to be diligent in ascertaining, at the very inception of the employment relation, all available or discoverable facts relative to the perspective employee's physical condition. This should subserve the interest of both employee and employer."

Added Dr. Kelly: "I think that places at least some emphasis on the need for us to do something with the back x-ray. How much, I presume, we are here to try to find out."

The point drew strong reinforcement from Max P. Rogers, M.D., medical director of the Southern Railway System. The nation's railroads are the leading proponents of use of the low back x-ray in pre-employment physical examinations.

"We are governed by federal statutes under which liability is almost absolute in every case," said Dr. Rogers. "They allow for recovery on the part of the plaintiff and the sky is the limit, with practically no defense whatsoever."

"I thoroughly realize that by means of a pre-employment back x-ray we cannot possibly exclude from employment all the potential back injury cases, nor am I naive enough to believe that we can accurately predict by a pre-employment x-ray all of the back injuries that will occur . . . "

"On the other hand, there are those conditions which, although they may not be 100 percent in every case, we know are certainly apt to make an individual more prone toward a particular back injury."

"In the face of staggering claims and settlements, we feel we must do

everything possible to exclude the potentially serious back injury."

Dr. Rogers said the records of more than 60 of the nation's railroads indicated a total of 795 cases, in 1971, of personal injury claims based on back cases. The total cost in settlements, he said, was $18,515,539.

Settlement of the "ordinary" back case, excluding disk cases, was $17,971. The average cost per case to settle with the employee with a ruptured intervertebral disk was $32,403.

Dr. Rogers said the average cost to the Southern Railway System for a pre-employment back x-ray was in the neighborhood of $45. He estimated that in 1971 they paid $200,000 for such examinations. He concluded that all of the x-rays could be paid for by just a very few "expensive case settlements."

As the first day of the sessions drew toward an end an orthopedic surgeon, a neurosurgeon and a radiologist presented their points of view on the question.

John Schwartzmann, M.D., a Tucson orthopedic surgeon, acknowledged the needs of the railroads and of other heavy industry for protection. And he realized, he said, the value of the low back x-ray in ruling out obvious disabling situations.

But he also warned that an injustice can be done to the individual who is refused employment on the basis of an x-ray alone. Such an individual, he said, "is put into a situtation of not being able to get a job in many areas of this state, and I think it is true probably in other areas, too. Once refused on a back basis, the problems of getting a job are nearly insurmountable in some instances."

He concluded: "I believe that there is a reasonable case for x-rays, but not without orthopedic examination, in my own experience, to be fair both to the employer and the employee."

Neurosurgeon Joseph Epstein, M.D., of New Hyde Park, New York, reviewed methods of repair of back injury. He said his practice involved few compensation cases, and that he had had little experience in the pre-employment examinations under discussion. But he suggested that perhaps x-rays or evaluation should be done long before the patient or the prospective employee arrives at his job, "perhaps during periods of guidance, at the high school level, if we are really going to push it to the extreme point.

The entire patient might be evaluated, not just his x-rays, and preventive measures and back-health programs could be started early in life rather than late."

Radiologist Robert Moreton, M.D., from the M. D. Anderson Hospital in Houston, urged legal reform. Too often, he said, employees who suffer back injury are caught in a legal web. Some sign contracts with the attorneys who represent them, then find that they cannot back out of a suit for compensation even if they want to return to work.

Statistician Harlan Amandus, M.S., from the National Institute for Occupational Safety and Health, wound up the day with a review of the literature on prediction of future low back injury from the pre-employment x-ray.

"In my opinion," he said, "there has not been a controlled long-range study as of yet that has really answered this question. Extraneous variables have not been controlled or the studies have not been designed in an adequate way to answer the question in the first place."

A long-term prospective study of the problem, the most ideal statistical approach, would not be acceptable to management because it would involve assigning high-risk employees to heavy work loads, Mr. Amandus noted. He urged that a retrospective study be conducted in which groups of injured and uninjured employees would be selected, stratified or matched for age, amount of weight lifted, duration of stress and other factors relating to low back injury. Presence of abnormalities in employment x-rays could then be evaluated within each group. But he warned that such a study would have to be conducted over a long period of time.

Summing up that night, Dr. Present, the conference chairman, said: "We have responsibilities to the employee, to the employer and to the profession we represent. Thus we have the responsibility to be certain that if an examination is to be done, that it is done safely and that we have to be very cautious in classifying individuals on the basis of any defect, whether it is physical or emotional, for fear that we mark that man with a daub of the brush as an individual who does not qualify to assume responsibilities in industry, and this may cause him great harm in the future."

Three major points had been made repeatedly during the sessions, Dr. Present said. Prospective employees should receive a competent physical

examination in addition to x-ray before a decision is made; one cannot predict the individual who will have discogenic symptoms; and, yet, certain industries, particularly the railroads, "must keep men well and hire the healthy for costs of judgments in the low-back cases are truly overwhelming."

The next day, the conferees split into interdisciplinary groups for three hours of debate over the issues.

The chairman of one group of 12 polled the members on whether there was a predictive value to low back pre-employment x-rays. The vote: 11 to 1 against the validity of such forecasts. In another group, Joseph Gitlin, of the Bureau of Radiological Health, was closely questioned as to radiation hazard. Public Health Service figures indicate that some 3 million lumbar x-rays are done each year, Gitlin said. He guessed that between 150,000 and 1,200,000 of these may be pre-employment x-rays. The procedure is the largest single contributor to gonadal dose of radiation, Gitlin said, but he also noted that the individual dose has been substantially reduced from an average of 2.5 rads for the male in 1964, to 0.7 rads in 1970. As to genetic hazard, Gitlin said, "We know it is dangerous, but we don't know how dangerous."

Meeting at luncheon that day, the chairmen of the interdisciplinary groups reported on their discussions. These, in capsule form, were the results:

Sydney Thomas, M.D., radiologist from Chico, California — Railroads are anachronistic now but they are powerful, and their position in this field is "clobbering a clear look" at pre-employment low back x-rays. Their problem is large but they are approaching it from a negativistic view. A blanket x-ray program for everyone is not realistic, is management oriented and is not in the best interest of the individual. But if there is a problem, x-ray, certainly. It has a place.

The x-ray should be part of a total examination. Most felt that two films, rather than four or six,are adequate for a screen. Shielding should be used; and both large prospective and retrospective studies are essential for the future.

Max Rogers, M.D. — The procedure has not been shown to be of predictive value in determining the future disability status of an employee. However, there are certain industries in which this examination may be of medicolegal or socioeconomic significance, and this aspect warrants further investigation.

John McClenahan, M.D., Philadelphia radiologist — X-rays are only one, and perhaps a minor criterion in the selection of job applicants. In general, four films should be ordered when indicated. Protective shielding is indispensible. And, "We agreed that each patient should be individually considered, that the role of one or more specific anomalies was hazardous in determining whether or not he was qualified for a job."

Clinton Compere, M.D., Chicago orthopedic surgeon — "There was no one in our group who felt that the pre-employment x-ray, low back examination had been established particularly as being of significant value."

"But we also realized in our group that there were special industrial situations where x-rays were a necessary part of an overall history, physical evaluation for possible hiring and certainly for certain job placement routines."

During luncheon, Forrest Rieke, M.D., industrial physician from Portland, Oregon, and a former member of the recently disbanded A.M.A. Council on Occupational Health, asked for the floor. He warned that the public was continuing to grow, not only more aware, but more concerned about environmental safety. He urged that the conference adopt strong, clear-cut positions that would be understood by the public.

Conferees then reorganized in disciplinary groups to hammer out proposals for the conference as a whole the next day.

The debate the next morning, sometimes heated, lasted 2 hours and 40 minutes. But before it got under way, Lorin E. Kerr, M.D., of the United Mine Workers of America voiced his opposition to the use of low back x-rays in pre-employment examinations. There is no evidence that they have predictive value, no quality controls or reading controls have been developed and there is no provision for the confidentiality of the reports, Dr. Kerr said.

"In view of these and many other problems," he added, "it is my feeling that these x-rays, if indicated, should be part of the total medical care provided the worker and his family. This would be equally true of the pre-employment examinations."

Much of the discussion of the final resolutions of the conference boiled down to a battle over semantics. But after amendments and counter-amendments had been proposed, the conference reached two initial conclusions:

The first was that pre-employment low back x-rays should not be done except as part of an evaluation that also included competent history and physical examination.

The second was that no prospective employee should be rejected on the basis of x-ray interpretation without such history and examination being considered.

The conference discussed for some time the evidence that had been submitted concerning the predictive value of low back x-rays in pre-employment examinations. The orthopedists, as a group, were generally more cautious in their approach to a statement on that issue. But, finally, the conference agreed that: "We find that pre-employment, or preplacement, x-ray evaluation of the lower back may be very useful, but recognize that such x-rays have yet to be proven clearly to be of statistically predictive value."

Proposals were made that would have detailed the procedures to be followed in low back x-ray examinations, but the radiologists, as a group, objected. As consultants, they said, radiologists should be free to use those procedures they felt best in terms of the patient and in terms of obtaining the information desired.

The conference finally settled on a statement which read: "The conduct of the examination shall be conducted according to the state of the art, including pertinent aspects of radiation protection."

A fourth conclusion reached by the conference dealt with the socioeconomics of the problem. It read: "There are barriers to employment and to rehabilitation and re-employment of persons with low back problems due to workmen's compensation laws and certain federal and state laws and regulations as well as in management and union rules and procedures.

"Certain of these nonmedical factors will influence the use of low back x-rays as a preplacement screening procedure."

A move to adopt a statement as to the application of examinations to specific classes of work was defeated.

The conference, looking to the future, did adopt this final statement: "Because of the lack of knowledge about the value of preplacement low back x-rays in preventing low-back injuries, it is recommended that NIOSH design and implement a prospective study of this subject with the assistance of the Industrial Medical Association and other appropriate resources to determine if information learned from low back x-rays is in fact useful in predicting low back pain and/or injuries."

That resolution was to be forwarded to funding agencies in Washington. How it will fare in the growing competition for the research dollar from federal sources may well determine the final outcome of whether low back x-rays should be used to determine whether or not a workman gets a job.

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CONFERENCE ON LOW BACK X-RAYS IN PRE-EMPLOYMENT PHYSICAL EXAMINATIONS

January 12, 1973

CHAIRMAN ARTHUR J. PRESENT: I welcome you to this first conference of its type. It is my pleasure to introduce Merlin K. DuVal, vice president for medical affairs at the University of Arizona and a founding dean of the College of Medicine, who has returned from being the undersecretary for Health, Education and Welfare in Washington.

DOCTOR MERLIN K. DUVAL: For those of us who have elected down through the years to make Tucson our home and who are serving as hosts for your visit today, may I say welcome.

Tucson is the home of the University of Arizona and on behalf of its president, I would like to welcome you. The University of Arizona is the original land grant institution in the state. It consists of 14 colleges. One of the most recent is the College of Medicine. It has been my privilege to serve as its dean since it was founded in 1964.

I also want to welcome you on another ground. It is most unusual to see a group of persons come together to address a problem, the nature of which is a mystery or an enigma. I suppose all of us who have served in another capacity in medicine have wondered at what point in time we would really get around to addressing the problem of low back pain. Welcome, then, to this enigma and I hope you will get down to the basics and will come forward with some ideas that will help advance our thinking and our understanding of the problem of low back pain.

CHAIRMAN PRESENT: Anyone who has looked over the agenda will note that we are going to have didactic presentations of most of the aspects of the problem. We will be discussing the anatomy, physiology and the implications in the pre-employment examination.

On the morning of the second day, each participant is assigned to a relatively small conference group. These include representatives from industrial medicine, radiology and orthopedics, in addition to source people who have worked with aspects other than these.

Then we come together for reports from these people implying that they have come to great conclusions and have the answers to all the problems.

After that, the radiologists, the orthopedic surgeons and the industrial physicians, again with resource people, will meet in separate groups and will clarify the situation to the point that when they finally come to their conclusions and bring all this information forward, they will have the answer to the problem.

The first speaker on our program is Dr. G. E. Erikson of Brown University who will speak on the "Morphological Perspectives of the Back."

MORPHOLOGICAL PERSPECTIVES OF THE BACK

G. E. Erikson, Ph.D.

DOCTOR ERIKSON: I've had to decide among several approaches that I might take for this introductory session with you. Among those I did not choose was one of attempting to give you a rapid-fire review of all the basic textbook minutiae of the region. That would be futile. A good number of you know those details very well. Those of you who do not probably would not listen and any who want those details can go to textbooks for them.

Another I might have chosen would have been to focus on just the very most critical, clinically important points -- but as has already been implied by our host this morning, we are not quite sure which these are. There is a lot of supposition, legend and tradition surrounding some few, very hard facts.

It seemed to me that since it is a cardinal sin in approaching any clinical entity to assume too early that you know the focal cause of the trouble or have it reduced to a few alternatives, it would be healthy in this opening session for me to paint the picture in the very broadest of perspectives.

I am a morphologist. My section at Brown University is the section of morphology -- not anatomy. Like many other anatomists today we offer more than the traditional fare to our students -- and I mean the first-year medical students, students in surgical anatomy, and surgical residents. We try to introduce as broad a biological perspective as we can for any clinical entity.

My own research work has been on comparative functional anatomy -- particularly that of locomotion -- and I have enjoyed following its extensions into clinical fields -- for a couple of decades at the Harvard Medical School and the Lahey Clinic and now in our new medical science program at Brown University and in the department of surgery at the Rhode Island Hospital. I find that surgical residents and the staff in general will follow such excursions into basic science when they are assured that it adds interest and meaning to exploring their clinical cases.

So let me invite you to attempt a fresh look at this whole region. I will talk not only about the lumbar spine, that is at the center of it, but of the whole back region, which has had a long evolutionary history and hence a complicated embryological development. As in other similarly compli-

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EDITOR'S NOTE-Dr. Erikson's talk was illustrated by, and largely based on a series of colored slides of adult and embryonic anatomy of man and other vertebrates. Since these could not be reproduced here, the tapescript of his talk would not have been useful alone and he has generously agreed to revise his talk to stand alone.

cated regions, the interpretation of signs and symptoms has much to gain from appreciation of the biological background.

If we look at the flayed back of a man, we really see none of what is morphologically the back. That introduces a key theme that runs through a great deal of the topographic and functional anatomy of the region. The back has undergone a long and complicated evolution, clearly reflected in its intricate embryological and postnatal development, which results in subtle and wide-spread functional and clinical inter-relations with other regions. A thorough grasp of this biological history is necessary to understand an otherwise puzzling complex of signs, symptoms and etiologies.

The largest muscle covering the low back, the latissimus dorsi, is functionally, of course, not a back muscle but a proximal, extrinsic muscle of the upper extremity. It passes along the back wall of the axilla to be inserted on the humerus and is innervated from the brachial plexus. It is a true limb muscle -- an extension of the teres major muscle -- and it is only late in embryology and evolution that it has spread out of the limb and over the lower trunk.

The trapezius, similarly, is a muscle that moves the shoulder girdle and, therefore, the upper limb. It is a back muscle only in position. Embryonically and evolutionarily it is a pharyngeal muscle that has evolved from a mover of the last gill bars to become a broad, proximal buttress and mover of the upper limb.

The true back lies entirely deep to these two muscles usually regarded as consitituting the "superficial layer of the back" -- as a matter of fact, deep to two more layers of it -- the levator scapulae and rhomboids of the second layer and the two dorsal serrati of the third layer.

These have all spread over the true back muscles and the sources of their nerve supply reflect their origin from beyond the back -- 1) from a cranial nerve (the eleventh) in the case of the trapezius; 2) from the ventral primary rami of spinal nerves -- via the posterior cord of the brachial plexus in the case of the latissimus, the cervical plexus in the case of the levator-rhomboid, and the intercostal nerves, in the case of the dorsal serrati. None of these muscles are supplied by the nerves proper to the back -- that is, by the dorsal primary rami of the spinal nerves.

The drastic remodeling of the vertebrate back becomes clear when we consider our aquatic ancestry and examine the basic anatomy of a fish. The familiar lateral line on a shark marks a horizontal septum that divides the dorsal extensor muscles from the ventral flexors. This corresponds to a fundamental division in the organization of the nervous system -- the division of every spinal nerve into a dorsal and ventral primary ramus. This is a fundamental morphological concept that holds for every limbed vertebrate including man.

So everything above this septum in lower vertebrates is true back: the dorsal, extensor trunk musculature innervated by dorsal rami and the overlying skin innervated by the terminal twigs of those rami that continue beyond those muscles to provide sensory and sympathetic cutaneous inner-

vation. Ventral to this septum is the territory of the ventral primary rami. It is very important to not that the two pairs of limbs are built into the ventral half of the body and consequently all true limb muscles as well as the ventral trunk muscles are innervated by ventral primary rami. Furthermore, since the precursor of our arm lies right behind the gill region, this explains why our upper extremity is cervical in nerve supply, blood supply and general orientation, though it is now pectoral in position. Similarly, our pelvic limb has undergone a caudalward migration which brings lots of complications in relation to the pelvis and sacrum in the distribution of that plexus.

If we take a quick glance at the stages of vertebrate evolution between a fish and ourselves, we will be reassured that these superficial back muscles actually did invade the back from ventral matrices.

The first stage is a salamander, essentially a fish on land. Its musculature is still largely axial. Its limited limb musculature is restricted to its ventral half. Dorsally, the extensor muscles of the back lie directly deep to the skin with absolutely no covering by other musculature.

A second revealing stage is a lizard, which has much longer limbs. It must have much longer-fibered muscles in order to accomplish the necessary excursion of the limbs, which have begun to extend dorsally to cover the deep muscles of the back. Toward the head region, a muscle that was, in the fish, a gill arch muscle, has spread up onto the head and back. This is the trapezius, innervated by a gill arch nerve, the eleventh cranial or spinal accessory nerve. The hind limb girdle, originally mounted only in the flank muscles, now articulates skeletally with the backbone forming a rudimentary sacroiliac joint.

The third transitional stage can be represented by any quadrupedal terrestrial mammal -- a dog, for example -- which will show all but the final degree of this covering of the intrinsic back muscles by these limb muscles.

This story is recapitulated beautifully in the embryological development of the region. A survey of the strategically chosen human embryos shows the development of these same patterns of adult, clinical anatomy that would otherwise seem inexplicable.

Rather than repeat this story in its embryological parallel, it would seem better to focus on some other cardinal morphological points in it that are constantly in the background of the functional and diagnostic anatomy of the back.

One is certainly that of a pervasive matamerism or segmentation. This is clearly visible in the trunk of the earliest embryos and while it is masked by the overgrowth of limb muscles both ventrally and, more especially, dorsally, it is still prominent in the deeper structure of bone, muscle, nerve and vessels and is still manifest even superficially in the dermatomes. Much of diagnostic examination and reasoning accepts this segmentation as fundamental.

A second basic morphological concept is that of the distortion of the originally simple sequence of segments by disproportionate growth, by actual migration of much of the mass of certain metameres and by the dominance of the ventral over the dorsal half of the body. Thus:

a) the simple cranial to caudal order of dermatomes, though complicated by the contrasting direction of rotation in the two pairs of limbs, is still evident in the sequence down the pre-axial and up the post-axial borders of opposite-facing pairs of limbs;

b) both pairs of limbs migrate caudalward -- especially the pectoral ones -- so that the limbs' myotomes and dermatomes stem from the region next cranial to that of the adult location (i.e. the pectoral limb is actually cervical and the pelvic is largely abdominal, as evidenced by their nerve and vessel sources).

c) the dorsal "half" of the trunk is dwarfed by the dominant, ventral hypomere with its greater role of enclosing the visceral cavity and producing the limbs. The dorsal primary rami of the spinal nerves are thus smaller and serve much more restricted dermatomes and muscular masses. Furthermore, though they must penetrate three layers of "back" muscle to reach the skin, they contribute nothing to their nerve supply.

A third basic morphological concept is that of differential growth -- not only of certain regions of the body, but also of certain systems. The precocious development of the central nervous system and its later relative dwarfing by the tardily developing vertebral column and general trunk results in the failure of the spinal cord to extend much more than one segment caudal to the thorax -- resulting in a whole host of familiar clinical consequences.

A fourth biological principle manifest in the back is that of variation in the extent of development of the potential inherent in each segment -- and the frequency and range of individual variation in this development. Several points might be emphasized:

a) We are so used to treating an articulated vertebral column as an entity that we may need to be reminded that only in the thoracic region is it truly a simple set of articulated vertebrae -- in the other regions it is augmented by assimilated costal elements -- the ventral elements of the transverse processes in the cervical region, the major part of the so-called transverse processes in the lumbar region and the lateral masses of the sacrum. Congenital variation in the relative development and fusion of these costal elements results in functionally and diagnostically important consequences for patient and physician.

b) These variations are overwhelmingly more frequent and fraught with more functional and clinical consequences at the lumbo-sacral than at either the thoraco-lumbar junction or, most especially so, at the cervico-thoracic border. The spinal column of the neck and upper thorax is developmentally very stable in man and other mam-

mals. Virtually all have seven cervical vertebrae. While a cervical rib is a troublesome anomaly, it is minor compared with developmental defects more caudally. Pre- and post-fixation of segmental inflow to the brachial plexus is also more moderate and the variations in dermatomes and myotomes less perplexing to the anatomist and diagnostician than those in the lower trunk and limbs.

A fifth morphological perspective gives the functional accompaniment of this greater variability in the lumbar and sacral regions. It is this section of the trunk skeleton that underwent the most drastic structural and functional changes in our evolution from a pronograde quadruped to an erect biped. There were important accompanying changes in the skull, shoulder girdle, rib cage, pelvis, knee and foot -- and each has its own clinical problems -- but clearly the back is the most trouble-prone.

Whole libraries of books and papers have been written on the anatomical facts and theories of human evolution and the choice of a few items to cite here is difficult. I would focus on the following trends as reflecting clinically involved complexes of adaptive features in the evolution of our locomotor system:

1. Shortening of the lumbar region by a) reducing the number of vertebrae from seven -- the modal number in generalized mammals -- to five, and b) contracting the cranio-caudal length (height) of each vertebral body (in proportion to its breadth).

2. Broadening of the trunk and the shifting of the vertical weight-bearing axis dorsally -- with the consequent change in the cross-sectional shape of the bodies of the lumbar vertebrae to one similar to the kidney-shape required by the trunk as a whole. This results in an intervertebral disc with a lateral curvature of small diameter and therefore most vulnerable to herniation -- at just the site where it is most likely to impinge on neighboring spinal nerve roots.

3. Increasing size. It is frequently not well enough appreciated that the tree shrew -- lemur -- monkey -- ape -- man sequence results not only in a radically different locomotor type but also in a hugely larger one. For tectonic reasons, if for not other, we must have quite differently shpaed and proportioned skeletal elements but we still have a locomotor mechanism originally designed for a small arboreal quadruped with a long, alender and suppel spinal column.

4. Basic conservatism in the redesign of our vertebral column for verticality and gigantism. In view of the radical new functional stresses put upon the human frame it is surprising how generalized it still is. We lack any extreme specialized trait such as those that instantly mark other extreme locomotor types among mammals -- swimmers, flyers, gliders, diggers, hoppers, fast runners, slow climbers and so forth. In tracing our lineage from our prosimian ancestors we might have expected to find some radically made-over mechanical features but there are none. I will mention

only one example of such a detail — one which seems to shout for redesign. The mortise joints between the zygopophyses of the lumbar vertebrae were splendid mechanisms in the locomotor spring of a catapulting small, arboreal lemur — preventing, as they do any unwanted longitudinal rotation — but in our huge, vertical frame they predispose to subluxation.

Perhaps this will suffice to sketch in the morphological background for our more detailed concentration on the clinical problems in the lower back.

CHAIRMAN PRESENT: Dr. Henry LaRocca will speak on the "Pathophysiology of the Lower Spine."

Dr. LaRocca is from Tulane in New Orleans.

PATHOPHYSIOLOGY OF LOWER SPINE

Henry LaRocca, M.D.

DOCTOR LaROCCA: The clinical problem of low back pain constitutes a large and complex matter which continues to offer scientific medicine an unresolved challenge. Although the complaint is an extremely common one, responsible for the addition of thousands of new cases each year, clinical management has not yet reached a point of sophistication which is capable of preventing protracted suffering and even instances of permanent disability. Although there are doubtless many reasons for this state of affairs, two broad generalizations seem to describe the fundamental difficulties inherent in the back pain problem. The first arises from the fact that the low back responds to a great multiplicity of derangements by producing only a few types of symptoms and signs which are not frequently specific enough to allow diagnostic and therapeutic precision. As an illustration, the symptoms produced by an osteoid osteoma may differ very little from those produced by an intervertebral disc prolapse, and unfortunately, the ordinary radiography in both problems may provide no exact diagnostic information. The second general difficulty is that in any given case, there are two components which must be understood: the pathological changes producing the back pain and the psychosocial reactions of the individual to the pain. Although some of the pathological factors for low back pain (e.g. acute compression fracture) would compromise nearly all afflicted individuals, the more common ailments exert a variable effect which is modified substantially by social role and by psychological constitution. Hence, what is inconvenient to the clerical worker may well cause disability to the manual laborer. That which merely troubles the well-integrated personality may incapacitate the hysterical or the inadequate. An appreciation of these difficulties should allow the astute clinician to test the relative weights of all the factors which have precipitated a back pain problem before formulating an opinion. Judgement error arises when too much or too little importance is assigned to the psychosocial components or when the awareness of the variety of organic pathology is restricted.

Low back pain can arise from many different types of organic disorders, and for purpose of organization, the responsible factors may be tabulated (Table 1). Doing so in no way implies that each of the factors is fully understood at present. Information regarding some is reliable, but in others, knowledge is fragmentary and speculative. Continuing technological development will permit identification of still others not yet even suspected. There is more certainty regarding the operations of metabolic, inflammatory, and neoplastic disease in the production of back pain than there is in regard to degenerative disease. Yet in fact, degenerative disease is responsible for greater numbers of cases than any of the aforementioned etiologies, and it can act to produce symptoms through several mechanisms.

DISC DEGENERATION

A pivotal issue in low back disease is the meaning of intervertebral disc degeneration, a phenomenon which begins in the third decade of life and continues thereafter. Given sufficient age, this phenomenon occurs in all specimens, and therefore must be considered a physiological feature of aging. Although the changes which occur in this process are not necessarily productive of pain, the majority of patients with low back disease demonstrate disc degeneration with no other obvious pathology. Hence, hypothesizing that there are two types of disc degeneration becomes reasonable. One produces pain while the other does not. What ultimately differentiates the two has yet to be defined since the morphology of the degenerated disc which produces pain is identical with that of the disc that degenerates quietly. However, there are clues to suggest that there is indeed an essential difference which operates in ways that lead to no readily recognizable morphological changes. One such clue is the finding that intervertebral disc material, which is usually isolated from the systemic circulation, can invoke an auto-immune response when it comes into contact with a blood supply. A second clue lies in the suggestion that there is a genetic pre-disposition toward low back disease in that individuals with the problem often are members of kinships in which other involved persons can be identified. An interplay between genetic and environmental factors may be responsible for the ultimate decompensations observed. There are some constitutional disorders of connective tissue (e.g. achondroplasia) in which intervertebral disc degeneration occurs predictably and can lead to profound disability. A third clue is the recent demonstration that low back pain can be modified substantially by the injection of the intervertebral disc with the enzyme chymopapain which causes profound alterations in the chemical anatomy of the disc protein-polysaccharide without yielding substantial morphological changes in disc structure. Another chemical observation of importance is the demonstration of lower pH than normal surrounding prolapsed disc material which suggests that the altered chemical environment may be responsible for symptom production.

The process of disc degeneration converts the normal intervertebral disc with three distinct morphological components into one that is more or less homogeneously collagenized. The healthy disc is composed of a nucleus pulposus constrained within a multiple layered annulus fibrosus, and both of these structures are interposed between two hyaline cartilage end plates of vertebral bodies (Fig. 1). This disc is isolated from the systemic circulation, and is avascular as long as it is healthy. It receives nutrients and eliminates waste through pathways of fluid diffusion across the cartilage end plates.

The nucleus pulposus is sharply separated from the other components and in health, contains high concentrations of chondroitin sulfates arranged with collagen into a lattice work which has high water binding capacities. As a result, the nucleus is maximally hydrated and thus can function as an incompressible elastic body. When load is delivered to it, the nucleus does not flatten out but instead redirects the load centrifugally and thereby dissipates force to protect the spine from damage. Further, the nucleus guides motion of one vertebra on another since its ovoid shape

Table 1

PATHOLOGICAL FACTORS ASSOCIATED WITH LOW BACK PAIN

1. Inflammatory disorders
2. Metabolic disease
3. Neoplasm
4. Fracture and dislocation
5. Disc degeneration
6. Segmental instability
7. Neural encroachment syndromes
8. Spinal anomalies

Table 2

NEURAL ENCROACHMENT SYNDROMES

1. Herniated nucleus pulposus
2. Foraminal stenosis
3. Pedicular kinking
4. Spinal stenosis

permits a ball-bearing function. Thus, vertebrae roll on one another rather than slide, and as they do, the nucleus is displaced toward the convexity of the curve thus formed.

The constraint on the extent to which the vertebra can roll on its neighboring nucleus is provided by the annulus fibrosus which becomes taut when stretched, and thus stops motion. This structure is composed of a series of concentric lamellae of collagen fibers which attach to the cartilage end plates of the two adjacent bodies. These fibers have great tensile strength which not only imparts the ability to restrain motion but also permits the annulus to absorb the load delivered to it by the nucleus without losing its integrity.

In disc degeneration, changes in the concentration of the chondroitin sulfates occur, and these moieties become quantitatively reduced. Other protein-polysaccharides which are less hydrophilic appear, and the net result is a diminished level of hydration. Similar alterations occur at both nucleus and annulus, but the nucleus, having a greater initial water content, becomes more notably different. To the degree that it dessicates, it loses its ability to behave as an incompressible body and becomes subject to damage from the load delivered to it. It can no longer transfer this load normally, nor can it continue to guide a rolling type motion. As degeneration advances, the disc stiffens, and the border between nucleus and annulus becomes ill defined (Fig. 2). The layers of the annulus begin to fuse and to lose their continuity by cracking. With the cyclic loading of this stiffer structure, tears occur centrally and radiate peripherally (Fig. 3). Lakes of mucoid degenerated material accumulate between annular layers. The dessicated nucleus fragments (Fig. 4), and the pieces are more relative to one another. Thinning and fracturing occur in the end plates. The multiple fissures created permit the ingress of vascular granulation tissue. At this stage, the pristine structure of the disc is irretrievably lost, and the structure becomes quite heterogeneous, containing several tissue types, each with slightly different load bearing capacities. The motion of the vertebral unit is thereby deranged.

Occurring simultaneously with the ravages inflicted by reduction in hydration, increased proportions of collagen develop within both the nucleus and the annulus and tend to cause binding of one vertebral body to another. Collagenization of the disc progresses to eventually establish a new state of order in which the disc becomes homogeneous. The two vertebrae in the unit are thus tethered to one another and demonstrate restricted capacity for motion. This is the end stage (Fig. 5) in disc degeneration and in it the loss of motion compensates biologically for the loss of those structures which permitted regulation of motion. Thus, the aged spine has an inherent restriction to its motion capacities.

What determines whether the process of intervertebral disc degeneration will produce disability or not remains an unknown. The chemical changes which are associated with the degenerative phenomena may be different in individuals suffering pain thus allowing discs which appear to be morphologically similar to cause different clinical problems. In addition, the sequence of derangement of the intervertebral disc may be more rapid or may lead to more heterogeneous intradiscal responses to load in individuals

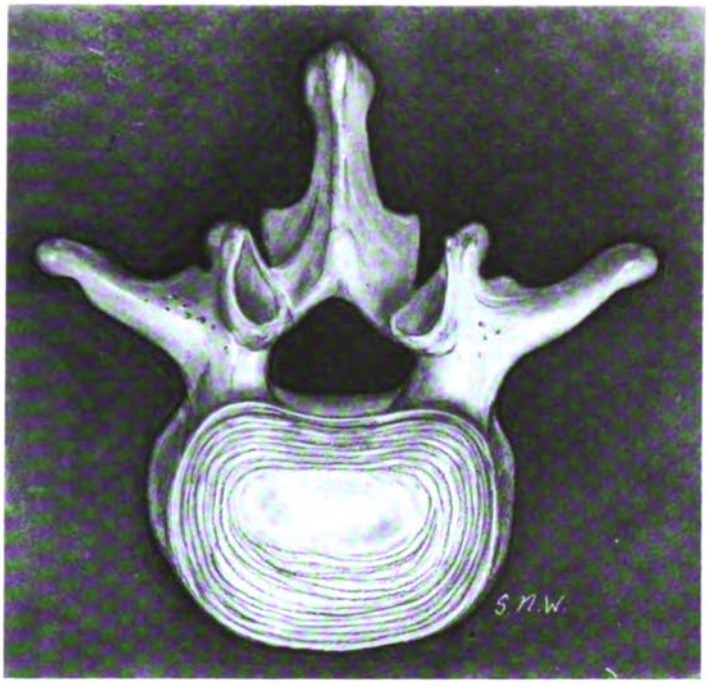


FIGURE 1. The normal intervertebral disc as viewed from above. The glistening nucleus pulposus is sharply differentiated from the multiply layered annulus fibrosus.

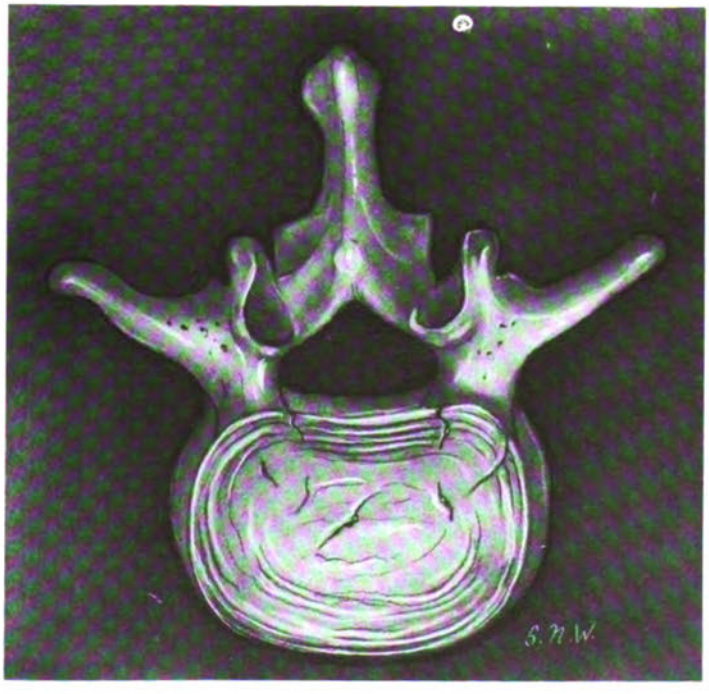


FIGURE 2. Disc degeneration results in dessication and stiffening of the nucleus pulposus, disruption of the layers of the annulus fibrosus, and loss of definite distinction between the two structures.

FIGURE 3. **Advancing degeneration results in structural failure of the disc with radial tearing of the annulus and the development of concentric lakes of debris and granulation tissue.**

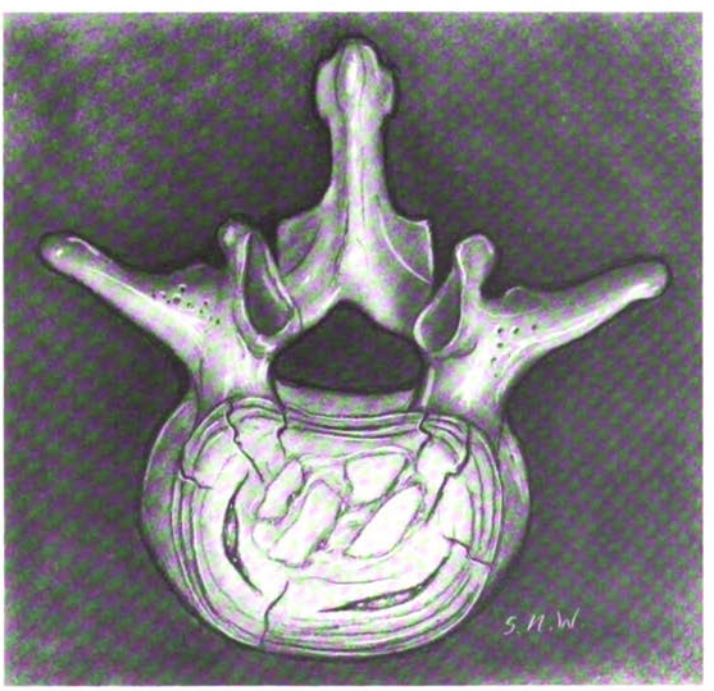


FIGURE 4. **The stiffened nucleus undergoes fragmentation, with islands of dessicated nuclear material embedded within a fibrous stroma (diagrammatic).**

experiencing the pain phenomena. The ultimate stiffening of the intervertebral unit provided by the process of collagenization may be permanently impaired in the disabled group.

SEGMENTAL INSTABILITY

In the normal disc, the nucleus functions as a ball-bearing to permit motion about an arc. When the disc degenerates and fragments, the smooth rolling motion characteristics are lost and linear directions of motion are added. The instant centers of rotation, which are normally restricted to specific regions in the intervertebral unit, become dispersed in many directions. Motion then becomes irregularly directed, and, as the process progresses, the intervertebral disc tends to begin to collapse posteriorly and gape open anteriorly when the unit is extended and to deform in the reverse manner when the unit is flexed (Fig. 6). The amount of stress applied to the lamellae of the annulus fibrosus increases.

The structurally incompetent disc thus permits excessive motion and motion in abnormal directions. The stresses engendered in both the intervertebral disc and the apophyseal joints permit further degenerative phenomena to develop and lead to increasing incompetence. Once this cycle is established, secondary phenomena begin to appear as bony outgrowths from regions to which fibrous structures attach to bone. The most characteristic of the excresences is the traction spur which forms on the anterolateral margins of the vertebral bodies approximately two millimeters distal to the end plate, in the region of insertion of the fibers of the annulus fibrosus. The presence of traction spurs is indicative of the degenerative process occurring in the disc.

Mechanical incompetence of an intervertebral unit is associated with pain which arises from stresses on those regions of the posterior annulus fibrosus which have innervation, stresses and destructive changes in the zygoapophyseal joints.

NEURAL ENCROACHMENT SYNDROMES

Several clinical syndromes in which neural elements are compromised by anatomical alterations are known (Table 2). In the herniated nucleus pulposus syndrome, the contents of the spinal canal are compromised by protrusion of disc elements into the spinal canal. The term herniated nucleus pulposus is something of a misnomer in that it implies that the entire nucleus is displaced into the canal. This actually does not occur except in the rare case. Instead, the material which imposes itself onto the neural elements is a combination of fragments of the dessicated nucleus along with shreds of annulus fibrosus anf flakes of the cartilaginous end plates. Once the nucleus has fragmented, the pieces are relatively free to move and respond to the major directions of stress in the lumbar spine to begin a posteriorly directed migration. A migrating fragment may encounter a radial tear in the annulus and enter the tear to forge its way to the posterior region of the disc and ultimately into the spinal canal, taking along with it a front of annulus fibrosus and shards of cartilage end plate (Fig. 7). The outer annulus may remain intact, and the displaced material then produces a bulge into the canal which compresses an adjacent

nerve root. This is the stage of disc prolapse. If the outer annular fibers tear, the displaced material may actually be extruded into the canal, and this is the stage of disc sequestration. The extruded material may enter the canal as a loose body and as such it is free to move. Usually it will descend caudally to the next segment to produce neurological problems with a level different from that at which the disc disease occurred.

FORAMINAL STENOSIS

This is a second important cause of neural encroachment. In the healthy state, the neural foramen is sufficiently large to allow free passage of the emerging nerve root. As the degenerating intervertebral disc narrows, the amount of space in the foramen reduces, and the annulus becomes relatively redundant and thus imposes itself into the foramen. In addition, the facets of the zygoapophyseal joints tend to subluxate, and their capsules become relatively redundant and also occupy space in the foramen (Fig. 8). The emerging nerve thus becomes compressed within its foramen, in a situation analogous to peripheral nerve compression in fibro-osseous canals in other regions of the anatomy, and symptom production results.

PEDICULAR KINKING

This is an uncommon neural encroachment problem, but it can occur in degenerate segments with a measure of segmental scoliosis. Normally, the right and left pedicles of a vertebra are at the same level, but degeneration may lead to tilting of one vertebra on another in which one pedicle descends caudally more than its counterpart on the opposite side. As the pedicle descends, it may exert a drag effect on the nerve which emerges beneath it and produces nerve traction and compression and the symptoms and signs associated with this. The nerve is kinked by the descending pedicle, and such kinking may even be demonstrable on myelography.

SPINAL STENOSIS

This is another important neural encroachment syndrome. In it, all of the neural elements in the spinal canal at one or more segments become encroached upon circumferentially. The disorder begins with a canal that is smaller than normal on a developmental basis. Throughout youth, there is sufficient room in the canal to accomodate the neural elements, but with the advent of degenerative disease, the canal becomes increasingly encroached upon in all directions. From anteriorly, the intervertebral disc becomes patulous and occupies space. The segment narrows and the posterior longitudinal ligament and posterior annulus fibrosus become redundant. From laterally, the apophyseal joints undergo degenerative hypertrophy and their thickened capsules intrude themselves into the canal. The ligmenta flava likewise become redundant and encroach from posteriorly. The dura and associated nerves become constricted in a napkin ring configuration (Fig. 9). Symptoms arise from the neural compression and probably also from interference with the dynamics of the blood supply to the dura and the nerves. In addition, there is a functional derangement of the degenerate unit which also provides a cause for symptomatology.

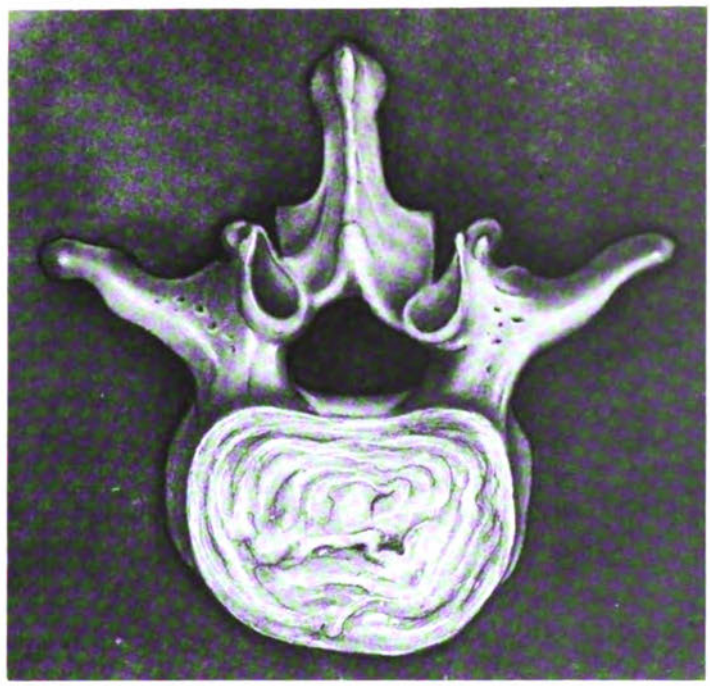


FIGURE 5. The end stage of disc degeneration is complete fibrosis of the structure, binding one vertebra to another.

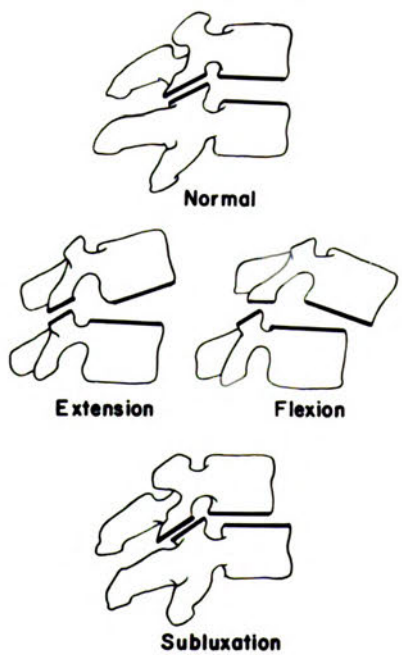


FIGURE 6. With segmental instability complicating disc degeneration, increased vertebral excursion occurs with motion leading to abnormal anterior widening of the segment in extension, and relative collapse in flexion. These motion patterns are no longer in the planes of the zygoapophyseal joints and lead to joint surgery. Subluxation may develop as the intervertebral disc height narrows.

FIGURE 7. Nuclear prolapse occurs as a fragment of dessicated nucleus ingrates posteriorly and carries with it elements of the annulus fibrosus and cartilage end plates, producing a bulge into the spinal canal.

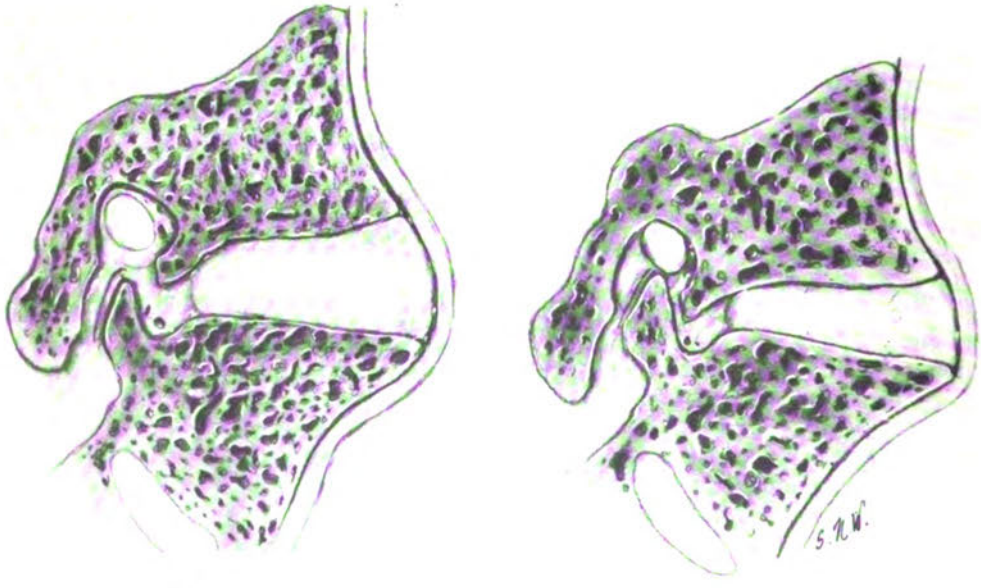


FIGURE 8. In (a), the emerging nerve normally has sufficient room to exit through the foramen. With disc narrowing, the foramen is encroached upon by an ascending edge of the superior articular facet of the vertebra below (b), and symptoms of a neuritis develop from compression of the nerve.

DEGENERATIVE SPONDYLOLISTHESIS

This also gives rise to a spinal stenosis syndrome. In this problem, the upper vertebra of a unit undergoing degenerative change (usually lumbar 4-5) slides forward on the partner below to approximately one-quarter of the sagittal diameter of the body. The facet joints develop extensive degenerative arthritis with an erosive component so that the listhesis results from incompetence of the facet joints to prohibit such displacement. There is no associated defect in the neural arch. The forward displacement of the upper vertebra causes the spinal canal to deviate posteriorly as it descends caudally and to be creased by the sharp postero superior border of the vertebral body of the lower member of the unit. Hence, circumferential constriction of the canal contents results.

SPINAL ANOMALIES

Those which occur on either a congenital or developmental basis are associated to some extent with the back pain problem, and their principal mode of contribution seems to lie in the mechanical instability or functional derangement they create. Minor anomalies, such as facet tropism, or spina bifida occulta, would seem to be of little consequence. Intermediate anomalies such as hemisacralization of the transverse process of the fifth lumbar vertebra are somewhat more likely to be associated with back pain problems, although the defect itself may not be the site at which the pain is generated. Instead, by causing abnormal concentrations of force reception at the next more cranial and more mobile segment, the anomaly contributes to the degeneration of the segment above itself. Gross structural anomalies such as congenital scoliosis cause aberrant concentrations of load reception and lead to degenerative changes which then become symptomatic.

Isthmic defects in the neural arch are termed spondylolysis. Such defects may be unilateral or bilateral. The replacement of a segment of bone with fibrous tissue in the vertebral ring creates a situation of mechanical incompetence which can give rise to back pain symptoms. Further, during the growing years, because the major thrust in the lower lumbar spine is caudal and anterior, a bilaterally defective neural arch may permit forward and downward displacement of the vertebral body of the interrupted segment. The resulting condition is known as spondylolisthesis. During adolescence, the motion occurring during the development of spondylolisthetic displacement can create pain crises which are associated with profound muscle spasm in the erector spinae groups and in the hamstrings. Once the deformity has developed and matured, any further displacement generally would require quite severe trauma. However, the altered anatomy of the spine is associated with abnormal responses to stress, and pain may develop without any additional displacement. The stress concentrations may be forcused at the segment above the abnormality, and the intervertebral disc degeneration may be hastened. Thus the segment above may become an independent source of pain in a spondylolisthetic spine.

In considering the position at which information regarding the pathomechanics of low back pain has reached currently, several observations seem to be warranted. The first is that a number of reasonably discreet syn-

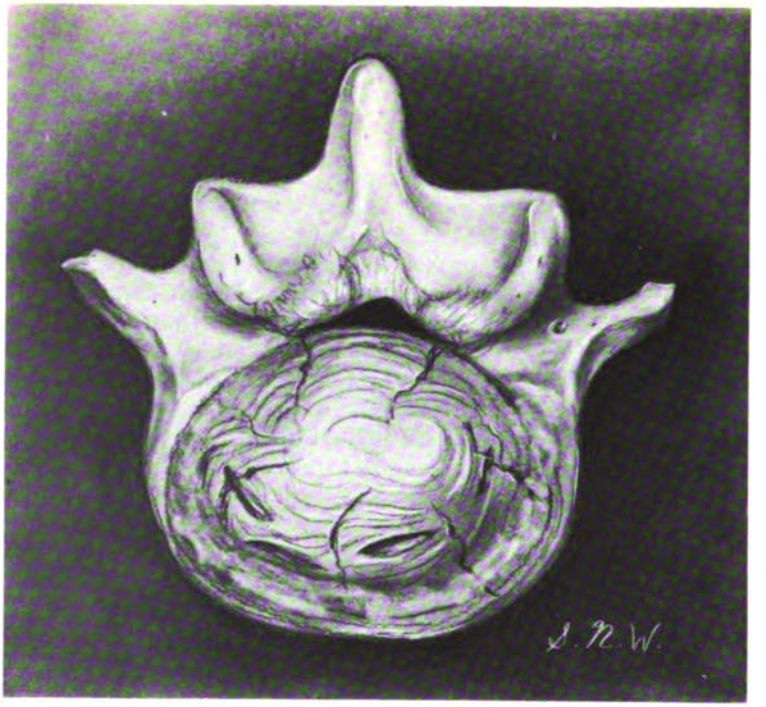


FIGURE 9. In spinal stenosis the capacity of the spinal canal is substantially reduced circumferentially by redundant and hypertrophic tissue posteriorly and laterally, and by bulging of the patulous disc anteriorly.

dromes have been delineated which permit a systematic approach to both clinical problem solving and to directing further research. Better definition of each of the syndromes in both clinical and biological terms is now required, as is the addition of others as they become recognized. The availability of a classification of syndromes, albeit incomplete and imperfect, provides a framework on which to build a thorough understanding of a disease.

CHAIRMAN PRESENT: The next subject has been, at least, alluded to in the radiographs that you have seen. Dr. Bernard Epstein from Long Island is going to speak to us on the "Radiological Anatomy of the Lower Spine."

RADIOLOGICAL ANATOMY OF THE LOWER SPINE

Bernard Epstein, M.D.

DOCTOR EPSTEIN: While it is easy enough to talk about the abnormal lumbar spine, the question as to just how one can differentiate between the ending of the normal from the beginning of the abnormal defies a definitive answer. This question becomes most important when the possibility of obtaining employment or being denied work because of a so-called "abnormality" faces the person in search of a livelihood. While no one would deprive another from his right to be gainfully employed on many grounds, it is debatable whether an undue emphasis on anatomic variants can determine the risk factor to both worker and employer and thus become the basis for acceptance or rejection. This conference is dedicated to a searching investigation of the role of low back x-rays in helping to settle this problem. Should, indeed, one of the many structural aberrations frequently found in the lower back become the sole reason for denying employment to individuals and to what extent and in what context should those back variations be considered as increasing risk to patient and employer?

The films which I will present are those likely to be encountered in pre-employment examinations. However, they were all found during normal radiological investigations and in this group, in patients who did not have back pain. The question naturally arises now as to whether the patient, had he been applying for a position in a variety of companies, should be permitted to accept employment or should be denied a job on the basis of a pre-employment back roentgenographic examination. This places great responsibility on the physician in determining whether or not a radiologic change is sufficient reason to withhold employment, and if so, under what circumstances. We return, then, to the question, "What is a normal adult spine?"

The architecture of a normal lumbar vertebra is far better demonstrated graphically than verbally. Figure 1 is a normal fourth lumbar vertebra selected from our collection of normal and abnormal spines. The purpose of this illustration is to stress the fact that the neural arch and the spinal canal are most important in evaluating structural normalcy. The factor of the available space in the spinal canal, particularly in the lateral angles and in the intervertebral foramina, surpasses in significance osteophytic overgrowths or minor architectural variations which will be demonstrated later. In the normal individual the shape of the lumbar spinal canal varies from the first to the fifth segment. In the fourth and fifth segments, most frequently affected, together with the upper sacrum, a normal foramen will present as a rounded, somewhat triangular (sometimes described as a pentagonal) structure, with the lateral angles rounded and wide. This can be identified accurately only anatomically. Nevertheless, the sagittal width of the canal can be estimated fairly well from the size and configuration of the lumbar inter-

FIGURE 1. Caudad view of normal 4th lumbar vertebra. Note the height and smoothness of the pedicles, and the disposition of the articular facets.

FIGURE 2. Cephalad view of the 4th lumbar vertebra with a stenotic spinal canal. Note the narrowness of the lateral angles. The bony overgrowth of the articular facet, and the lamina intrude into the right side of the spinal canal.

vertebral foramina, best seen on true lateral views. A measurement of 15 mm. is normal. Anything below 13 mm. may be regarded as quite suspicious of a narrowed sagittal canal, now accepted as a "stenotic lumbar canal."

An obviously narrowed canal is suggested (Fig. 2) when the pedicles are short, the sagittal diameter narrowed and the lamina are thick and convergent. These factors all influence the available space in the canal, particularly important insofar as the emergence of nerve roots from the canal into the intervertebral foramina is concerned. Based on these factors, plus pathologic changes which often appear as part of the aging process, in the articular facets as well as in the vertebral bodies, significant alterations affecting pressure against the cauda equina and the emerging nerve roots may take place. Here, therefore, we have a problem in identifying the normal from the abnormal, particularly in the age group over 40.

In the two instances presented here we can contrast the normal smooth, rounded lateral angle, the height and smoothness of the pedicles, with the diminished space resulting from a shortened pedicle, bony overgrowth of the posterior vertebral rim, the articular facets, and sometimes the pedicle itself. Between 20 and 30 percent of a lower lumbar intervertebral foramen is occupied by the nerve root with the remainder taken up by fat, fibrous tissue and blood vessels. Should this take place in a stenotic canal, the intrusions are far more likely to produce symptoms referable to the cauda equina and the emerging nerve roots than in a normal canal. In the present examples, degenerative changes appear in the pedicles, along the articular facets and along the floor of the canal and emphasize the diminution in available space already predicated on a stenotic canal.

In Figure 3, we have the fourth lumbar vertebra of a man estimated to be about 60 to 65 years old. Here we can reiterate the fact that in the genesis of stenosis of the lumbar canal with consequent nerve root syndromes, overgrowth of bone along the margins of the anterior and lateral aspects of the vertebral body may have little importance. It is interesting to speculate on the stress placed on the extent of osteophytes rather than on their position. The bony overgrowth seen on this specimen underlines the face that in the genesis of nerve root compression, the presence of osteophytic and arthritic overgrowth of the articular facets and lamina may be quite significant. Arthritic changes may be the cause of gross pitting, broadening, thickening and eburnation of the articular facets and extend along the lamina. In this vertebra a hammer-like downward spur projecting into the intervertebral foramen is evident.

A stenotic lumbar canal may occur on a congenital basis, or partly so, augmented by overgrowth of bone and inflammatory and osteoplastic changes incident to true arthritis of the apophyseal joints as well as bone response to wear, tear and prolonged exertion. The question as to how to separate these components at the moment is best answered by careful investigation of the sagittal diameter of the canal, the configuration of the pedicles and laminae and of the intervertebral foramina, and the condition of the articular facets. These factors are sometimes

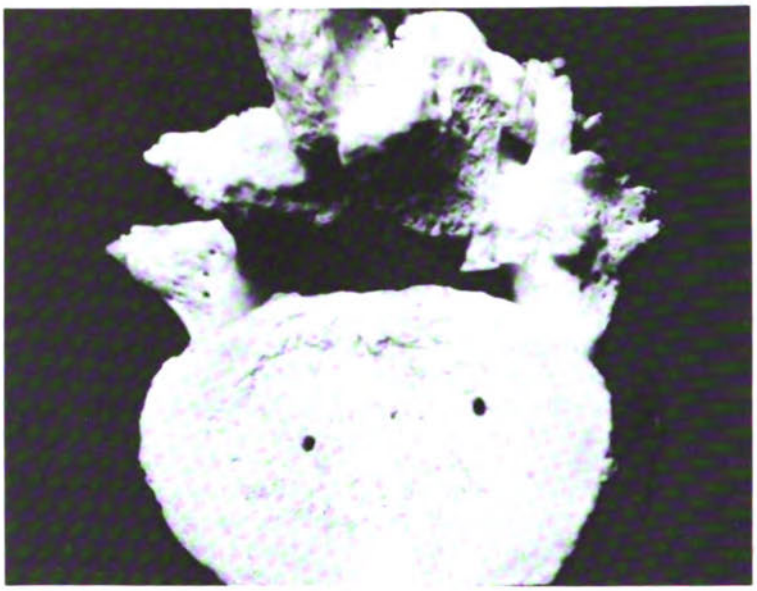


FIGURE 3. Caudad view of another 4th lumbar vertebra. The broad, pitted surface of the articular facet indicates an old arthritis. A spur projects downward from the junction of the pedicle and the lamina sharply into the right lateral angle and intervertebral foramen.

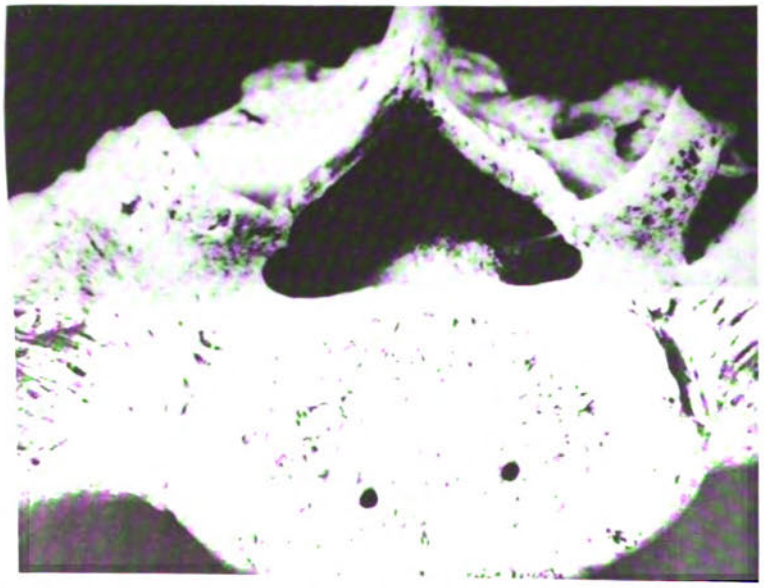


FIGURE 4. Caudad view of a normal first sacral canal. The lateral angles are wide. The canal is almost triangular in configuration.

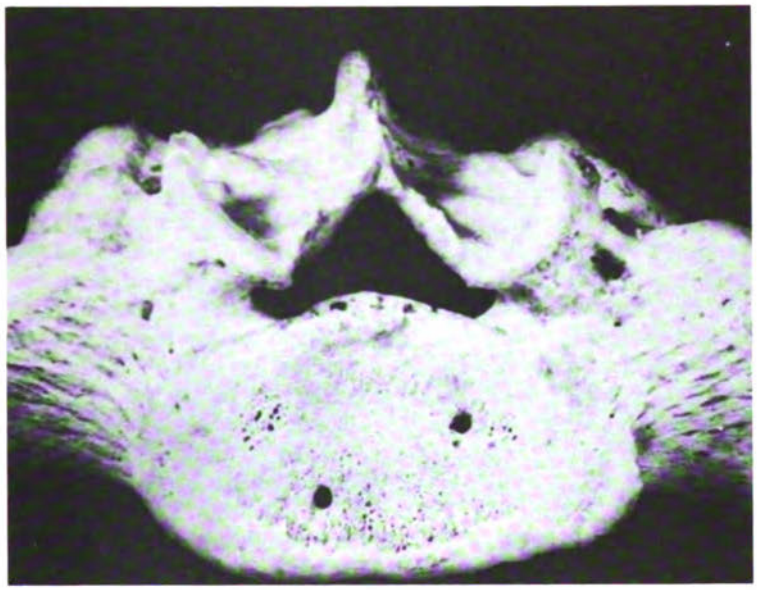


FIGURE 5. Caudad view of a narrowed sacral canal. Impingment of the lamina into the lateral angles diminishes the available space for the emerging nerve roots.

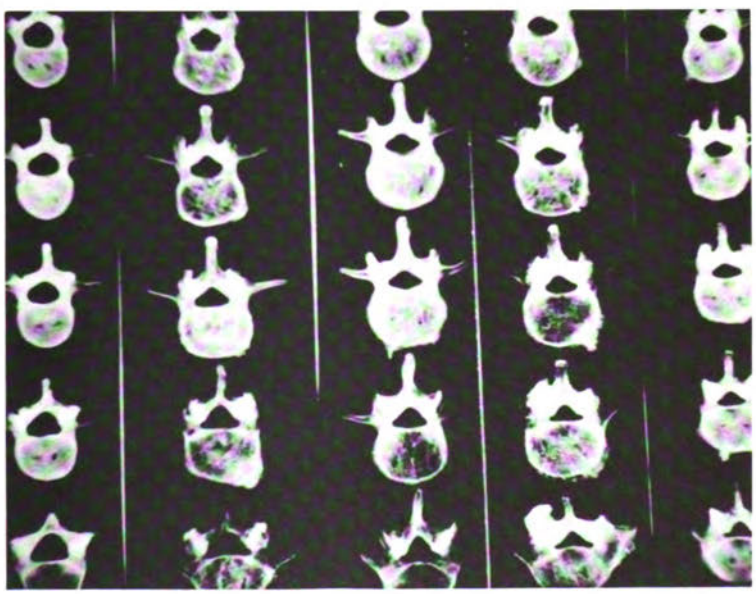


FIGURE 6. Five lumbar spines laid out from L-1 to L-5. From left to right, the canal is wide on the first strip, diminishing in capacity to the fifth strip. Note how the spinal foramina at L-4 and 5 become triangular and how the lateral angles narrow out as the canal becomes more stenotic.

quite difficult to evaluate and narrowed lumbar canals sometimes are apparent and sometimes one can be deceived even with the best of roentgenograms.

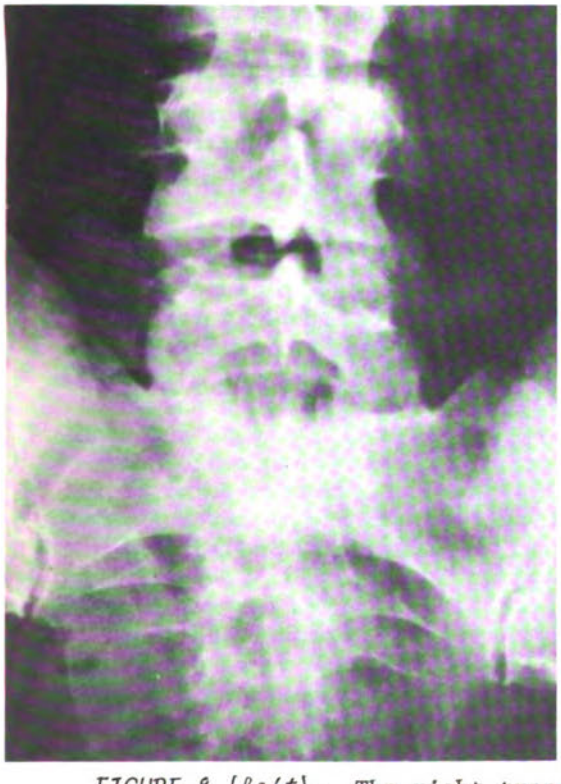
Equal important in the evaluation of the lumbar spine and low back pain is the configuration of the first sacral segment. The normal canal is rather large with wide open lateral angles (Fig. 4), while others display changes quite similar to those seen in stenotic lumbar canals (Fig. 5). The configuration of the upper sacral canal may be compromised by overgrowth of bone at the middle or lateral aspects of the canal with overgrowth of the articular facets and narrowing of the lateral angles, which may compromise the emerging nerve roots with consequent radicular manifestations. At times, all of these compromising elements may be present. If we examine a series of spinal canals laid out in sequence of the order of magnitude of the spinal foramina, we go from a young person with a wide canal to the other extreme of an elderly individual with a deformed, stenotic canal (Fig. 6). All are dried specimens with no history available. Nevertheless, a concept as to what happens to the spinal foramina in this sequence is apparent. You will note that the bodies of the vertebrae are quite alike. Some may be a little smaller or larger than others, some show bony overgrowth peripherally. As you inspect the vertebrae from L-1 to L-5, a definite change in the configuration of the spinal foramina is evident. It is circular at the upper levels, becomes triangular or pentagonal lower down, and ends with small, trifoliate configuration with marked narrowing of the lateral angles. These are developmental as well as overgrowth changes and the element of heredity as well as of stress and strain will co-exist. Suffice it to say that those most likely to have pain and radicular symptoms are people with narrowed canals, small intervertebral foramina and narrowed lateral angles.

In the past, and even now, there are some who place great emphasis on minor vertebral changes in the low back. I do not agree with them as to the clinical significance of such architectural alterations in many cases. All of the films I will present now are from patients without back pain who were referred for examination of the urinary or the gastrointestinal tract or other conditions unrelated to low back pain. We may start with an example of a congenitally wide canal in a young man of 17, in whom the pedicles are thin, widely separated, and whose laminae are divergent, with plenty of space in the spinal canal. The lower articular facets are asymmetrically placed and dyssymetry of the articulations between L-3 and L-4 are demonstrable as well as in those between L-4, L-5 and S-1. On lateral views the pedicles are high and the intervertebral foramina are wide. The significance of this is that a wide canal with or without asymmetric articular facets does not indicate intraspinal mass lesion, nor are symmetry of the apophyseal joint surfaces necessarily significant.

In evaluating the articular facets, the question as to the need for oblique projections is often raised. While these may be helpful, I believe that for survey purposes they are usually unnecessary. With today's rapid development of films, inspection of the preliminary pair of anteroposterior and lateral films will disclose need for further examination, which then can be carried out as indicated.

In the evaluation of the vertebral column, the appearance of the inter-

FIGURE 7. The transverse processes of L-5 are elongated, and articulate with the sacrum and iliac bones bilaterally.



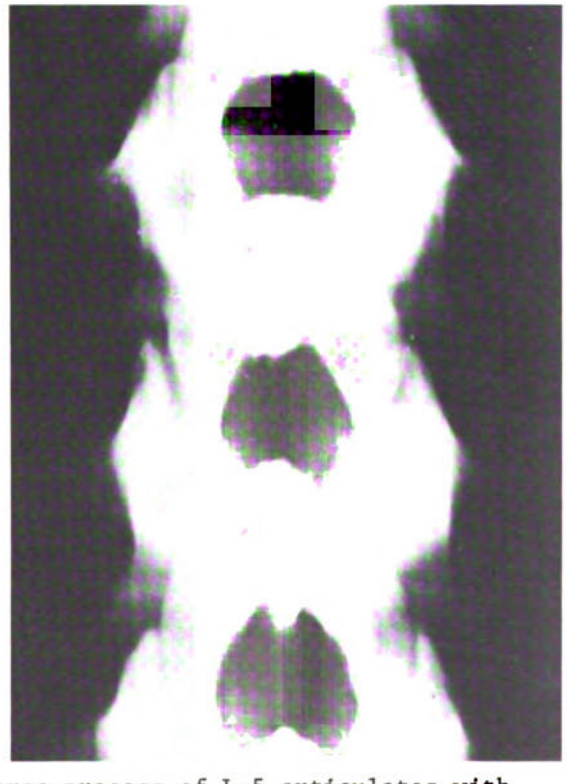


FIGURE 8 (left). The right transverse process of L-5 articulates with the sacrum and the iliac bone. The left is normal in size and position.

FIGURE 9 (right). Laminagram of a normal lumbar spine showing the neural arches of L-3 and 4. Note the space between the spinous process and the disposition of the laminae. The articular facets can be seen fairly well.

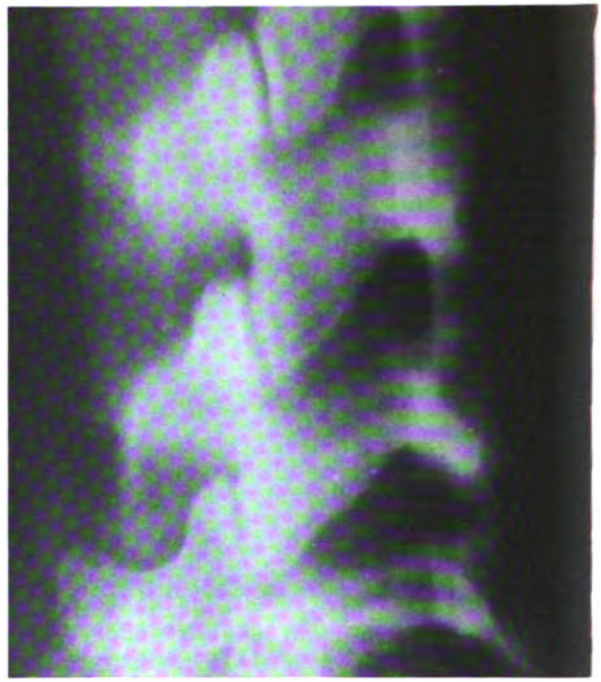


FIGURE 10 (left). A laminagram of the 3rd, 4th, and 5th lumbar vertebra in a patient with a stenotic canal. Note the thickness and the convergence of the laminae, and the lack of space between the respective vertebral segments.

FIGURE 11 (right). Laminagram showing the pars interarticulari and the articular facets in the oblique position.

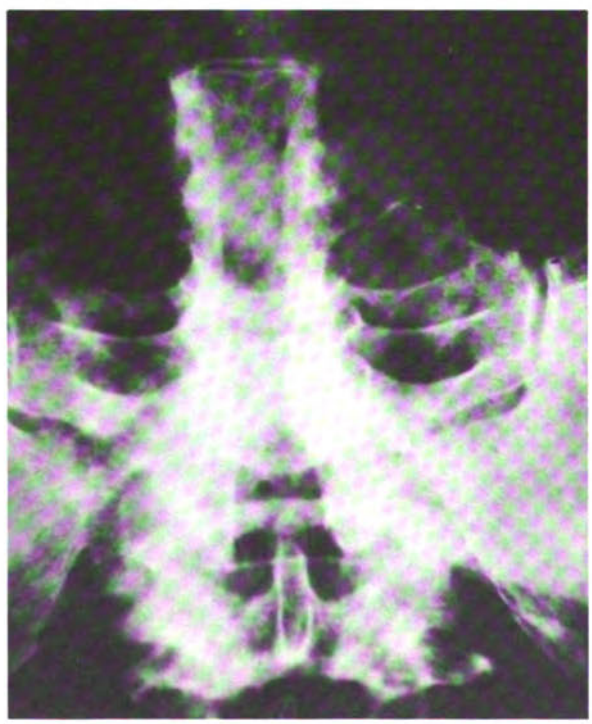


FIGURE 12. Anteroposterior view of the sacrum reveals failure of fusion of the dorsal plate of the sacrum. This patient was asymptomic.

vertebral discs, their height and symmetry, and the curvature of the lumbar spine as well as the dorsal tilt of the sacrum have all been measured and clinical conclusions sometimes are drawn from these observations. Here clinical correlation becomes essential. Not every straight spine, or exaggerated lordotic curve, or tilted sacrum, or narrowed disc, is necessarily important either at the time of examination or as an index of future disability. Not every disc surface need be parallel and often the posterior discal height is less than its anterior aspect. Flexion and extension films with measurement of movement of one articular surface on the other similarly have been considered significant. Here, again, a shift in configuration is not an indication of disease and must be correlated with the clinical picture.

Congenital anomalies to which little attention is paid are illustrated by this film which demonstrates complete fusion of the transverse processes of L-5 to the adjacent sacrum and iliac (Fig. 7). The lateral roentgenograms reveal marked narrowing of the L-5 disc, probably a consequence of the fusion and of no clinical import. The irregularity visible in the anteroinferior aspect of L-4 represents a discal herniation, similarly of no significance.

In the next illustration (Fig. 8), there is an asymmetric alignment of the articular facets between L-5 and S-1 and between L-4 and L-5. More important is the fact that the right transverse process of L-5 articulates with the upper sacrum and the iliac bone. According to some, this deformity in itself is sufficient to withhold employment requiring heavy work because it is presumed that a unilateral anomalous L-5 transverse process articulation such as the one described may result in instability and local joint responses to heavy work with consequent disability.

While plain film roentgenograms often suffice to provide information as to the articular facets, laminagrams offer certain advantages in visualization of the joint surfaces and the intra-articular areas. The next illustrations are of normal articular facets and laminae as seen in the anteroposterior view both on plain films and on laminagrams (Fig. 9). Similarly, the next illustrations show the same anatomic areas in a patient with a stenotic canal (Fig. 10). The laminae are convergent and the space between the respective vertebrae is narrowed. Incidentally, one can often predict with some accuracy whether or not difficulty is likely to be encountered in lumbar puncture by evaluating the space to be penetrated by the needle. Laminagrams are easily available and can supply detailed information as to the structure and configuration of the neural arches. In particular, detailed information as to the thickness, disposition and bony surfaces can be obtained (Fig. 11). Congenital alterations, such as accessory articular facets which might be mistaken for fractures or arthritic changes along the facet surfaces, become clearly demonstrable and thereby can supplement conventional examinations. Interruptions in the continuity of the neural arches, which might or might not interfere with employability, similarly can be investigated. In my opinion, such breaks are usually insignificant unless associated with structural alterations in the thecal sac and its contents. For example, this student nurse, who was athletic and a member of a gymnastic team, had three ununited spinous processes in her thoracolumbar area. She had no history of pain or disability referable to this area. Another

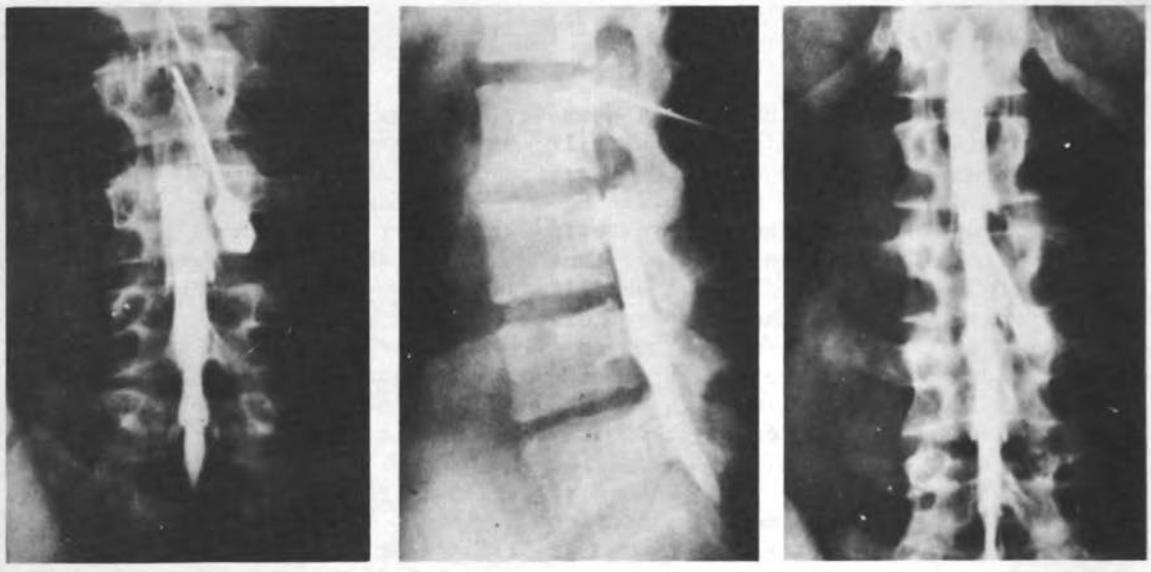


FIGURE 13 A *(left)*. A 16 year old boy with right-sided sciatica and low back pain. The plain film roentgenograms were considered to be normal. Erect anteroposterior myelogram, after the installation of 4 cc. of Pantopaque, indicates narrowing of the thecal sac. B *(center)*. Lateral myelogram of the same patient. C *(right)*. During strain, the thecal sac contracts and the level of the Pantopaque column reaches the 12th thoracic vertebra. At operation this patient had a right laterally situated herniated disc at L5 S1 interspace.

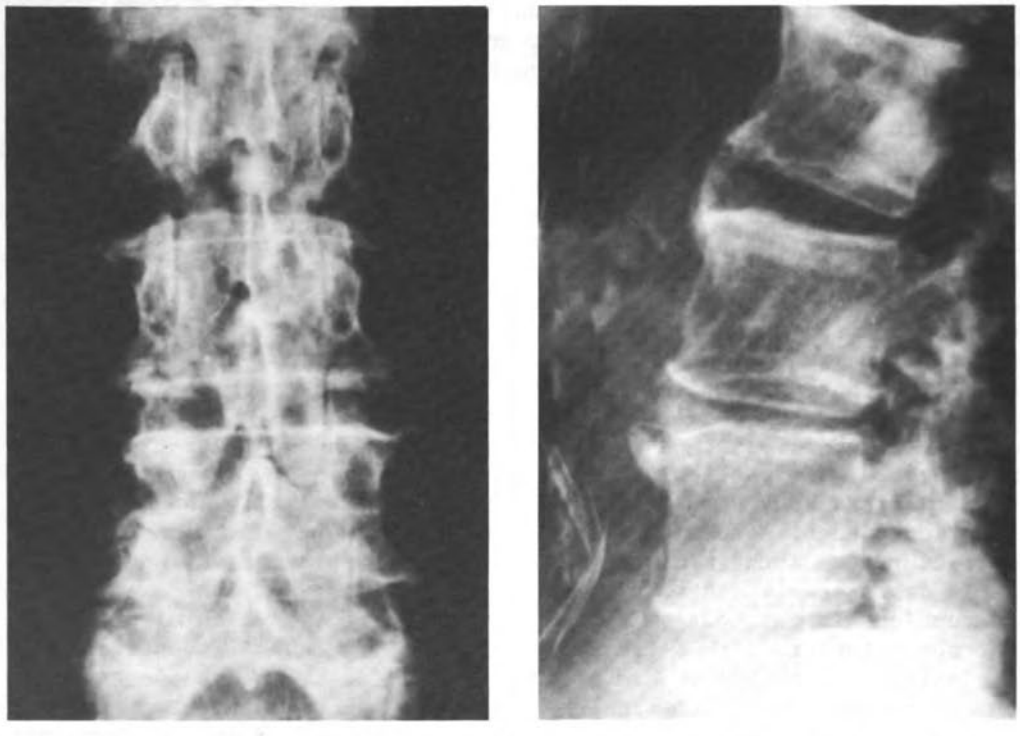


FIGURE 14 A *and* B. Anteroposterior and lateral roentgenograms in an asymptomatic 55 year old male patient with pronounced spondylosis, irregular narrowing of the intervertebral discs, convergent laminae, and probable stenosis of the canal.

example is presented in the next illustration of an unusual failure of fusion of the dorsal plate of the sacrum (Fig. 12).

Lastly, it must be realized that the spinal canal and its contents, the vertebral bodies and the dorsal elements, together with the intervertebral discs, the fascial and muscular layers, the periosteum, the blood vessels and nerves supplying these regions, constitute a system in which pain may be caused by a wide variety of pathologic changes, not all of which are revealed by radiologic examination. In evaluating the spinal canal, plain film roentgenograms may be misleading. In this 16 year old boy who had normal roentgenograms, the complaint of low back pain and sciatica indicated that further investigations were in order. When a myelogram was performed, a congenitally stenotic canal was found (Fig. 13AB). The most reliable method of determining this, in my opinion, is determining the quantity of pantopaque necessary to fill the canal to the level of the upper aspect of L-3. In the present case, this was accomplished with 4 ml., as compared with 8 to 12 ml. in normals and with up to 20 ml. or more in patients with congenitally wide canals. Incidentally, he did have a herniated disc which was not revealed on the myelogram with certainty because the discal fragment was laterally situated and intruded into the intervertebral foramen rather than toward the thecal sac.

The concept that the spinal canal is a static space is not valid. Observation of the contrast medium column while the patient is at rest or straining or coughing readily reveals the activity within the canal. Changes in the width of the thecal sac during strain sometimes can be striking (Fig. 13C) and the pantopaque column can rise for the height of a vertebra or even more in some instances during straining. This causes rapidly changing tensions on the emerging nerve roots as well as on the thecal space and its contents and constitutes another factor in the evaluation of the normal spine.

To conclude, I would like to show you this 55 year old man who came in for an intravenous pyelogram. After looking at his spine (Fig. 14AB), I expected to get a history of prolonged intermittent pain. He had been a laborer all his life, still works hard and had never taken a day off because of backache. Nevertheless, he has many changes that we look for - spurring, narrowing of intervertebral discs, atypical articular facets, a narrow canal, slippage, bony overgrowth, but no pain.

So we return to the question - what is a normal spine? The answer must take into consideration the patient and his history to an extent which may exceed that of x-ray examination.

CHAIRMAN PRESENT: Before we begin this next group of papers, I would like to introduce an individual whom most of you have met and all of you know, I am sure. Dr. Purdy is the man responsible from NIOSH for this meeting and its funding and his enthusiasm has encouraged us in arranging the gathering.

The next paper is to be given by Dr. Lee T. Ford of St. Louis on "Orthopedic Considerations" of the problem at hand.

ORTHOPEDIC CONSIDERATIONS

Lee T. Ford, M.D.

DOCTOR FORD: In the orthopedic consideration of low back x-rays, it is important that we consider the x-ray actually as only a part of the pre-employment examination of the man.

There should be a history by the examiner or a questionnaire as to any symptoms that may have been present in the past which might be related to low back pain, conditions or disorders. There should also be an adequate physical examination of this prospective employee with reference to his lower back and to the lower limbs before the x-ray examination is carried out.

There are some important findings that may be present on physical examination which will not be shown on an x-ray. Examples include the age of the patient, his build, his posture, the presence of scars, his musculature, his weight, whether obesity is present or not. Personality and motivation of a man are harder to assess, but are very important.

As a former x-ray technician, I have had more than the usual interest in orthopedic x-rays and especially x-ray studies of the spine, both as to the technique and their interpretation.

In the x-ray evaluation of the lumbosacral spine, I routinely take six views. The AP view is made standing with a Bucky and a tilt top table and this helps show not only the lumbosacral spine, its alignment and anomalies, but it also shows the pelvis. It shows the hip joints and gives you an idea whether or not the limbs are of equal length. If a list is present, it will help establish this.

The lateral view is usually made with the left side of the patient to the table. In the event a scoliosis is noted, the convex side of the scoliosis should be against the plate.

Posterior oblique views are made with the hips and knees flexed some so that the lumbar spine is in some flexion or is straight and not in extension. You may see defects in the pars in more instances in that manner than you would if the spine were in extension.

If in doubt about the presence of pars defects, we take what we call rotational views. We will roll the patient 15 or 20 degrees to either side of the usual 45 degrees and will sometimes see defects that may otherwise be missed. In a few special cases we have had laminagrams made and have seen defects that were not otherwise visible.

The portion of this exam that I find most helpful is the stress lateral x-ray. This is made with a patient standing and in full flexion and in full extension as much as his condition will allow. We have tried them

FIGURE 1. The patient stands directly in front of the table for the AP view on a 14 by 17 inch plate.

sitting on a stool, sitting on the table, lying on the table on the side and flexing and extending, and by far the most effective way of demonstrating evidence of instability in the lumbar spine is with the patient standing and bending.

Instability can be seen on the x-ray by forward or backward slipping of one vertebra upon the other in either flexion or extension, or by excessive opening either on flexion or extension of the intervertebral disc space.

A defect in the pars may be better visualized in the flexion lateral view

because the space is opened an eighth of an inch or so and you may see it where you have failed to on your regular posterior oblique views.

Several years ago, Floyd Goodman and I reviewed a series of x-rays of the low back of 1614 patients that I had seen over a ten-year period as outpatients.[1] This was a select group because all of these people had some complaint with reference to their low back or were sent in for evaluation of some symptoms that might have been related to the low back. These were not pre-employment examinations. We reviewed these and we found that of these 1614 patients, only 7.3 percent had x-rays that I interpreted as perfectly normal. Degenerative arthritic lipping was actually the second most common finding. We found that narrowing of one or more disc spaces was the most common finding. Disc narrowing was found in 55 percent of these patients at one or more spaces.

Degenerative changes were present in 47-1/2 percent. These were either lipping and/or sclerosis and we did not distinguish traction spurs from regular osteophytes.

Spondylolisthesis, or slippage of a vertebra on the plane film without a defect being present — usually there is some degenerative change or there are other anomalies of the facets or a thin pedicle may be present -- was seen in 155 patients.

True spondylolisthesis was found in 7.2 percent and isthmus defects were found in 10.5 percent, including the cases of spondylisthesis.

Abnormal mobility was seen in about 20 percent of these patients and in quite a number of these, the abnormal displacement was not noted on the neutral lateral view. It was found on the stress views. This is an additional type of examination that can be of value in helping you demonstrate spinal abnormalities.

In the AP standing x-ray film, we found a tilt, a list or scoliosis in 17 percent.

An interesting finding was the presence of the vacuum phenomenon, that is, an air bubble in the disc space, said by some to be nitrogen. It is usually present only in the extension view and it does not last too long. If your patient stays in position, then the air bubble or vacuum phenomenon may disappear.

For the standard anterior-posterior view, we position a patient (Fig. 1) in front of the x-ray tube as straight as we possibly can and we are careful that the knees are straight and the patient is not wearing shoes with a lift. If we have found, on examination, gross discrepancy in leg length, we have a set of blocks. We try to build up the short leg and then take that into consideration in deciding whether the pelvis and the head of the femur are level on the 14 x 17 film.

The lateral bending film is made with the patient extending as far as he can and flexing as far forward as possible. If the technician does not take him to these extremes of motion, he may not demonstrate instability in all of the joints in which it may be present.

FIGURE 2A. Neutral lateral shows satisfactory alignment of L-4 on L-5.

This is a patient (Fig. 2a) on whom Dr. J. Albert Key had done a spinal fusion some years ago at the lumbosacral joint. The fusion was quite solid. He developed low back pain and came in with this x-ray and there is no gross abnormality at the L-4, L-5 space but on flexion film (Fig. 2b), it opens excessively posteriorly and he is displaces forward a slight amount.

Another patient (Fig. 3a) with an old, grossly degenerated lumbosacral disc had a large osteophyte and a sclerotic margin. He was having an

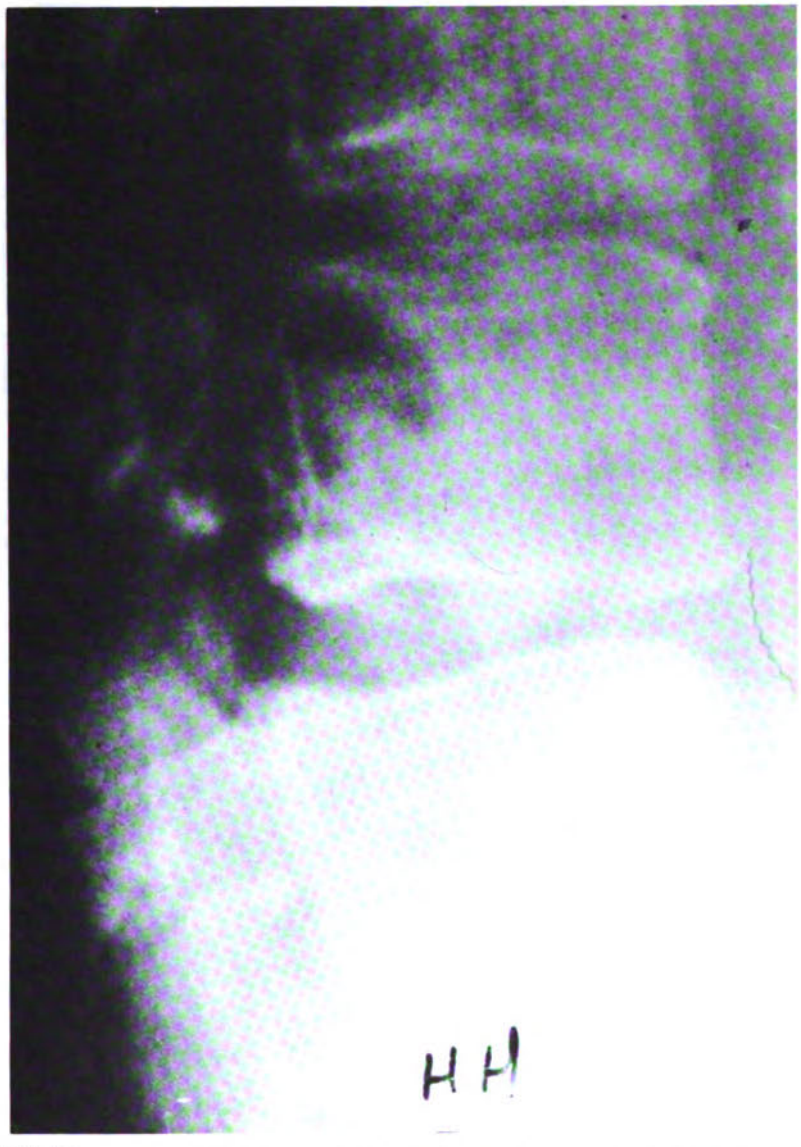


FIGURE 2B. Lateral view in flexion shows forward displacement of L-4 on L-5.

episode of back pain and on flexion (Fig. 3b) had a slight forward displacement of L-4 and L-5.

Another patient (Fig. 4a) has narrowing and degenerative change at the L-3,L-4 space. On extension, (Fig. 4b) there is a posterior slip of L-3 on L-4 indicating instability.

The patient (Fig. 5a) has relatively good alignment of the lower three lumbar spaces, but on flexion he has gross forward displacement of L-4 (Fig. 5b).

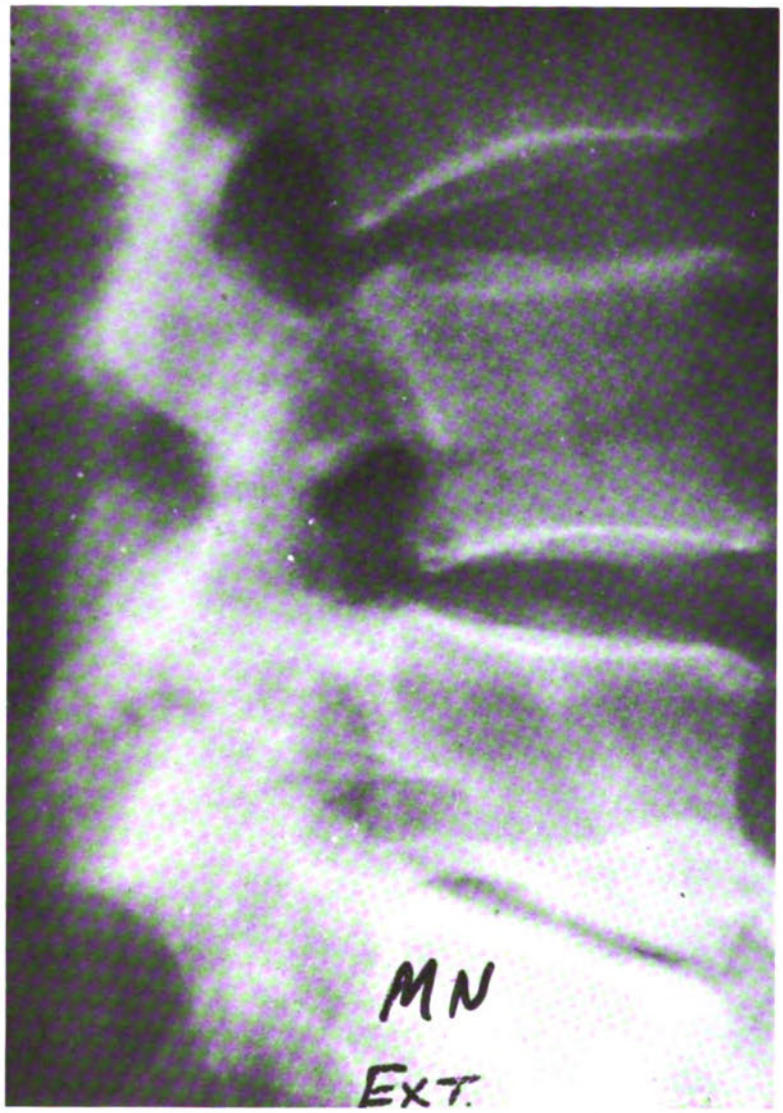


FIGURE 3A. Grossly degenerated lumbo-sacral space with slight forward displacement of L-4 which increases on flexion (Figure 3B)

I liken the unstable joint in the lumbar spine to that of a knee that has had ligamentous injury and has ligamentous instability. A plane x-ray may show good alignment but the stress films can show that the ligaments are not intact.

The lateral film (Fig. 6) may show a vacuum phenomenon when made in extension. This represents the fact that there is fissuring of the intervertebral disc as a result of very marked and gross degeneration.

In some patients, there is a question as to whether or not a defect is

FIGURE 3B

present in the pars and whether or not a true spondylolisthesis is present. The oblique view may be equivocal as to whether or not a pars defect is present. On the flexion view (Fig. 7), however, the defect in the pars may be obvious.

For some years at the Missouri-Pacific Hospital, Dr. Wilbur Miller, now retired, and Dr. Don Wier, chief radiologist, have reviewed lumbosacral spine x-rays on all prospective employees for several railroads in the St. Louis area.

Over the years they have only taken an AP and lateral view. They have

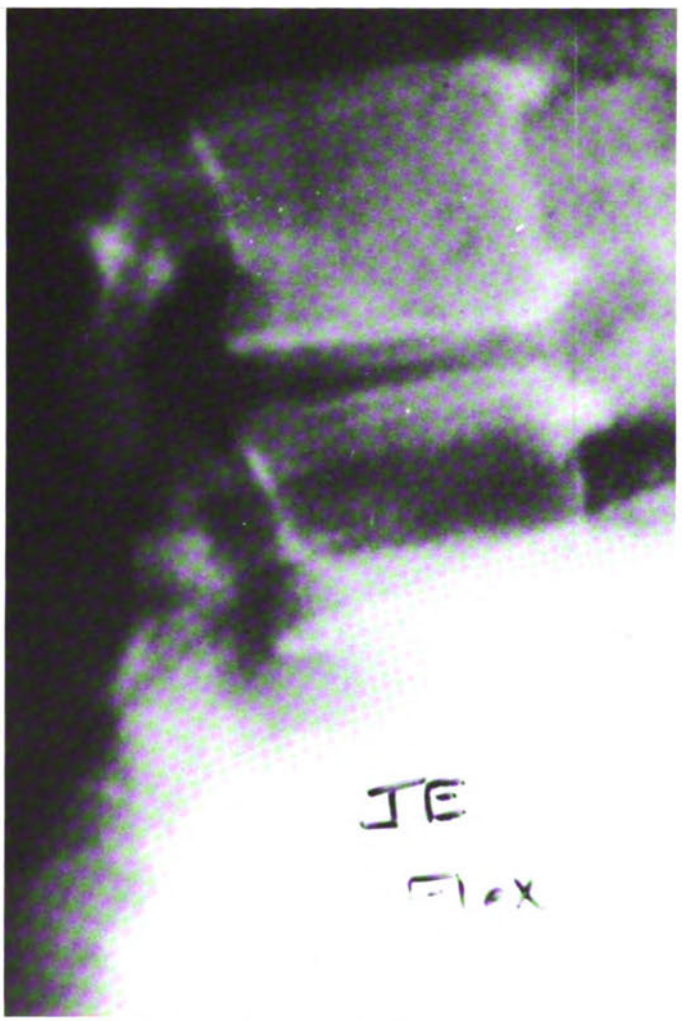


FIGURE 4A. Narrowed and degenerated disc at L-3, L4 shows reverse spondylolisthesis on extension (Figure 4B).

examined over 20,000 prospective employees and their average disqualification rate, based on the x-ray findings alone, has run from 37 to 40 percent.

In the last year they have begun to take oblique views along with the AP and lateral and Dr. Wier told me recently that their rejection rate is now up to 43 percent.

This is <u>not</u> on the basis of physical examination.

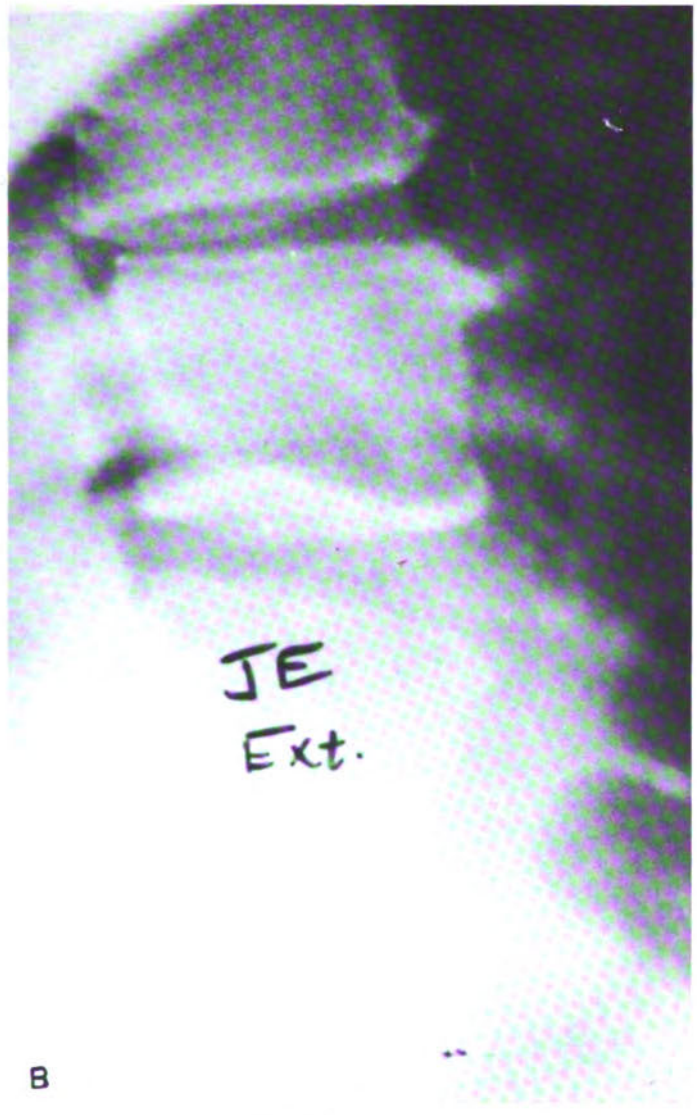


FIGURE 4B

They have five categories similar to those that you have read. There are no restrictions to Category I. In Category V, there are quite a few common conditions, including spondylolisthesis, that would not be employed for any position. Categories II, III and IV are in between.

They do not have follow-up studies on the rejected individuals and we do not have follow-up studies on those who were accepted to give you any percentages of what happened to these men. I do know that we continue to see many railroad workers with back injuries and other back conditions who make up a good percentage of the orthopedic load at the hospital and are very difficult ones to treat.

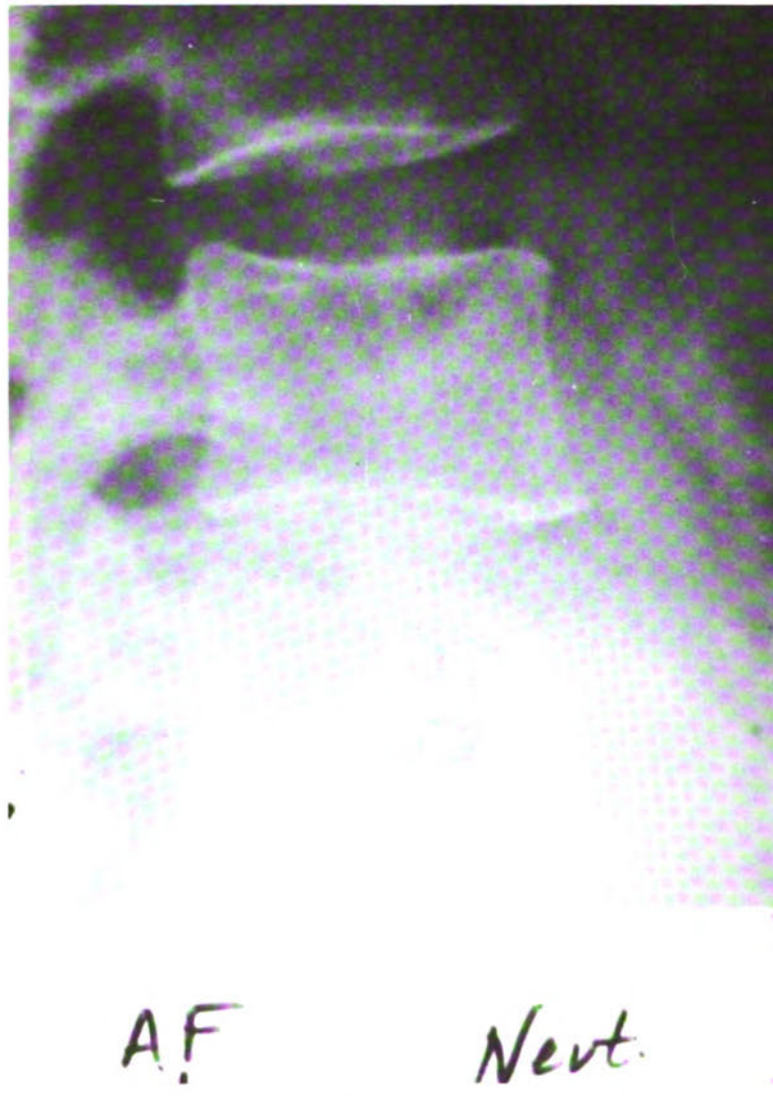


FIGURE 5A. Instability at L-4, L-5 shown only on flexion (Figure 5B)

Railroad workers are, needless to say, a very expensive area to the railroads because of the fact that they deal with interstate commerce. Their cases go to federal court or their judgments do and they have settlements that are quite substantial.

Functional or psychogenic overlay is a very major factor in many of these cases and their claims, and is directly related, in my opinion, to the large sums that the injured worker may seek and often successfully gain.

Again, what we do not know is the subsequent work history of the rejected

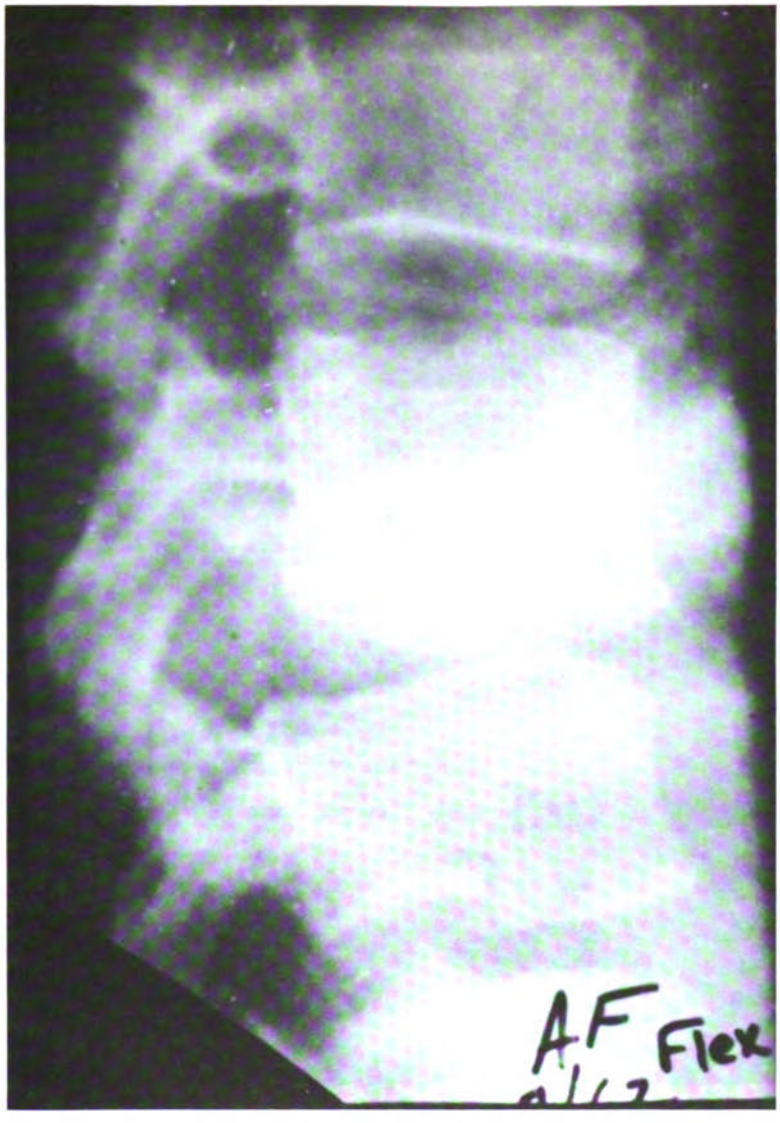


FIGURE 5B

individuals. We cannot say with any precision what the work experience is of these employed workers who pass the radiologist. The present status of the pre-employment x-rays of the lumbosacral spine certainly is of interest and probably of help to the treating physician if and when a back injury does occur. On the other hand, we have all seen retired farmers and other workers with spondylolisthesis with a very marked degenerative arthritis who have done heavy work for many years without symptoms and they happened to have had their spine x-rayed for some other cause.

In conclusion, I hope that this illustrious group of experts can resolve

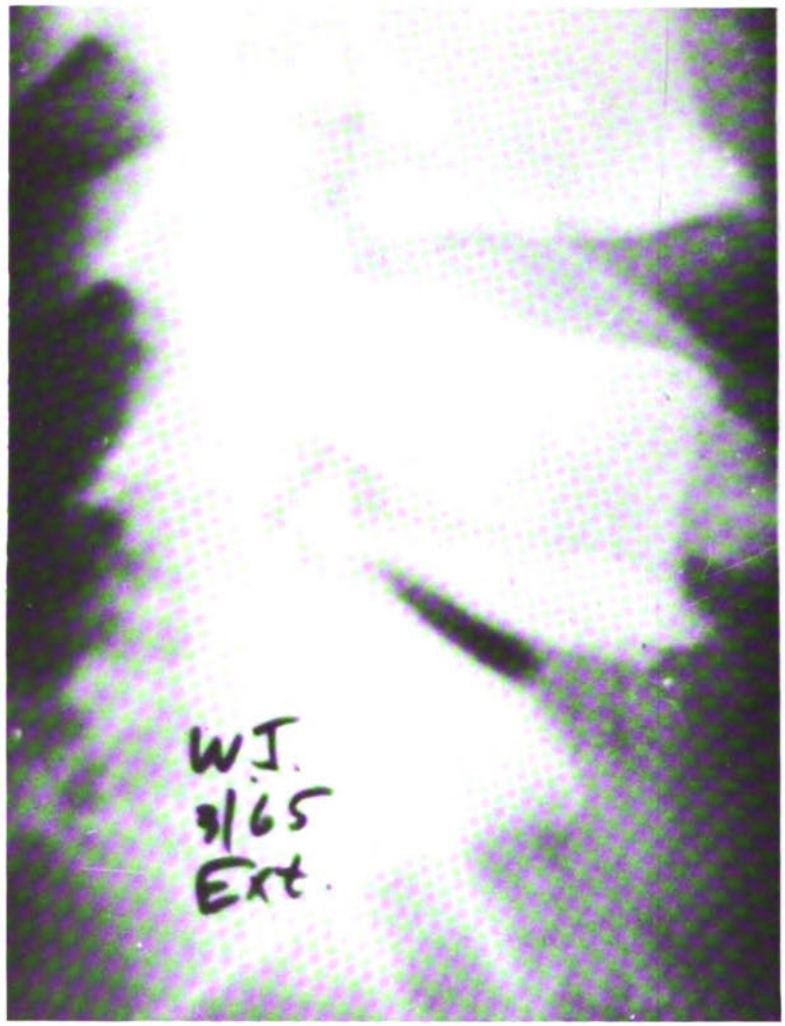


FIGURE 6. Vacuum phenomenona at degenerated lumbo-sacral disc space seen on extension.

the question as to whether pre-employment x-rays of the lumbosacral spine are of sufficient value to advocate their more widespread use as is the case with the chest x-rays.

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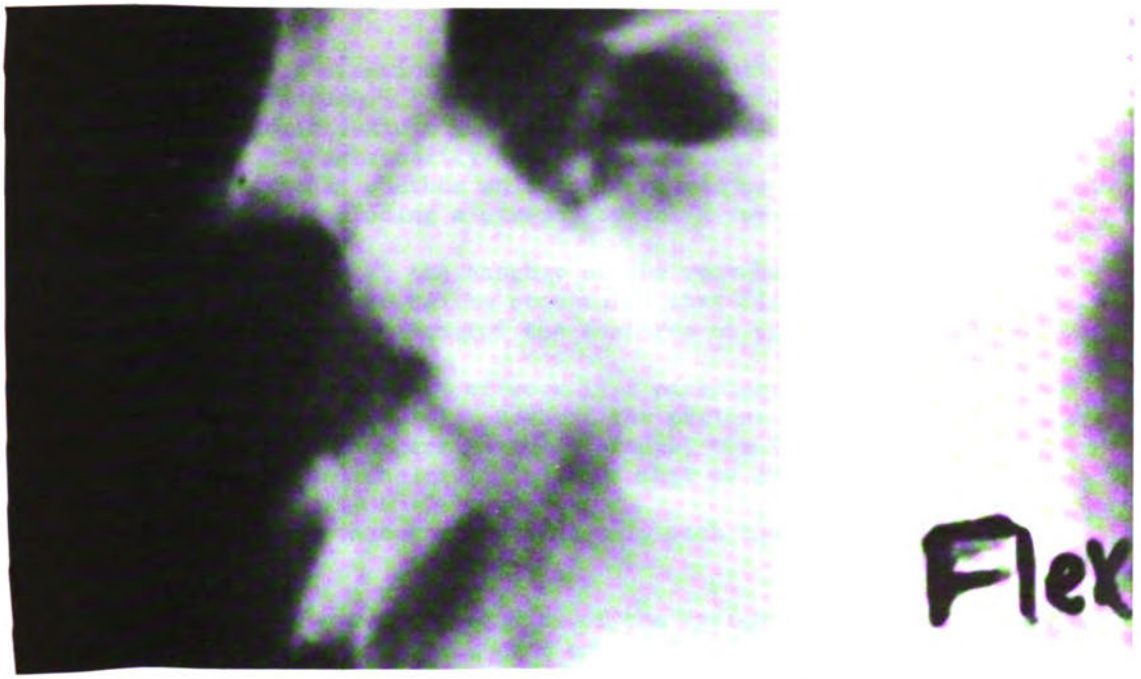

FIGURE 7. Defect in pars is well demonstrated in the flexed position.

CHAIRMAN PRESENT: Our next speaker is Dr. Benjamin Boshes of Northwestern in Chicago who will speak to us on "Neuropsychiatric Aspects of Lower Spinal Injuries."

NEUROPSYCHIATRIC ASPECTS OF LOWER SPINAL INJURIES

Benjamin Boshes, M.D.

DOCTOR BOSHES: The previous speakers have in part laid the groundwork of what I want to discuss. I want to carry it a little deeper in the anatomical-physiologic feature and then move from the anatomy and physiology to the person, his personality and even into some aspects of the culture and how it determines whether an individual can be measured by one or another procedure including a pre-employment x-ray.

The anatomy of the back, the anatomy of the vertebral column, are important only as they relate to the structures that lie below and I should like to point out to you some of the features of the subjacent structures.

This comes out of many years of work in a paraplegia center which carried us through World War II. Some of the patients I took off the front in Africa and Italy and carried them through, the Korean veterans, the Vietnam veterans, and the civil injuries that we saw in the interim.

(Table 1) We shall concern ourselves only with that which goes on in the lower back.

The lumbar spine covers two segments of the vertebra, T10 to T12, and the sacral spine, S15. The sacral cord covers T12, L1 and the coccygeal is below. The spinal cord ends at the lower end of vertebra L1 or at the interspace.

(Table 2) When we look at the structures at these points, we can see the potential for pathology.

A lesion at T10-11 will pick up the lower lumbar cord and 8 roots. At T12, again, lumbar cord and 8 roots. At T12, lower lumbar cord and ten roots.

When we get down between T12 and L1, not only do we have cord involvement but five roots times two (both sides), and a little lower six times two. So we are getting into a very complex area and as we come down, the nerve cluster becomes more dense. At L1, we have nine times two or 18 roots implicated plus the lower sacral cord.

S1 to four are very important segments of the spinal cord. What goes on at that point? Sensation from the bladder, proprioception, the sense of a full bladder, depends on the integrity of S1 to 4. The drive of the bladder is S2 to 4, especially the second and third sacral roots, the parasympathetic.

The sympathetic which comes from higher up has a much different function. This permits the detrusor to relax. It locks the trigone. It unlocks the

Table 1

GENERAL RELATIONS OF SPINAL CORD SEGMENT TO VERTEBRAL LEVEL

Spinal cord segment	Vertebrae
C 1- 8	C 1-7
T 1-12	T 1-9 to 10
L 1- 5	T 10-12
S 1- 5	T 12-L 1
Cc 1-	L 1- 2

Table 2

Cord Level	Roots	Vertebral body	Spinous process
C1	C1	C1	C1
C2	C2	between C1-C2	between C1-C2
C3	C3	between C2-C3	C2
C4	C4	between C3-C4	C4
C5	C5	between C4-C5	C3-C4
C6	C6	C5	between C4-C5
C7	C7	C6	C5
C8	C7-C8	between C6-C7	between C5-C6
T1	C8-T1	C7	C6
T2	C1-T2	T1	C7
T3	T1-T2-T3	T2	C7-T1
T4	T2-T3-T4	T2-T3	T1-T2
T5	T3-T4-T5	T3-T4	T2-T3
T6	T4-T5-T6	T4-T5	T3-T4
T7	T5-T6-T7	T5-T6	T4-T5
T8	T6-T7-T8	T6-T7	T4-T5-T6
T9	T7-T8-T9	T7	T5-T6-T7
T10	T8-T9-T10	T8	T6-T7-T8
T11	T9-T10-T11	T9	T7-T8-T9
T12	T10-T11-T12	T10	T8-T9
L1	T11-T12-L1	between T10-T11	T9-T10
L2	T11-T12-L1-L2	T11	T10
L3	T12-L1-L1-L2	T12	T10-T11
L4	T12-L1-L2-L3-L4	T12	T11
L5	L1-L2-L3-L4-L5	between T12-L1	T11-T12
S1	L1-L2-L3-L4-L5-S1	L1	T11-T12
S2	L1-L2-L3-L4-L5-S1		
	S2	L1	T12
S3	L1-L2-L3-L4-L5-S1		
	S2-S3	L1	T2
S4	L1-L2-L3-L4-L5-S1		
	S2-S3-S4	between L1-L2	T12-L1
S5	L1-L2-L3-L4-L5-S1		
	S2-S3-S4-S5	between L1-L2	T12-L1

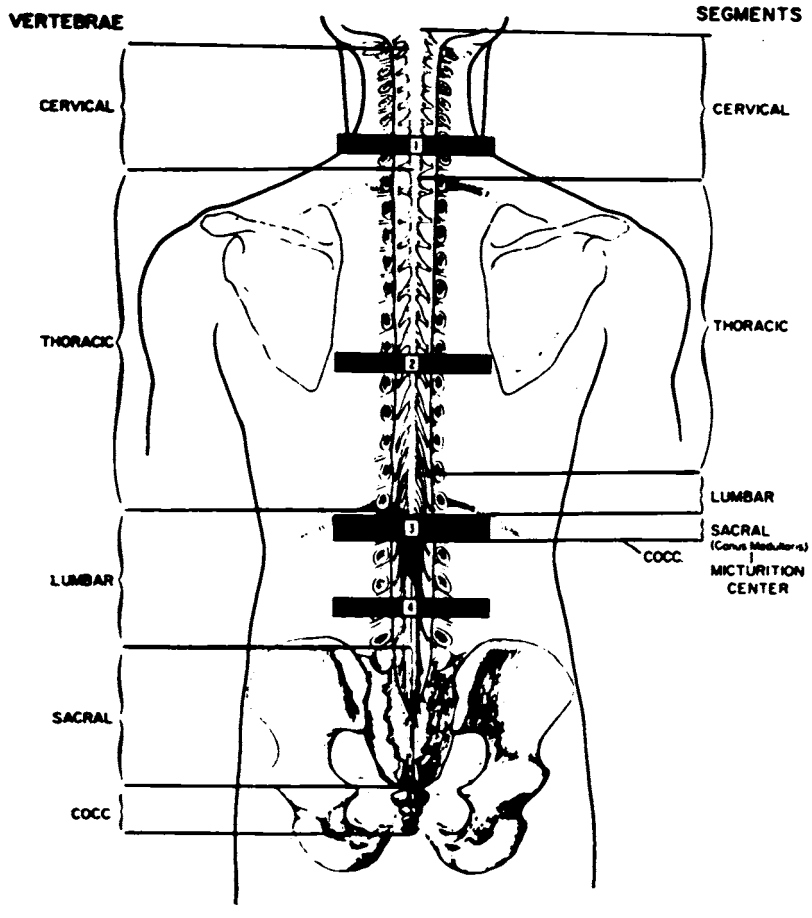

FIGURE 1

ureters and it locks the urethra; this enables the bladder to fill. However, comparatively speaking, the sympathetic has little to do with the motor factors in the bladder. It does, however, conduct some pain and temperature sensations from the bladder.

The rectal physiology and anatomy follows that of the bladder.

Sexual function is an important psychological factor in persons of working age. The erection area is in the lumbosacral, the ejaculation in the upper lumbral cord.

(Fig. 1) A common spinal cord lesion like after an injury to the neck or in multiple sclerosis produces a bladder which acts like an exaggerated tendon reflex. Such a bladder is trainable. We call it an autonomous bladder which is too active but this can be reduced easily with drugs of the parasympathetic inhibitor variety, probanthine or the like.

But when we see lesions lower in the back, we encounter a bladder which

Table 3

COMPARISON OF KOREAN AND WORLD WAR II SPINAL CORD INJURIES: TOTAL DISTRIBUTIONS

Site of Injury	Korean		World War II	
	No.	%	No.	%
Cervical	40	40	23	8.7
Dorsal	47	47	125	47.3
Lumbar	6	6	37	14.0
Cauda and conus	4	4	37	14.0
Cauda equina	3	3	42	16.0
Totals	100		264	

Table 4

COMPARISONS OF DISTRIBUTION OF CASES WITH GUNSHOT WOUNDS

Site of Injury	Korean		World War II	
	No.	%	No.	%
Cervical	8	22.2	5	2.7
Dorsal	21	58.3	95	51.0
Lumbar	3	8.3	26	14.0
Cauda and Conus	1	2.8	28	15.0
Cauda equina	3	8.3	32	17.2
Totals	36		186	

is essentially disconnected, one nerve supply where the entire sympathetic and parasympathetic are cut away and we are dealing only with the intrinsic plexus. This is the autonomous bladder which is completely disconnected from the spinal cord.

Here is a bladder that has no "order" in its action; it does what it pleases. Part of it starts emptying; part of it starts filling. It is a bladder that becomes small and dribbles in spurts. A person bears down and is able to empty it in part by intra-abdominal pressure but the urinary act is very difficult to manage here.

The last neurogenic bladder is the so-called tabetic or sensory bladder. The problem is in the cauda equina. The individual is not aware that the bladder is filling and it becomes enlarged, overdistends and dribbles. Again, this is a very difficult bladder problem to manage.

(Tables 3,4) Here are some of the injuries which we have encountered in our studies of the past, chiefly on the paraplegia unit at Hines VA Hospital where we had a 300-patient population. The unit had a good turnover, so that in the course of some 12 years we have seen several thousand patients. Some were followed continuously.

You notice that lesions of the conus and cauda and of the cauda equina alone make up roughly about 30 percent of the patients, almost a third, so the group becomes important from the standpoint of frequency. Individuals with gunshot or open wounds of the conus and cauda account for about 32 percent.

(Fig. 2) This illustration shows the changing picture. Up to World War II, the patient with a spinal cord lesion, as a result of the heightened reflexes of the disconnected segment, would develop what we call a paraplegia-in-flexion. This was because the decubiti, the infected bladder and other diseased parts fired nociceptive or noxious impulses into the spinal cord causing the limbs to come up in flexion. No one paid attention to this flexor state and contractures set in to produce the picture of paraplegia-in-flexion.

The result was a patient who was completely nonrehabilitable. He could not be kept on his back comfortably and had to lie on his side. Decubiti formed and the survival rate was low.

H ere is an illustration (Fig. 2) of what was achieved in World War II, the paraplegia-in-extension. By keeping decubiti clean, avoiding fractures, avoiding the osteomyelitis and the infected bladders, the centripetal noxious stimuli were reduced so that the severed cord segment was not fired off.

The position of paraplegia-in-extension provides a limb that can be splinted. The patient can develop a tripedal gait using crutches with two legs acting as one. Or, if there is any voluntary movement at the hip, ambulation can be taught using both limbs as parts of the steppage mechanism. This, plus the two crutches, provides a quadripedal gait.

(Fig. 3) Here we see extensive atrophy of the lower limbs as a result of the involvement of the anterior horn cell of the spinal cord. This is

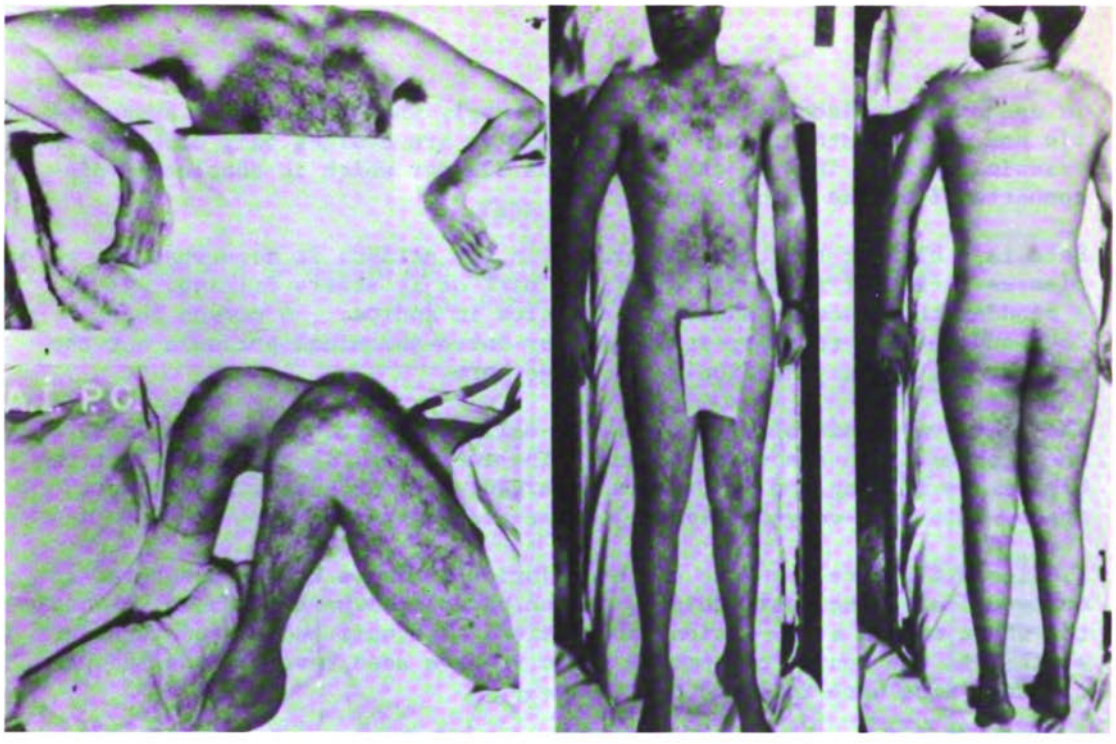

FIGURE 2

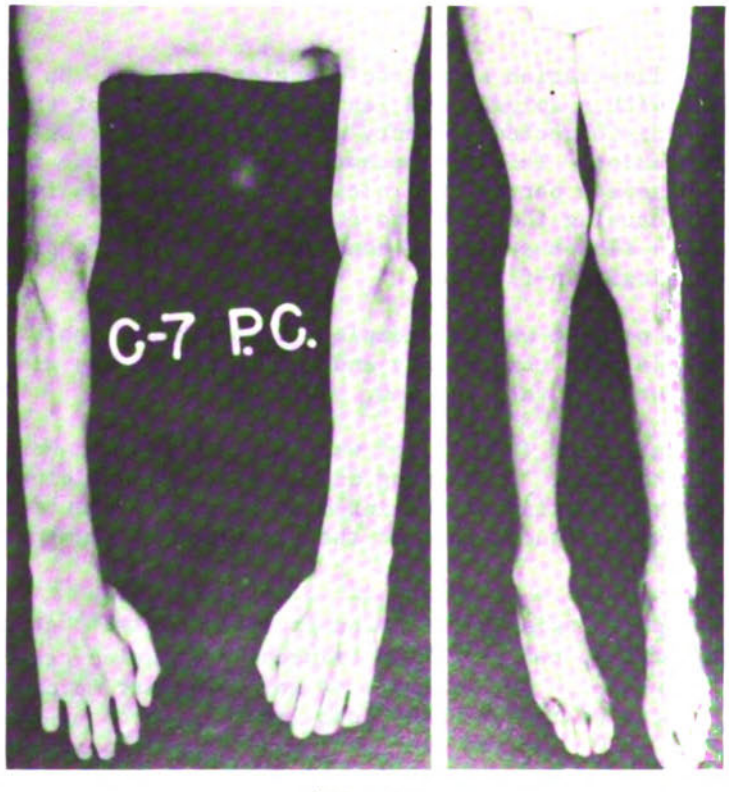

FIGURE 3

lower motor neurone atrophy. The other limb shows atrophy of disuse. With recovery, these limbs fill out because this is an upper motor neuron form of atrophy which is not as severe because the architectonics of the muscle are retained.

(Fig. 4) Here we see trophic changes, ulcers, particularly in the distribution of branches of the sciatic nerve. In the posterior tibial nerve division we see such ulcers just as they appear in the upper limb in the median nerve distribution after injury. These nerves are rich in autonomic elements and injury produces trophic disturbances.

(Table 5) Pain is an important complication in lesions of the lower back, even in physiologically complete lesions. Here is a comparative series of World War II, civilian and Korean War casualties.

You notice that with lesions in the cervical cord, only about one-third of the injured will have pain, but when we get down to the conus and cauda, everyone develops severe pain. This is the nature of the involvement of a peripheral nerve and the cauda equina acts as such a nerve to produce the pain.

Over and above the physical disability produced by the paralysis and loss of sensation with the complicating decubiti and infected bladder, there is an enormous psychological overlay.

When a man or a woman finds that it is impossible to move the limbs voluntarily, there is first a period of serious depression, occasionally even to a wish to die or an attempt at suicide. Then comes anger and with this a regressive reaction. He wants to quit; he will have no part of rehabilitation.

In the early days following World War II, occasionally we experienced some acting out against personnel, particularly nurses. The latter might be bending over a patient, her gloved hands deep in an infected decubitus, irrigating and cleaning it. The patient might reach down and flip her breast or pinch her on the buttock. This act was not one of teasing or being "cute." It represented the enormous anger as he tried to destroy or depreciate that which he could not achieve. He had no feelings, only the memory of sexual activity and he would attack the object that he wanted most of all. For a while we had difficulty keeping nursing personnel until we set up á government among the patients, a self-government system, where some of the older or more mature men would counsel the others. We did not crack down or fire these patients from the hospital. Fire them from what? They could not care less. They would go home and commit suicide. Therefore, we could not threaten them but in their own group we set up a system of control where they made their own rules, their own punishments, their own limitations. This is how we solved the problem.

Can any of these people with spinal cord injuries recover?

(Table 6) Ordinarily we think of recovery occurring in the first few months, and indeed, about three-quarters who showed any recovery did so in the first three months but some did not begin to improve until the

Table 5

PAIN

Site of Injury	Battle Cases			Civilian Cases			Comparison (Percent)	
	Pain		Total Percentage	Pain		Total Percentage	Recent Cases	World War II
	PC*	P1†		PC	P1			
Cervical	0 of 2	1 of 5	14.3	5 of 21	7 of 21	36.4	32.5	20.0
Dorsal	11 of 20	1 of 1	57.1	9 of 9	1 of 7	38.5	59.5	32.1
Lumbar	2 of 2	1 of 1	100	0 of 2	1 of 1	33	66.7	39.8
Cauda and conus	1 of 1		100	2 of 2	1 of 1	100	100	100
Cauda equina		3 of 3	100				100	100

Pain: Recent patients, 46 percent; World War II patients, 39.2 percent.
*PC, physiologically complete.
†P1, physiologically incomplete.

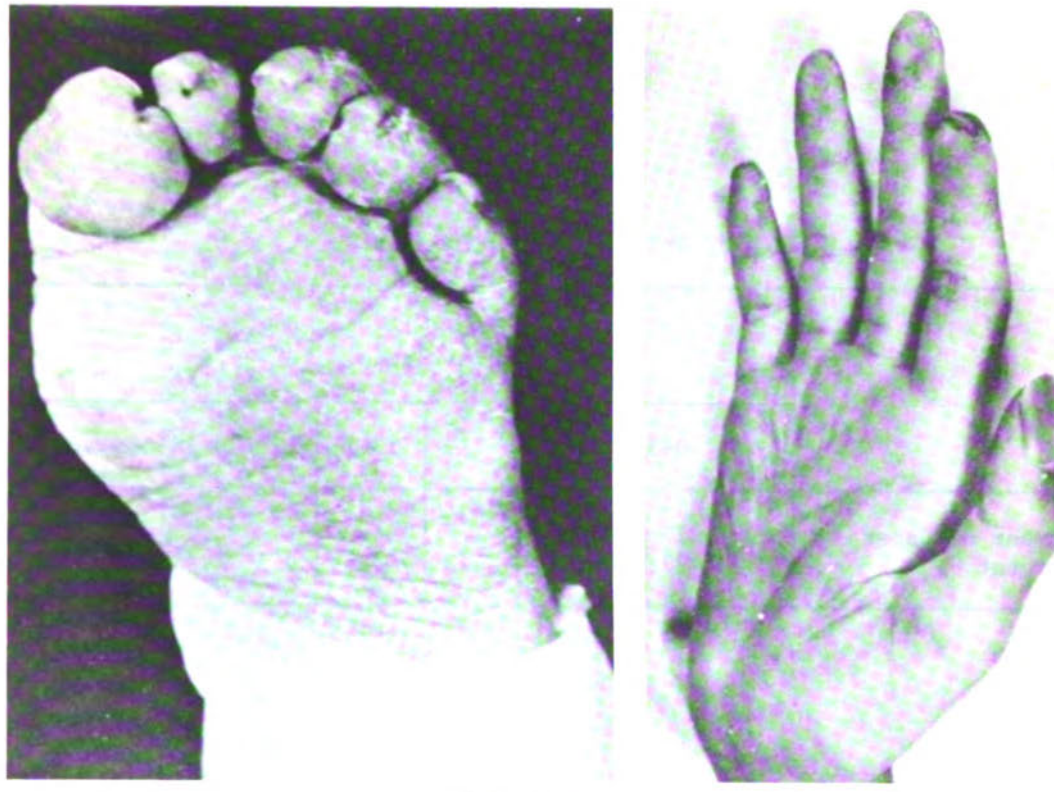

FIGURE 4

fourth year. This is because of other factors, medical, metabolic and so on. It is possible for some recovery to start at the end of the first, at the end of the second and even in the third year.

(Table 7) If recovery is delayed, how does this relate to the degree of return of function? Here is a group which I studied. One patient's recovery started in the fourth year and he had a fair return. We had a recovery incidence of 24 percent in several thousand patients which means that not every patient with paraplegia is entirely hopeless.

(Fig. 5) This shows an uncommon complication in paraplegia, myositis ossificans. This is rare nowadays but after World War II we saw it, particularly when there was bleeding, as after an injury or spasms.

Occasionally, we see another kind of patient, chiefly in civil practice, who becomes paraplegic. (Fig. 6) We pick up the cause in what is considered a routine back examination.

Here is a woman who was sent into our hospital in a deep depression and very suicidal. In those days we were using more electro-shock therapy than we do nowadays. We always took an x-ray beforehand to get an idea of the bony structure. (Some spines at this age are osteoporotic. We also did this for medico-legal purposes. Some x-rays showed old fractures.) Here we see the evidence of a metastatic lesion.

Table 6

TIME OF ONSET OF SENSORY RECOVERY

	Time of Onset of Recovery in Months					
	0-3	4-6	7-9	13-15	22-24	46-68
Number of Cases	17	2	1	1	1	1
Percent	73.9	8.7	4.3	4.3	4.3	4.3

Table 7

DEGREE OF RECOVERY OF SENSATION vs TIME OF ONSET

	Time of Onset of Recovery in Months					
Degree of Recovery	0-3 17 Cases	4-6 2 Cases	7-9 1 Case	13-15 1 Case	22-24 1 Case	46-48 1 Case
Poor	0	1				
Fair	3		1			1
Good	7			1		
Excellent	7	1			1	

FIGURE 5. Myositis ossificans

She had no complaint about her lower back but this is apropos of what one of the previous speakers said. Sometimes we pick up abnormalities incidentally without any previous knowledge.

In another instance where we found metastic carcinoma, the follow-up myelogram showed a complete block. Again, there were no symptoms or complaints from the patient.

(Fig. 7) Here is another patient who was sent in with the complaint of impotence. When I turned him over, he had a bit of a tail with a tuft of hair and here is the picture on x-ray. Two of the previous speakers have already shown the spina bifida. This man actually had a tail, a tuft and extensive abnormal neurological findings. This is one of the infrequent instances where impotence has an organic basis. Most of the time it is functional.

Here, therefore, are a few aspects of pathology of the lower spinal cord and cauda equina which one may encounter in so-called low back syndrome associated with a paraplegic state.

A much more frequent problem, one that has already been alluded to quite extensively today, is that of the herniated intervertebral disc. Every

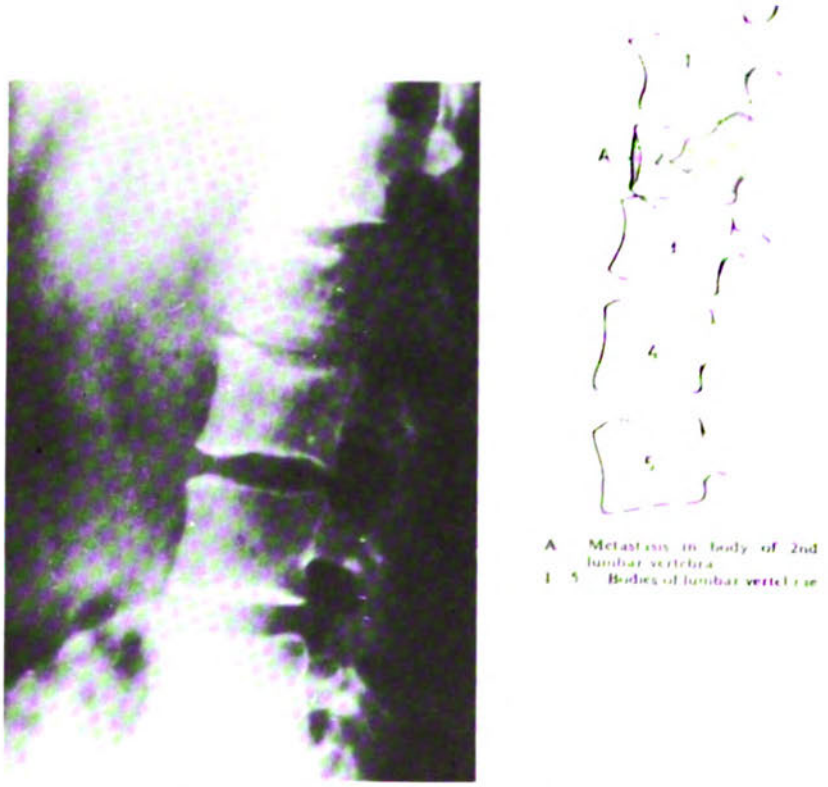

FIGURE 6. Carcinoma of the breast with metastasis to the body of the lumbar vertebra.

time I get into a discussion of ruptured intervertebral disc, look at the mechanics of the lower back and collate this with the scandalous conduct of man as reported in the headlines of the newspaper and the television news, I have an impulse to sew the tail back on homo sapiens and return them to the tree on all four limbs. The only trouble is that someone has cut down that tree and there is no going back. We have to live with what we are and mechanically, man is paying a high price for having two free hands to do clever things with tools.

What we used to call sciatica and now name the lumbosacral radicular syndrome, is in 95 percent of cases associated with a herniated intervertebral disc usually in the lumbar region and chiefly at the lumbosacral joint.

Remember, we are far below the lumbar cord, below the sacral cord. We are in an area only of the cauda equina and the lateral protrusion of the extruded disc, as shown by the previous speakers, will buckle one or another of the nerve roots, usually L5, S1, occasionally L4, to produce pain along that root.

In ten or 15 percent of the cases, the anterior root is implicated, producing weakness. These we can detect quite readily on neurological exam-

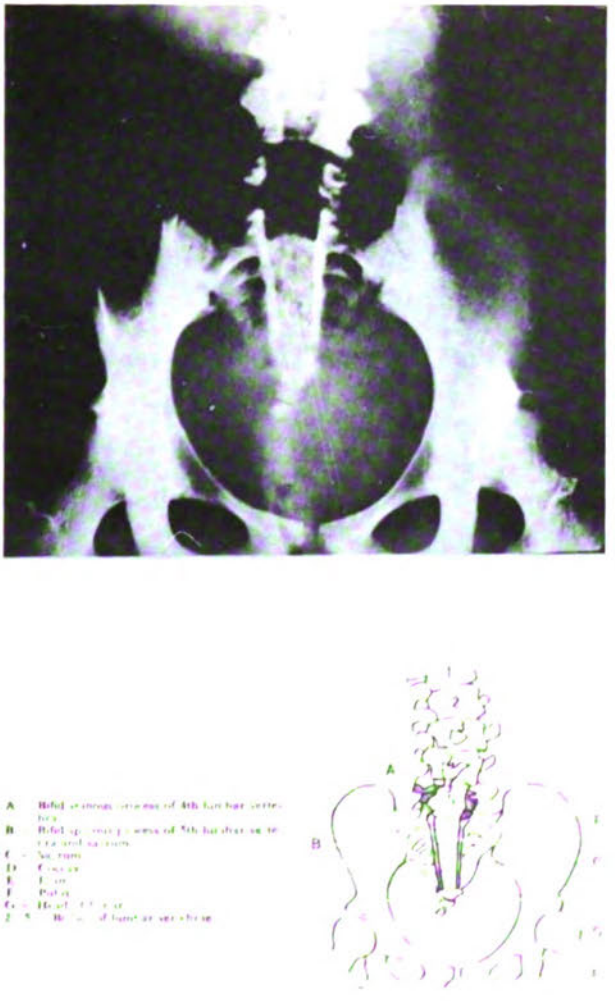

FIGURE 7. Spina bifida of the lumbar and sacral spines.

ination by the alteration of the reflexes, usually the diminution to absence of the ankle jerk, for the lumbosacral syndrome, or the knee jerk when L3 and L4 are involved.

Sensory deficits are often only an area of hyperpathia. Excessive sensitivity to the pin or cold and later diminshed response help mark out the affected root. Usually that area is more sensitive than less responsive.

We now have additional diagnostic tests, electromyography and nerve conduction velocity to help us define the root. We can mark out the specific root that is implicated in the disc protrusion.

(Fig. 8) The myelogram, of course, is a procedure which all of you use daily so that I shall not belabor the subject. This helps establish the diagnosis. Usually the protein in the spinal fluid is elevated.

FIGURE 8. Myelogram in herniated intervertebral disc. Defect in Pantopaque column.

I wish to point out that it is important to measure the protein in the first three to five cc. of spinal fluid, not at the tenth or the 15th cc. point. Between the level of the spinal needle and the foramen magnum there are only about two or three cc. of fluid. After that you are gathering cisternal and after that ventricular fluid which has low protein. But the first two or three cc. come from the disc area and from the caudal sac; that fluid will contain the increased protein.

This is why protein analysis has not been as useful as it might be. The wrong fluid has been measured.

Two questions arise. Who shall be operated upon? Shall the patient be

managed by the orthopedist, the neurologist, the neurological surgeon, by the psychiatrist or should it be a team? Who should make the decision because we are dealing with a person who has and will continue to have a back mechanism. You can't add to it. Even putting a block of bone between the vertebrae will not solve the problem.

When you remove the ruptured disc you take something away from the patient, sometimes because it is producing pain, but you are leaving him with less anatomy. Cures, therefore, are rare. The symptoms are relieved immediately, sometimes for a short time, sometimes longer, but it is the rare patient who is totally and irrevocably cured. We have to face that fact because the recurrences fill our offices and our hospital beds.

The question arises not only what has happened mechanically, neurologically and physiologically, but what has happened to the patient. The anatomic deficit, the physiologic complaint, the neurologic symptoms which you are able to elicit, the reflex deficits, the sensory alterations, the slowing of the nerve conduction, the presence of fibrillations on electromyography, and the demonstration of the actual disc on a myelogram are all what make up his impairment.

You have seen spines that were excessively osteoarthritic, spines that were excessively deranged mechanically with no symptoms. In other words, despite what you saw on examination or x-ray, despite what the patient should have, he showed no disability. Disability is defined as the defect that ensues from what is impaired in this man's field of operation.

When our Senator Paul Douglas of Illinois suffered a gunshot of the left brachial plexus which left him with a flail limb, as a senator, he had no disability. In other words, a massive anatomical defect may have no disability in a given life process. Impairment and disability are quite different.

Now we come into the question of cultural definitions. Those of you who have read "Death in an Afternoon" by Ernest Hemingway or have read or seen "The Godfather" were brought to face the question of the measure of a man. Does he have balls? Such a culture measures the man not by his sexual prowess, but by his fighting spirit as epitomized by the stallion or by the male animal who, when properly endocrine-equipped, will attack courageously. The index of these cultures is: Does the man have balls?

In industry a different question is asked. It may be asked of an executive or of a worker: Does he have a strong back? You mean not only: Does he have a back that is physically strong, but does he have a back to stand up under emotional pressure?

In 1942, when we brought the men back from the Tunisian front and after they had their spree in wrecking part of the city of Oran, Algeria, they were regrouped and told that they would have to go into amphibious training for a future invasion. The cry of the First Infantry Division and the First Armored Division was, "Oh, my aching back! Colonel, why don't you get off our back? We've had it." In other words, the back is an American symbol of maleness, strength, fortitude, as it is in many cultures. It has symbolic meaning over and above any actual anatomical implication.

Some years ago I saw a man with a camptocormia, a bent, hysterical back. He had walked that way for five years. He had been a motor dock worker, a man out of the Ozarks with a second grade education who had seven children. One day in unloading lumber, he was struck by a two by four. It was not much of a blow. He stayed on the job until about one o'clock in the afternoon when the foreman came around and said, "I heard you were hit by some lumber. Where were you hit?" The man showed him. He said, "You had better have that x-rayed."

The man who had had no complaint until then went to this industrial office where he waited for two and a half hours. Then a girl popped her head out of the door and said, "Send in the man with the broken back." As this man describes it, "I felt something go in my back." He slumped in his chair and five years later he was still bent. This man was absolutely honest, a very solid worker; he had a perfect work attendance record. He was known as the best worker on that dock up to that point.

Had he never been x-rayed, had he never been sent to that industrial office, that man would undoubtedly have been working today. But he was abetted by his lawyer who said, "We can't take a chance on settling," and this man picked up the word, "I can't take the chance. I can't straighten out," and five years later someone was still paying full disability for him.

You may call this iatrogenic; you may call it cultural. It is a combination, but this man's back was his measure as a man. It meant he could support a wife and seven children. He loved his home and his family. Without his back, he was useless.

When we begin to question how do we examine a patient for a back that will stand up under stress, can we solve it only with a pre-employment x-ray?

The answer is no, of course. The x-ray may add some important information but it is only information in part, as has already been suggested by the other speakers.

The life history of the individual, his pattern of living, his successes and his frustrations, the meaning of the back to him, all have to be taken into consideration.

You cannot sit in an industrial office where you have to screen many people and ask all these questions, find out what kind of life this man has had. Time does not permit this luxury. But it is necessary, when the situation demands, when an injury has occurred, to learn what kind of a person this is because this may be much more important in solving the problem immediately than to wait for later.

In World War II, we learned a lesson concerning early definitive solutions. During battle when we used lieutenants at the battle line to do the triaging, we had a 90 percent loss of manpower from the standpoint of sending them back to duty. When we replaced the lieutenants with

lieutenant-colonels on the line, we achieved a 90 percent retrieval of man. A quick, definitive diagnosis was made at the battle station and most were sent back to duty.

This was the difference between the lieutenant who "couldn"t take any chances" and the more experienced older officer. The soldier might have an ulcer. "Let's send him back for the x-ray." The lieutenant-colonel with much more experience separated the truly sick from the non-sick, sent the latter back to his outfit and these men served. We had a 90 percent success in the Italian campaign.

These lessons are equally applicable to industry.

Once you are presented the full-blown problem, you have to utilize other resources than the strictly mechanical. Psychological testing gives an idea of what the man's makeup is. It is not only a question of his intelligence, although the higher the IQ, the more resource you have to work with, but his emotional needs and his reaction patterns. Does he react by regressing or by attacking? How does he utilize the pattern? And how does he express it in organ language?

One man gets into an argument and "his gut gets into an uproar" or his "gut gets tied in knots" -- organ language. "I hate to go down to the office this morning. I have got a headache waiting for me;" this is the cerebrovascular expression. Or, "I have got a back-breaking day ahead of me."

Every person has his own form of expression and if you are dealing with one who has a psychophysiological language directed toward his back, then if he is involved in an accident, you will find that organ complaining. This is entirely unconscious and is the most important factor blocking your attempts at rehabilitation.

Time and again when I have come onto the ortheopedic wards at our hospital and I have heard the nurse say, "We have only one consultation for you but we have got about ten or 12 on this floor who really need it." Such patients give the nurses a workout and the nurses know what is going on.

This is not malingering. It is not being put on but it describes the individual with the difficult back .

Therefore, the question of disc pathology will not be solved by finding a narrowing of L5-S1 or by discovering osteophytes in an intervertebral foramen by the myelogram only.

Are these important procedures? Absolutely yes, because we cannot deny the mechanical factor but even when the disc is removed or the osteophytes have been chiseled out of the foramen, you are still dealing with the person with whom you have to live afterwards.

Therefore, when you are faced with such a patient, a number of questions come up:

First, how does the clinical picture, plus the x-ray, fit with the dynamic operational aspects of that back? If a man has tingling in his median nerve distribution, with weakness in the index finger and thumb and you find osteophytes in his lumbosacral spine, there is no connection.

What physiologic disturbance of motion and sensation is brought out by neurologic and orthopedic examination and is confirmed by tests? How do they relate to what is found on x-ray, electrical examination and myelography?

Third, what is the personality makeup of the patient? And how does his concept of person and body image fit into his formulation of illness?

A man who is an executive, who is working with his hands and his head, is not too concerned about his back except as how it affects his golf game or driving. But to the laborer, this becomes the total symbol. Therefore, a sign-out diagnosis that I sometimes see on charts like back sprain, or lumbosacral sprain, or low back problem, leaves me a little perplexed. I do not know what the pathology is.

If it is a sprain, it ought to heal up rather quickly. If it is a low back problem, just what is it? Is the difficulty described on the sign-out page a topalgia, a local pain in the back like a local bruise? Is it a root syndrome associated with root pathology, secondary to osteoarthritis, to fracture, to metastasis, to herniated disc or to a congenital deficit?

Is it a psychophysiologic expression of that individual's personality need? He is hanging onto a symptom that represents his language. Or are we dealing with a person who started with a mild organic syndrome that long since has recovered but he has now incorporated that organic picture into his language, into his internal thinking, so that it becomes part of his personality? Therefore, you can see that the lower back is complex.

The back is complex anatomically and physiologically as pointed out this morning. It is complex mechanically and often defective. Any anthropologist will prove that to you, and it is an area that can become defective psychologically by the nature of organ language.

Therefore, the x-ray becomes only part of a diagnostic pattern. It is useful and, if I may use the analogy, it is another tile in a mosaic. But to complete the whole picture, once the problem is engaged, you have to see what all the tiles show.

CHAIRMAN PRESENT: The last paper in this morning's collection is from a friend of many of us and certainly a close friend of radiologists, Dr. E. Dale Trout of Oregon State University at Corvallis.

RADIATION SAFETY

E. Dale Trout, Sc.D.

DOCTOR TROUT: The title given to me was "Radiation Safety." This had to do with patient exposure and the gonadal dose.

To have something to work on, I asked Dr. McClenahan to send me a set of his films for low back examinations and Dr. Bond to send me a set.

Dr. McClenahan sent me four films, an AP pelvis, an AP lumbar spine, a lateral lumbar and a cone-down of the fourth, fifth, and sacrum.

Dr. Bond sent me four films, an AP and a lateral, a right oblique and a left oblique.

(Fig. 1) This is Dr. McClenahan's AP lumbar spine. You will note the gonads are outside the field.

(Fig. 2) This is the AP pelvis and the gonads are in the field. Dr. McClenahan and I did a little conniving and no gonadal shield has been used.

(Fig. 3) This is the lateral lumbar. The gonads again are outside the field.

(Fig. 4) This is the cone-down with the gonads pretty well outside of the field.

(Fig. 5) Some years ago, we published a paper in which we reported on scattered radiation.[1] The scatter comes from the face of the collimator, from the blades of the collimator and from the air column between the collimator and the patient. We had a six-foot long water tank filled with water and we could analyze the scattered radiation at any point outside the field, that is, how much of it came from the face of the collimator, how much of it came from the air column, and how much was just due to lateral scatter.

(Fig. 6) As you progress from the edge of the field outward, this scattered radiation falls off very rapidly. These dimensions outside the field --- how far is it from the point of interest to the edge of the field --- become very critical. They make any calculations of this kind subject to large error because it is very difficult to be sure what these are. We took the best data we could get from the size of the patient, as shown on the films, for calculations.

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[1]"Scattered Radiation in a Phantom from Diagnostic Quality Radiation", Radiology, Vol. 85, No. 3, Pages 546-554, September, 1965.

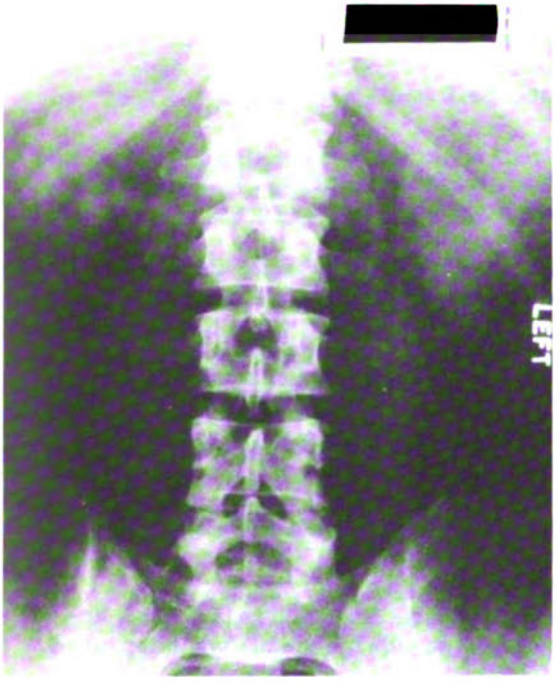

FIGURE 1

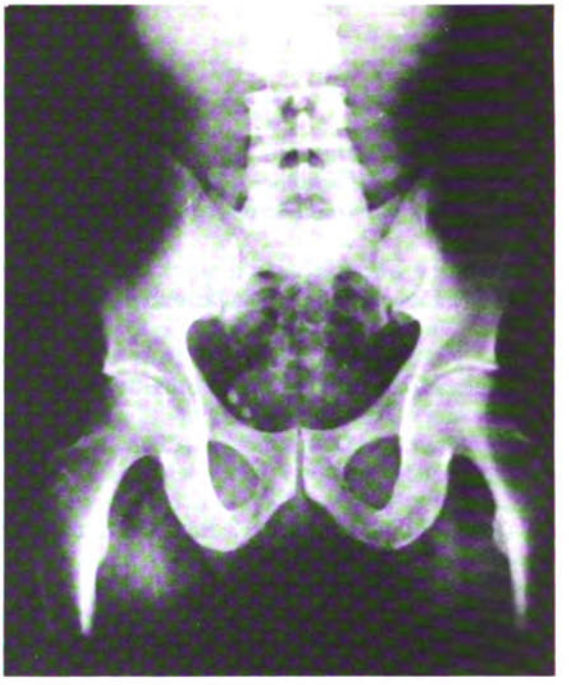

FIGURE 2

FIGURE 3

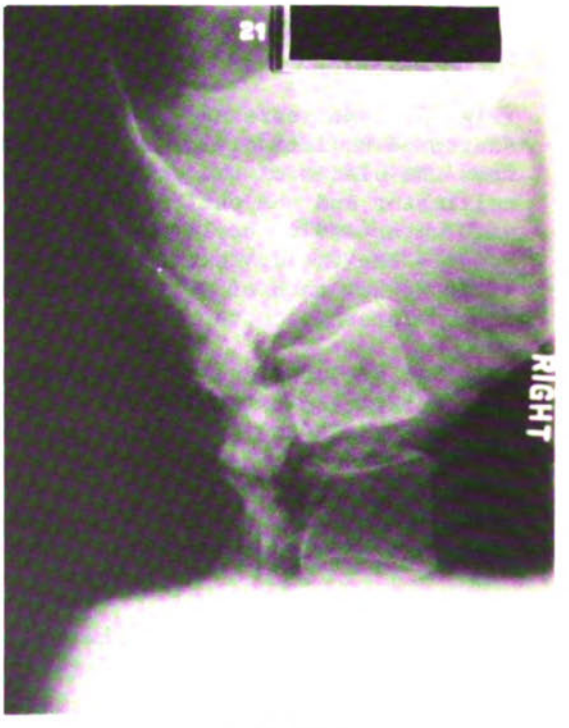

FIGURE 4

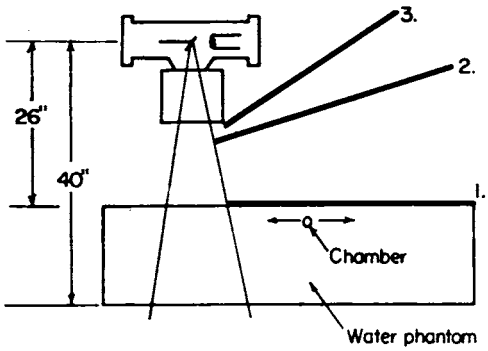

FIGURE 5. Conditions of Measurement

Condition	Chamber Measures
A (no added lead)	Lateral scatter, casing and collimator leakage, collimator scatter, air scatter
B (1/8 inch lead at 1)	Lateral scatter
C (1/8 inch lead at 2)	Lateral scatter, air scatter (collimator face plate removed)
D (1/8 inch lead at 3)	Lateral scatter, air scatter, collimator scatter (collimator face plate attached)

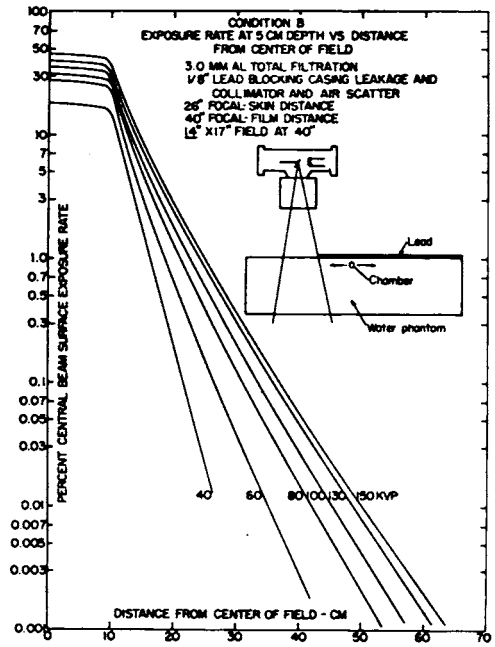

FIGURE 6. Lateral scatter at 5 cm. depth with 14 by 17 inch field, 40 to 140 kVp.

(Table 1) In considering Dr. McClenahan's four films, here is another variable. He used medium speed film and high speed intensifying screens. There is another variable that you can feed into these calculations. Various speeds of films and screens can be used and the exposure can be changed accordingly. As the speed of these systems is increased, the resolution will decrease.

The grid ratios can also be varied. Dr. McClenahan used the 12 to one and Dr. Bone used an eight to one grid.

These are the dimensions of the patient. These are the exposures that Dr. McClenahan used. Dr. Bond's exposures were different because he used medium speed film and medium speed screens and an eight to one grid.

This AP was done with a stationary grid, while the others used a moving grid. These are the factors and this is the size of the film that was used and this is the distance from the edge of the field to the best location that we could get the gonadal area.

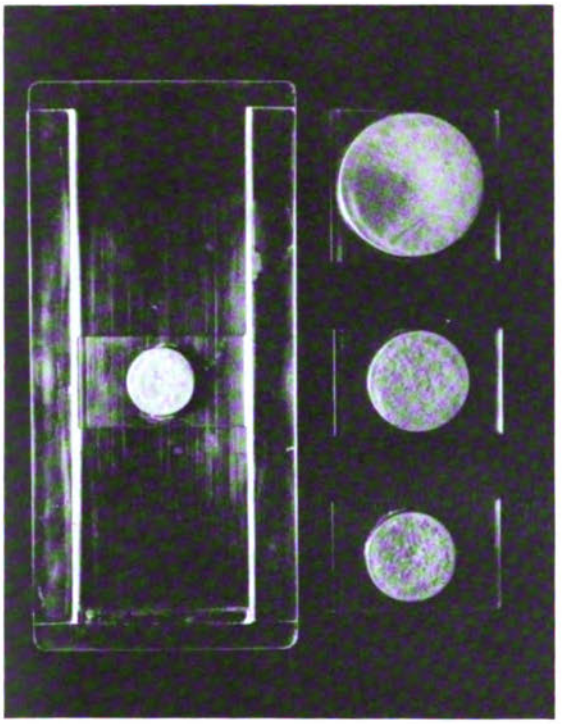

FIGURE 7

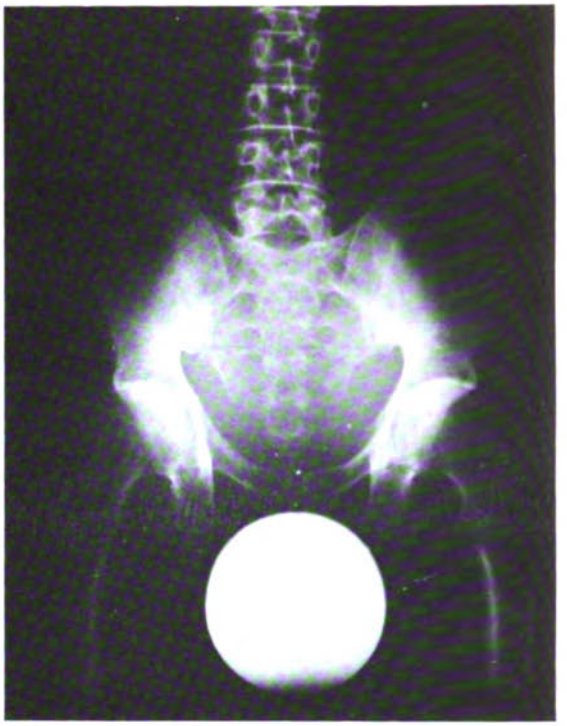

FIGURE 8

(Table 2) If you look at the patient exposure, just at the skin, which you have to have if you are going to start calculating, here is what you have. You will see that this lateral film with the cone-down is a heavy exposure. All of these exposures in the low back are going to be heavy exposures because you are dealing with dense parts and if the patient is standing and thus everything falls into the area being radiographed, this is further increased. But these are the kinds of skin exposures that are represented in the examination here.

We used .874 rad per roentgen, assuming that the energy was about 30 kev.

(Table 3) This is a four-film spinal examination using no gonadal shield. The AP lumbar spine does not contribute much at the surface and these are different depths. The gonads are outside the field. The dose to them is very low. But when you come to the pelvis, without a gonadal shield, they are in the field and the dose becomes very high.

When you get to the laterals that are outside the field in one case, but partly inside the field here, you have the absorption of this overlying leg and thigh and so the dose goes down.

You may wonder why we included ten and 15 centimeter depths. Large patients and lateral views give rise to large tissue thickness.

(Table 4) A conventional piece of lead rubber with about a quarter of a millimeter lead equivalent put in the useful beam, that is, on the surface of the patient as many of you, I suspect, do, will cut scattering

Table 1

FOUR FILM SPINE AND PELVIS EXAMINATION

EXPOSURE AND PATIENT FACTORS

Medium Speed Film
High Speed Intensifying Screens
12:1 Ratio Grid
18 cm AP, 23 cm Lateral Patient Thickness

Examination	kVp	mAs	SFD	SSD	Film Size	Gonad Location
AP Lumbar Spine	74	100	40"	31"	10"x12"	12.5 cm outside field
AP Pelvis*	82	100	40"	31"	14"x17"	5 cm inside field
Lateral Lumbar Spine	85	175	40"	29"	7"x17"	10 cm outside field
Lateral Lumbosacral Artic.	85	200	36"	25"	8"x10"	5 cm outside field

*Stationary grid. All other exposures made using oscillating grid.

Table 2

FOUR FILM SPINE AND PELVIS EXAMINATION

PATIENT SKIN AND EXPOSURE AND DOSE

Medium Speed Film and High Speed Screens
12:1 Ratio Grid

Examination	Skin Exposure - mR	Skin Dose - mrad*
AP Lumbar Spine	967	845
AP Pelvis	1259	1100
Lateral Lumbar Spine	2719	2377
Lateral Lumbosacral Articulation	4182	3655
Total	9127	7977

*Assumes 0.874 rad/R at 30 keV.

Table 3

FOUR FILM SPINE AND PELVIS EXAMINATION

PATIENT GONAD EXPOSURE AND DOSE
EXAMINATION AS PERFORMED, NO GONAD SHIELD

Medium Speed Film, High Speed Screens
12:1 Ratio Grid

	Gonad Depth - cm							
	0	5	10	15	0	5	10	15
Examination	Exposure - mR				Dose - mrad			
AP Lumbar Spine	3.1	3.1	3.1	3.1	2.7	2.7	2.7	2.7
AP Pelvis	1259	504	189	63	1100	441	165	55
Lateral Lumbar Spine	17.7	17.7	17.7	17.7	15.4	15.4	15.4	15.4
Lateral Lumbosacral Artic.	125	125	125	125	110	110	110	110
Total	1405	650	335	209	1228	569	293	183

down to 230 milliroentgens here and down to 201 millirads. Scattering from the air column, lateral scatter and what-have-you will come into the field.

These changes are dramatic any time you put any kind of a gonad shield in there, even the worst one, such as where you just lay something on the skin of the patient.

(Table 5) If you take what you would like to call a perfect shield, where you can surround the critical tissue completely with a quarter millimeter of lead or a quarter millimeter lead equivalent, this comes down still further to 57 or 58. You can get a reduction to about four percent.

This is the kind of thing that Dr. Brown is working on with his gonadal shield. If he ever gets that thing going, it will be a fine device. He doesn't quite restrict the beam to four percent all around the point of entry because unless he can put a drawstring in there between the patient and the scrotum somewhere, he is going to have a little trouble closing that one channel for scattered radiation but certainly he is going in the right direction.

(Fig. 7) We teach premedical and predental students in our place and we try to teach principles. They don't know that you can make a radiograph without a collimator that cuts the radiation down to the size of the field. We use these shadow shields which is what you would have had in the second case here where you just had a piece of lead on the surface. We mount them on the collimator. We do not cut out all of the scatter but we can use them in either a standing position or with a patient lying on the table. This is one of the problems you have when you try to just lay a piece of shielding on the patient. This is where Dr. Brown's device will take care of things because it is going to be a pair of lead

Table 4

FOUR FILM SPINE AND PELVIS EXAMINATION

PATIENT GONAD EXPOSURE AND DOSE
Assuming 0.25 mmPb Equivalent Gonad Shield Transmitting
4% of Useful Beam but Having No Effect on Scatter

Medium Speed Film, High Speed Screens
12:1 Ratio Grid

	Gonad Depth - cm							
	0	5	10	15	0	5	10	15
Examination	Exposure - mR				Dose - mrad			
A P Lumbar Spine	3.1	3.1	3.1	3.1	2.7	2.7	2.7	2.7
AP Pelvis	84	54	42	37	73	47	37.2	32
Lateral Lumbar Spine	17.7	17.7	17.7	17.7	15.4	15.4	15.4	15.4
Lateral Lumbosacral Artic.	125	125	125	125	110	110	110	110
Total	230	200	188	183	201	175	165	160

Table 5

FOUR FILM SPINE AND PELVIS EXAMINATION

PATIENT GONAD EXPOSURE AND DOSE
Assuming 0.25 mmPb Equivalent Gonad Shield
Transmitting 4% of Useful Beam and 4% of Scatter

Medium Speed Film, High Speed Screens
12:1 Ratio Grid

	Gonad Depth - cm							
	0	5	10	15	0	5	10	15
Examination	Exposure - mR				Dose - mrad			
AP Lumbar Spine	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.11
AP Pelvis	52	21.6	9.2	3.86	45	18.7	7.5	3.37
Lateral Lumbar Spine	0.71	0.71	0.71	0.71	0.62	0.62	0.62	0.62
Lateral Lumbosacral Artic.	5.0	5.0	5.0	5.0	4.4	4.4	4.4	4.4
Total	57.8	27.4	15.0	9.7	50.1	23.8	12.6	8.5

pants and the patient can wear them whether standing or lying on the table.

We like these simple devices and our students go through exercises because they can cut disks to cover different sizes of field and different shapes of field. This is probably the best way that we have found to use the simple collimator.

(Fig. 8) When you take a radiograph, you can make this circle anything you want. If there is anything that this august body should do at this meeting, it is to say that some kind of gonadal shielding should be used on all of these patients where the gonads are in the useful beam, that collimation should be such as to exclude them from the useful beam wherever possible.

I think we should think about the women that are coming into this business and when you get into that, you not only have to think of a different area of shielding entirely, you have to think about the pregnant woman. You have all heard about the ten-day rule and the difficulty of application. We are getting into a whole new ballgame with this thing but there are many devices that can be used to reduce these exposures.

I don't think you can pass laws to make people do these things. These are things that you should do because they are right and it is really a simple of kind of business. We send our students around to spend a few days in hospitals with radiologists and technicians. If they see some patient being exposed for something where they know some kind of a gonadal shielding should be used, one of the first questions they ask is "Why don't you do this?" It is having a very good effect.

FRIDAY LUNCHEON SESSION

January 12, 1973

CHAIRMAN PRESENT: I think we are, indeed, fortunate to have with us Dr. Stover Snook of Liberty Mutual Insurance Company who will speak to us on "Human Engineering, Jobs and Low Back Pain."

HUMAN ENGINEERING

Stover Snook, Ph.D.

DOCTOR SNOOK: Human engineering is simply engineering for human use or more specifically, the design of the job to fit man's capabilities. In this country, human engineering is also called human factors. Elsewhere in the world, it is known as ergonomics. Ergonomics is a term that originated in England, and is derived from the Greek ergos (work) and nomos (natural laws).

In principle, human engineering and ergonomics are the same. They are both interdisciplinary, drawing primarily upon the disciplines of psychology, physiology, and engineering. However, in actuality, there are some differences. The Americans place a greater emphasis upon psychology, whereas the Europeans place a greater emphasis upon physiology. The application is also quite different in that the Americans have applied most of their human engineering research to military and space systems. In Europe they are more concerned with the industrial tasks. So in many respects, ergonomics is the more appropriate term to use in this setting.

Whatever we call it, human engineering or ergonomics, notice that the goal is much the same as it is for industrial medicine, namely, a good match between the worker and his job. However, the approach is quite different. Generally speaking, the industrial physician tries to select or fit the individual to the job, whereas the ergonomist tries to design the job to fit the individual. It is important to recognize that one approach does not exclude the other; they are both important. Obviously, we can't design all tasks for all people, since there is much too much variation among people. Consequently, selection of the worker is also needed. The optimum approach is really a combination of selection and job design.

Today I am going to talk about job design and particularly about the relationship between the job and lower back pain.

According the the IMA criteria[1], low back x-rays are used to assign workers to various classes of jobs based upon the degree of physical activity or physical stress inherent in the job. There are four classes of jobs. Class I is administrative, or white collar type of work. Class II is clerical or light physical work that involves occasional light lifting. Class III is moderate physical activity that involves occasional lifting of objects weighing over 50 pounds, or frequent lifting of objects less than 50 pounds. Finally, Class IV is work involving heavy physical stress on the back, e.g., heavy construction workers, outside craftsmen, foundrymen and so forth.

Table 1

INCIDENCE OF BACK INJURIES IN INDUSTRY
(Percent of all injuries)

New York[2]	12.4
California[3]	16.0
Pennsylvania[4]	17.1
Florida[5]	21.4
Great Britain[6]	15.4

Table 2

INCIDENCE OF BACK INJURIES IN PENNSYLVANIA INDUSTRY[4]
(Percent of all injuries)

Other Transportation	31.3	Local Government	16.4
Construction (Other)	22.6	Machinery (except elect.)	16.3
Communication & Utilities	22.4	Local Transportation	16.1
Wholesale Trade	21.8	Crude Petroleum and Natural gas	16.0
Services	20.4	Machinery (electrical)	15.5
Bituminous Mining	20.2	Food	15.4
Motor Freight	20.0	Primary Metals	15.3
Stone, Clay, and Glass	19.5	Paper	14.4
Construction (Building)	18.5	Transporation Equipment	14.4
Railroads	18.5	Textiles	14.2
Furniture	18.0	Other Manufacturing	13.9
State Government	18.0	Lumber	12.8
Finance	17.8	Mining & Quarrying	12.1
Rubber	17.8	Apparel	11.5
Construction (Special)	17.5	Leather	10.6
Petroleum Refining	16.9	Fabricated Metals	10.3
Retail Trade	16.9	Agriculture	9.3
Printing	16.6	Anthracite Mining	7.5
Chemicals	16.4		

Table 3

INCIDENCE OF BACK INJURIES IN THE HEAVY CONSTRUCTION INDUSTRY[7]
(Percent of all injuries)

Cement and Concrete Finishers	33.0
Mechanics	30.9
Pipefitters	26.7
Drillers	26.3
Cranemen, Hoistmen	26.1
Bulldozer Operators	25.8
Foremen	25.6
Linemen	23.7
Iron Workers, Reinforcing	21.2
Deckhands	21.2
Trench Digging Machine Operators	20.6
Carpenters	17.9
Truck Drivers	17.8
Laborers	17.8
Welders	16.9
Power Shovel Operators	16.8
Pipelayers	15.5
Managers, Officials and Proprietors	13.7
Dregemen, NEC	13.2
Machine Operators, NEC	13.1
Apprentice Engineers and Oilers	11.4
Pile Drivers	11.2
Apprentices, Other	9.4

Table 4

INCIDENCE OF BACK INJURIES IN SEDENTARY
AND NON-SEDENTARY WORKERS
(Percent of Workers)

	Sedentary Workers	Non-Sedentary Workers	Percentage Difference
Swedish Industry[8]	52.7	64.4	11.7
Eastman Kodak[9]	35.0	47.0	12.0
Bell System[10]	43.0	57.0	14.0

Let's assume for the moment that we can identify the individual that is likely to develop lower back pain. The question is whether we can prevent lower back pain from occurring by placing him on a specific type of job - or is he going to develop it anyway?

Let's take a look at some of the data.

Table I shows that back injuries constitute 15 to 20 percent of all industrial injuries.[2,3,4,5,6] According to Table II, the percentage may be as low as 10 percent or as high as 30 percent, depending upon the particular type of industry.[4] The type of job within the industry is also important and results in a similar ten to 30 percent range, as indicated in Table III.[7] If the physical stress rationale underlying the IMA criteria was correct, then we would expect to find all the heavy industries and all the physically stressing jobs at the top of the list. This is not the case. Although there does appear to be some relationship between the job and the incidence of back injuries, the relationship is certainly not a very good one.

The poor relationship between the job and the injury is also expressed in the studies of sedentary and non-sedentary workers.[8,9,10] Table IV indicates that the incidence of back injuries in non-sedentary workers is only 12 to 14 percent higher than the incidence of back injuries in sedentary workers. This led Rowe[9] to conclude that "the kind of work done does not seem to be a significant factor in the production of low back disability, although it is reasonable to assume that a man with a backache would have more difficulty performing a heavy job than a light one."

Why isn't there a better relationship between back injuries and the type of job? I would like to suggest three reasons:

1. There may be some infrequent, but very stressing tasks involved in sedentary jobs.

2. Sedentary jobs may contribute to a general lack of physical conditioning, which in turn may contribute to back injuries.

3. Industrial jobs may only be a minor trigger of back injury.

Dr. Don Chaffin of the University of Michigan believes that heavy weight lifting, when specifically identified, is a major causal factor in back injuries.[11] Classifying jobs as sedentary or non-sedentary may not specifically identify all the infrequent weight lifting tasks. Dr. Chaffin studied 38 jobs in a communications industry and ranked each job according to the one manual element that required the greatest strenth to perform. He then reviewed the medical records of the 135 workers performing the 38 jobs on a daily basis for 20 weeks to determine the incidence of back injuries. The results are seen in Figure 1. Jobs requiring very high strength resulted in high back injury rates. However, the distribution appears to be non-linear and bimodal, with back injuries also occurring on two of the low strength jobs.

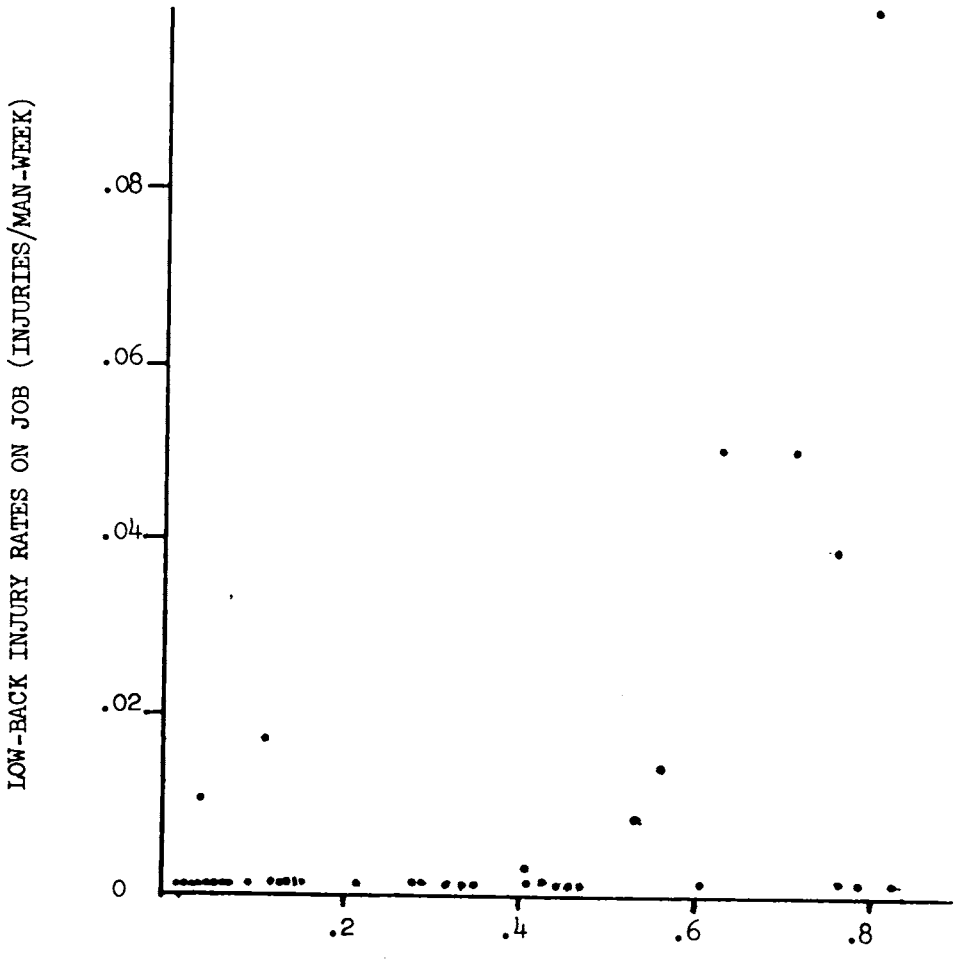

FIGURE 1. Low back injury rate versus strength requirements of job (from Park and Chaffin). *B_{mak} is a ratio of the strength required of a person while handling the heaviest weight in the most awkward position required by the job divided by the strength capability of a stitistically defined large strong man.

Cheny found a similar type of distribution when studying manual handling accidents as a function of the weight of the object being handled[12], as shown in Figure 2. Forty-six percent of the accidents occurred with weights of 100 pounds or more, although 41 percent occurred with weights less than 50 pounds. Figure 3 shows that yet another bi-modal distribution occurred in Rowe's study of pre-retirees.[13] Moderate work resulted in the least amount of back pain, followed by light work and then heavy work.

It appears from these studies that moderate work involving intermediate weights or strength requirements accounts for the smallest incidence of

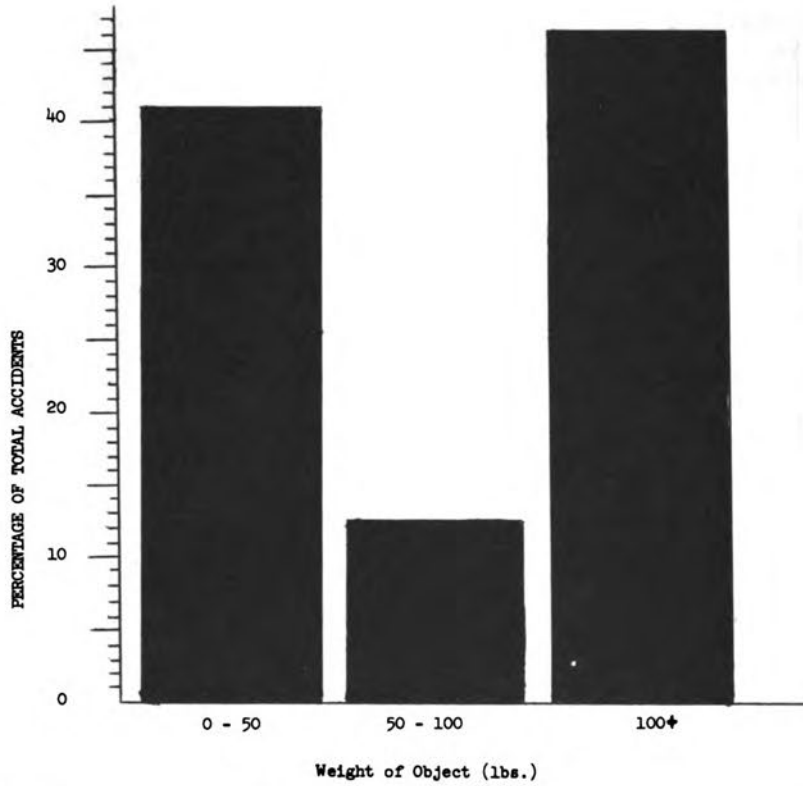

FIGURE 2. 312 high cost manual handling accidents (greater than $7500) (from Cheney[12]).

back injury. It is quite apparent that the heavy physical stress of Class IV jobs may contribute to back injury, but it also appears that the lack of physical stress found in Class I jobs may likewise contribute to back injury. This suggests that man's back functions best at the intermediate Class II and III jobs and that overloading as well as underloading may lead to breakdown - not an uncommon pattern in man's physiological and behavioral functioning.

Although the class of job appears to be important in the overall incidence of back injury, it is often difficult to relate specific injuries to the job. Hirsch[14] found that only 20 percent of low back pain followed some minor accident, such as a violent movement or strain. Another 20 percent did not appear until several days after the physical strain, whereas 60 percent of all patients found it hard to suggest any cause whatsoever. Rowe[9] reports very similar findings in that only 15 percent could clearly relate the onset of back pain to definite injury. Another 20 percent could make a possible connection between backache and some unaccustomed activity. The remaining 65 percent either could think of no unusual circumstances associated with the onset of symptoms or had sudden pain while performing usual and customary activity, without any accidental occurrences. Magora and Taustein[15] claim that 40 percent of their patients could not identify any cause or trigger of low back pain

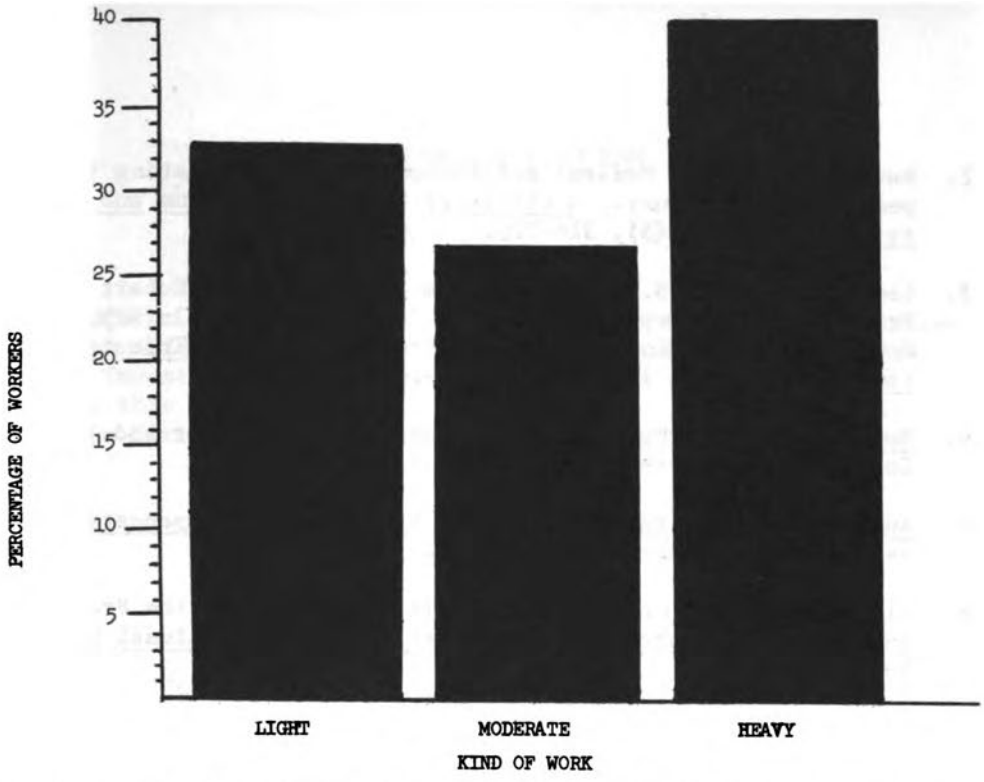

FIGURE 3. Distribution of workers with low back pain according to level of work activity (from Rowe[9]).

and that in most cases, the pain developed slowly and gradually so that the patient could not relate it to any specific event.

To summarize, we have seen that the incidence of back injuries is not as closely related to the type of job as commonly believed - or as commonly assumed by the IMA criteria for the use of low back x-rays.[1] We have suggested that the poor relationship may be due to (1) physically stressing elements of sedentary tasks, (2) the possibility that we may be understressing as well as overstressing the backs of our employees, and (3) the fact that approximately half of the cases of back injury are not triggered by the task at all. Even if we can use low back x-rays to identify the potential patient, there remains considerable doubt as to whether or not we can prevent the back injury by placing him on a specific type of job. One of the important questions for this symposium to consider is whether these relatively small benefits of job placement based upon lower back x-rays are sufficient enough to justify the substantial cost in time, in money and in radiation exposure.

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CHAIRMAN PRESENT: Are there any further questions? If not, we will gather in about ten minutes for the afternoon session.

FRIDAY AFTERNOON SESSION

January 12, 1973

CHAIRMAN PRESENT: This afternoon may very well bring out, in the introduction of the epidemiology of low back injuries, the orthopedic viewpoint of the industrial problem and so, some more controversy. The first speaker this afternoon is Dr. Laurens Rowe of Eastman Kodak in Rochester, New York, who will speak on the "Epidemiology of Low Back Injuries."

EPIDEMIOLOGY OF LOW BACK INJURIES

Laurens Rowe, M.D.

DOCTOR ROWE: An epidemiological picture of low back disability in industry may provide a fitting backdrop for the ensuing remarks by industrial physicians concerning the usefulness of pre-employment or preplacement x-rays of the low back. The picture to be projected has developed as the result of a twelve year continuing study of about 2000 male employees who have low back problems of sufficient degree to constitute a problem in job placement or absenteeism.

The study was launched some twelve years ago at the Kodak Park works of the Eastman Kodak Company in Rochester, New York. This plant is a mixed-job industrial complex with an unusually stable population of about 28,000 people. It has a highly developed medical department with complete clinical, x-ray and laboratory facilities and is staffed by fifteen full-time industrial physicians and a battery of consulting specialists including radiologists and an orthopedist. The medical department enjoys an excellent relationship with management on the one hand and with the working population on the other and this together with the stable work force promised unusual opportunity for unlimited follow-up. After a review of the extensive medical literature, it was decided to start the study with a clean sheet of paper avoiding so far as possible the specialist biases, the cliche and fad diagnoses and the pre-conceived notions upon which so many clinical studies appear to have foundered. The one new ingredient in the study was to be the time parameter. All patients were to be followed at regular intervals for an indefinite period in the hope that the natural history of low back disability could be delineated. The unusually stable plant population and the willingness of management and workers to allow unlimited visits to the medical facility have resulted in a follow-up rate of over 90 percent.

Several reports of the ongoing study have appeared in the medical literature which relate to the concerns of this conference. Briefly, some 2000 men have now been examined according to a standardized technique which included a detailed history not only of the current episode of backache but also of the life-time behavior of the back, a thorough medical and orthopedic examination, a laboratory profile and an x-ray study. Abnormalities discovered in any segment of the work-up are listed but no diagnoses are entered until evidence developed following original evaluation or, more commonly, after repeated follow-up observation, which may include therapeutic trials or repeat x-ray or laboratory examinations, allows establishment of solid, supportable diagnoses based upon objective findings. At any given time, 20 to 30 percent of the study group are undiagnosed. In addition to the patient group, a normal or control group has been similarly evaluated and remains under follow-up and, from time to time, certain special population groups have been studied by the same technique when this seemed valuable to elaborate or clarify information

being gathered in the patient group.

Using the above-described rigid diagnostic standards, it appears that about 70 percent of our patients have discogenic backache related to one of the several stages of degeneration of the lower lumbar intervertebral discs. About 20 percent have some type of inflammatory backache. Included in this group are patients with the various arthritides and those with backache secondary to lower urinary tract infection. The remaining ten percent form a miscellaneous group of widely varying diagnoses. Included in this group are those who have sustained true injury resulting in fracture, ligamentous sprain or muscular strain as tightly defined. They make up about four percent of the entire patient group. Also included in the miscellaneous group are a few men (about three percent of the total patients) whose disability is attributable primarily to bony structural defect in the region of the lumbosacral junction. Most of these have spondylolisthesis. About half of the spondylolisthetics have other mechanical defects in addition to the slip such as leg length difference, acute LS angle, and spina bifuda occulta. Several of the uncomplicated spondylolisthesis patients had had no back pain through many years of heavy work until an intercurrent illness or operation enforced a period of inactivity. Then, low back pain developed on return to work. Since spondylolisthesis occurs as frequently in our normal controls as it does in the patient group, we regard it as a descriptive term, not as a diagnosis.

The diagnosis in the inflammatory group is ordinarily not difficult and can often be made following the initial evaluation. Occasionally, therapeutic trials and serial laboratory checks are necessary before solid diagnosis is reached.

Much more difficult to diagnose are those in the discogenic group. For study purposes, we have required demonstration of objective evidence of nerve root involvement before a diagnosis of discogenic disease can be made. Since no nerve root involvement is usually present in the early phases of discogenic backache when only annular tearing is occurring, diagnosis usually must be deferred, often for several years. Gradually, one becomes adept at demonstrating subtle signs of nerve root pressure. An ankle reflex which may be normal when tested in the sitting position often becomes depressed if tested with the patient kneeling in a chair with the back straight or hyper-extended. Careful recording of baseline physical examination data allows us to spot degrees of calf or buttock atrophy during follow-up which would pass unnoticed in a one-shot evaluation. Weakness of dorsi-flexion of the big toe on the painful side has occasionally been a useful early sign of nerve root pressure. Painful or restricted lumbosacral hyper-extension and pain radiating in the sciatic distribution upon percussion at the lumbosacral junction are suspicious but not diagnostic signs. The signs of nerve root pressure are often evanescent, appearing for a short time during an attack and then clearing as the attack subsides. Day to day observation during attacks is necessary if these signs are to be detected.

Twelve years of observation of patients of all age groups entering the study with what ultimately could be diagnosed as discogenic backache has etched a fairly clear picture of the clinical behavior of the condition

and, at the same time, has spawned new ideas of medical and industrial management of the low back problem.

Men with discogenic backache come as frequently from white collar as from blue collar jobs. About 75 percent are in their thirties or forties when they enter the study. About ten percent are in their late twenties and the remaining 15 percent are in their early fifties. Attacks of low back pain usually start in the late twenties or early thirties. Only rarely are the attacks precipitated by definable injury. The early attacks are usually of short duration, are unassociated with any objective diagnostic signs and clear completely with or without treatment. The patient then becomes totally asymptomatic on full normal activity and may remain so for several months or a few years. Ultimately, another attack occurs, often somewhat more severe than the first. Again, clearing occurs but there is then commonly initiated a series of attacks and remissions, each attack being a bit more severe, each remission being a bit shorter. By the late thirties or early forties, the attacks have usually tended to lateralize to one side or the other of the low back and there may be radiation of pain into one buttock. Shortly thereafter, an attack may be associated with radicular pain, usually in the sciatic distribution, and textbook signs of nerve root pressure may appear. About 20 percent of the patients may require a disc operation at this point because of failure to recover with conservative treatment.

If the patient continues to clear his disc attacks without need for surgical intervention, the frequency of the attacks will gradually diminish and their severity will wane and, finally, by the mid-fifties or thereabouts, the patient will stop having acute attacks. He may, however, at about that time, note "arthritic" symptoms of the low back with reduced mechanical tolerance, morning stiffness and weather-associated ache.

The patient has then run the gamut of clinical manifestations of degeneration of the intervertebral disc. The early attacks which are nonspecific and undiagnosable presumably relate to early tearing of the annulus of the disc with ingrowth of granulation tissue. As the disc narrows and loses its stabilizing function, later attacks feature nerve root irritation or pressure. At this point, in some patients, the annulus may actually rupture, allow protrusion of nuclear material against the nerve root and produce an attack which will not respond to conservative treatment. Disc surgery consists of mechanical removal of the particles of degenerated nuclear material from the nerve root, usually relieves the sciatica, but leaves the patient (as it found him) with a degenerating disc which will, in most cases, continue to produce some degree of backache. Later on, as further disc narrowing and reactive productive bony changes from the adjoining vertebral margins proceed, the patient will frequently develop symptoms of an arthritic nature referable to subluxation of the posterior facet joints. Finally, in the sixties, fibrous stabilization develops across the degenerated disc space and back symptoms from this interspace cease.

Some notion of the high incidence and broad distribution of the low back problem may be gained from one segment of the study which involved the examination of about 250 unselected pre-retirees, ages 62-65, for whom

lifetime work and medical records were available. Entries in the medical record indicated that 60 percent had had low back pain of sufficient degree to warrant medical treatment during their working lifetimes. This represents a bedrock figure since an unknown additional number could have had treatment through outside facilities. Of the known 60 percent requiring treatment, about half had lost time from work because of low back problems on one or more occasions during their working years. The incidence of low back disturbances requiring treatment was evenly spread among sedentary, moderately active and heavy workers. There was no difference in the incidence of traditional backache determinants such as tall or short stature, obesity, or structural abnormalities of the low back skeleton between the group requiring treatment and the untreated. X-ray evidence of disc degeneration at the fourth or fifth lumbar interspace occurred in 70 percent of the men who had medical record of treatment and was present in only 20 percent of those for whom we had no such record.

We are convinced that the syndrome of discogenic backache accounts for about 70 percent of low back disability in industry. The question naturally arises as to why disc degeneration occurs in some men and not in others. It seems reasonable to guess that men who do heavy work would show more wear and tear on discs than would desk workers. Actually, there was no significant difference in the incidence of disc degeneration as determined by x-ray between the heavy workers and the sedentary people. Another attractive theory holds that structural abnormalities in the low back could be expected to produce distortions and asymmetries of stress patterns and thus lead to disc degeneration. Actually, degeneration of the lower lumbar discs was seen in 37 percent of the men with one or more structural abnormalities (spondylolisthesis, sacralized transverse process, spina bifida occulta, facet asymmetry, lumbosacral angle of more than 45 degrees or leg length difference of more than a half inch. inch). In the men with none of these commonly interpreted structural abnormalities, disc degeneration occurred in 55 percent. We are thus unable to pre-select the future disc degenerator at the usual age of hiring (late teens or early twenties) by any examination technique presently available. Our current feeling is that the occurrence of disc degeneration in a given individual depends more upon his genetic inheritance of basic connective tissue stuff than it does upon the environmental factors to which he may be exposed.

Now to cone this down against that background of epidemiology in terms of actual experience of working industrial physicians with preplacement or pre-employment low back x-rays, we have four experts. First, we will hear from Dr. Carl Zenz, medical director of Allis-Chalmers.

PANEL DISCUSSION

DOCTOR ZENZ: This brief discussion is intended to present an overview based on my 17 years of experience in pre-employment and periodic examinations and other occupational health activities relating to the "low back problem" and job placement. A few selected yet typical examples will be described.

As a matter of introduction to various work settings which may involve moderate to heavy work assignments, I have selected some illustrations as a beginning. Illustration number 1 points out major environmental factors (the long term effects of vibration and body positions deserve further study); number 2 summarizes the most important human factors - some of these factors are beyond the control of the employee and/or the employer. I believe the most important single factor or factors involved in accidents and prevention of accidents are the psycho-social components of workers with their environmental interrelationships, including those with co-workers, supervisors, management, unions and even family circumstances.

Generally, workers have no control in the investment of new technology or equipment and have even less control over normal aging processes. Illustration number 3 (large boring mill) shows older men on a large boring mill. In many factories, the average age of the work force is between 52 and 55 years.

Illustration number 4 (forging) of the forging or "drop hammer" work is considered heavy work involving considerable arm, shoulder, back and leg work in lifting and positioning heavy ingots. There are several major concommitant stresses such as heat, noise, vibration, along with a rapid and repetitive work pace with few, if any, well-designed or physiologically planned work or rest pauses.

Of most timely importance is the ever increasing number of women entering the work scene. The next pictures demonstrate some interesting work features involving what is generally known as an easy assignment, that is, driving a fork lift truck (illustrations 5, 6, 7). Note the refueling operation requires the changing of the empty LP tank for a full tank which weighs 56 pounds. The lady in the picture is 5'2", weighing 136 pounds. Originally, a man was stationed at the refueling location whose duty consisted mainly of exchanging the empty fuel tanks for fully charged tanks for the drivers. Reductions eliminated his job which created considerable furor among the women truck drivers for the first few weeks. I cannot go into further details of this interesting example as this is beyond the scope of this discussion.

FIGURE 1

However, let's take another moment to look into some foundry operations with a wide variety of ergonomic deficiencies. Illustration 8 shows typical "casting cleaning" work with the casting shown on the floor weighing 104 pounds. This common task was studied as part of an ergonomic survey of body positions during work. The chipping tool, air hammer, chisel and six feet of connecting hose weighs 18-1/2 pounds. The energy expenditure on standing and working in a correct position was 22 percent less than the kneeling position (as determined by oxygen consumption) (illustrations 9 and 10).

During the spring and early summer of 1968 when great numbers of new employees were being processed and a more detailed method of keeping records was used, we examined about 2200 new employees for the West Allis Works. Included as part of the pre-employment examination procedures were low back x-rays for those prospective workers who were to be assigned to heavier tractor assembly work, foundries, machine shop work as machine helpers and other miscellaneous labor assignments. These totaled 460. The average age was 24 years. The overall rejection rate for employment of all jobs was slightly less than eight percent or 176. Of these 460 prospective candidates for employment who had low back x-rays, 78 or 17 percent were found unacceptable for employment. They were rejected because of the risk of potential problems which appeared too serious by x-ray findings to be considered for selective and unrestricted placement.

According to the company medical standards, cause for rejection <u>may be</u>:

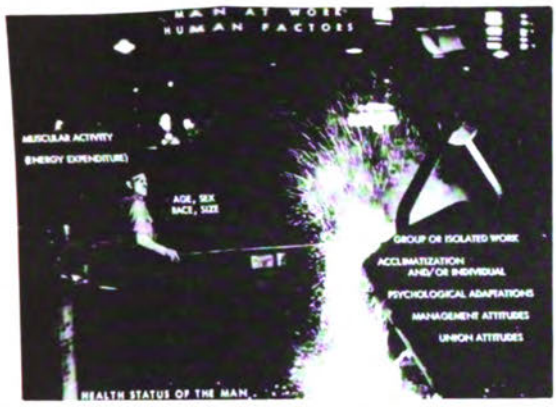

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5

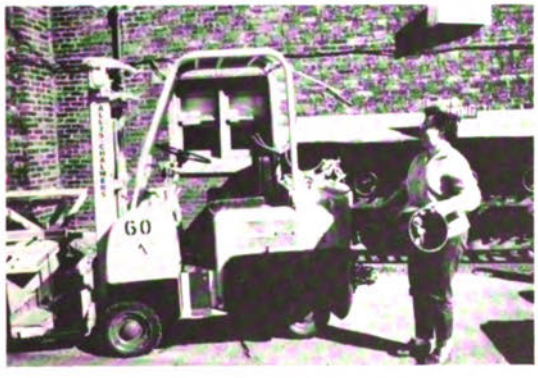

FIGURE 6

FIGURE 7

FIGURE 8

FIGURE 9

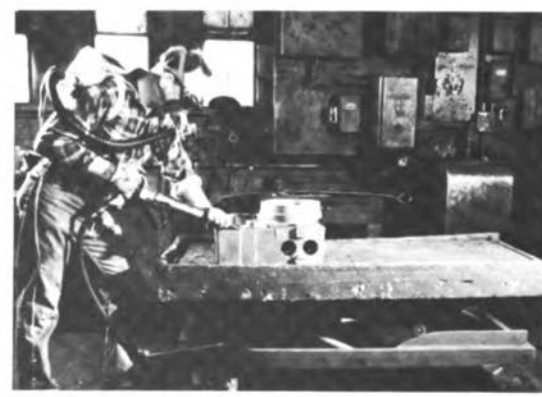

FIGURE 10

"(1) marked scoliosis with rotation of vertebrae, (2) marked narrowing of the intervertebral joint space (most common at lumbo-sacral joint), (3) advanced hypertrophic osteo-arthritis, (4) spondylolisthesis, (5) tumors of vertebrae, (6) infectious diseases of vertebrae, or (7) unilateral or incomplete sacralization or incomplete lumbarization."

DOCTOR ROWE: Dr. John Redfield has been with Weyerhaeuser, more recently with Kodak, and I believe his experience to be reported today is Weyerhaeuser experience.

PANEL DISCUSSION CONTINUED

DOCTOR REDFIELD: I reported on my experience with the pre-placement low back x-rays at Weyerhaeuser Company at the IMA annual meeting in Atlanta almost two years ago and what I propose to do now is to summarize that experience and to reflect upon it.

For years, all of the applicants for employment at Weyerhaeuser Company were subjected to low back x-rays as part of their selection process.

(Fig. 1) This illustrates the x-ray report form which was filed on each applicant for employment. If you are familiar with the criteria of the IMA Ad Hoc Committee on Low Back X-rays, you would recognize the similarity between those conditions listed in category C, abnormalities indicating substandard risk for sustained heavy work, and those conditions classed by the committee as unsuited to moderate or heavy physical stress on the back.

Conversely, those conditions acceptable under categories A and B were also acceptable for all classes of work by the committee.

As a reminder, this figure here has already been alluded to. In fact, it is a copy (Table 1) of the committee's arbitrary job class groupings and I show it simply to illustrate that in the forest products industry, virtually all jobs to which a new employee might be assigned are in the Class III or Class IV job grouping. In fact, most of them are Class IV.

(Table 2) A total of 2378 back x-ray series were done, each with four views and they were exposed between the period of January 1, 1967 to January 1, 1971, a four-year period. This figure illustrates in the upper part of the breakdown of the x-ray findings of these subjects groups A, B and C that we used as the Weyerhaeuser criteria.

When this is compared with the previous study, also done within the company - and this was done by Chuck McGill a few years previously and is on the right-hand side of the illustration - you can see that the new figures are rather similar.

The percentage of "C" backs was a little bit higher in the group that I did. The other groups are even closer.

In the lower half of this table, you will also see that when we break down the "C" subgroup into further subclassifications, as to specific diagnoses, there are some differences between Dr. McGill's figures and mine. For instance, the combined C-1, or the spondylolisthesis and spondylolysis together in my series was a total of 11 percent of all

WEYERHAEUSER COMPANY
BACK X-RAY REPORT

Date

Name Age Sex No.

Height Weight Job Assignment

Previous History

A. ABNORMALITIES OF MINOR IMPORTANCE
(Combination of several may be important)

1. ☐ Mild tropism lumbar joints
2. ☐ Minor spina bifida occulta (X-Ray findings only)
3. ☐ Schmorl's nodes L 1-2-3
4. ☐ Minor cong. defects – no symptoms
5. ☐ Minor lordosis
6. ☐ Osteoarthritis – X-Ray only
7. ☐ Minimal Scoliosis
8. ☐ 6 Lumbar Vertebrae

B. ABNORMALITIES OF INCREASED IMPORTANCE
Questionable Acceptable for Substantial Heavy Work
(Combination of several is significant)

1. ☐ Marked tropism lumbar joints or facets
2. ☐ Extensive spina bifida occulta
3. ☐ Schmorl's nodes L 2-3-4-5 – & loss lumbar curve
4. ☐ Moderate degenerative changes upper lumbar or lesser in lumbar spine
5. ☐ Mild to moderate scoliosis
6. ☐ Decrease in lumbar segments (5 to 4)
7. ☐ Transitional lumbosacral vertebra & no pseudoarthrosis
8. ☐ Minimal Narrowing L 5 S 1 interspace

C. ABNORMALITIES INDICATING SUBSTANDARD RISK FOR SUSTAINED HEAVY WORK

1. ☐ Spondylolysis or spondylolisthesis
2. ☐ Transitional lumbosacral vertebra with pseudoarthrosis
3. ☐ Narrowing intervertebral space L 3-4-5, especially associated with marginal spurring, sclerosis, etc. Upper lumbar narrowing possibly less significant
4. ☐ Marked hypertrophic degeneration – upper lumbar,
   Moderate " " L 4-5 and
   Milder " " if under 30 years
5. ☐ Collapsed or wedged vertebra, evidence old fractures of vertebral body or neural arch, or multiple defect spines or transverse process
6. ☐ Neoplasm or destruction of bone
7. ☐ Extensive spina bifida of 2 or more vertebrae
8. ☐ Prior back surgery, radio-opaque materials evidence previous infections; Marie-Strumpell spondylitis; major congenital anomaly, disease of lumbosacral or sacro-iliac joints
9. ☐ Active osteomyelitis or substantiated history of osteomyelitis or reactive change of sacroiliac in younger persons
10. ☐ Symptomatic osteoarthritis or rheumatoid
11. ☐ Herniated intervertebral disc(s), or history of surgery re
12. ☐ Disease of sacroiliac or lumbosacral joints, chronic with related pain, postural deformities and/or limitation of motion lumbar
13. ☐ Rotary scoliosis
14. ☐ Degenerative disease (i.e. osteoporosis)
15. ☐ Definite kyphosis deformity
16. ☐ Multiple S[illegible]

DESCRIPTION AND DIAGNOSIS

Signed M.D.

FORM 1019 2-65

FIGURE 1

Table 1

IMA Ad Hoc Committee on Low Back X-rays (excerpt): JOM 6; September, 1964:

All types of work have been arbitrarily grouped into four classes on the basis of the amount of stress apt to be placed on the low back.

Class I: Administrative work in which employee sits at desk. Possible hazards relate to company travel, from lifting and carrying luggage, from slips and falls when in unfamiliar areas. White collar worker.

Class II: Clerical and/or light physical work such as stockroom clerks, light bench assembly, first line supervisors, salesmen (retail, wholesale, traveling, etc.) Work is fairly active but with at least part of time at a desk or bench. Involves occasional light lifting, considerable walking, some bending, stooping, squatting.

Class III: Moderate physical activity, such as inside craftsman, many factory jobs, etc. On feet most of time; involves bending, stooping, squatting, twisting, reaching, working on irregular surfaces, occasional lifting of objects weighing over 50 pounds, frequent lifting of 10-25 pounds.

Class IV: Heavy physical stress on backck. Includes outside craftsmen, construction laborers, foundrymen, etc. Involves frequent heavy lifting (over 50 pounds)—often combined with bending, twisting, working above ground or on irregular surfaces.

those back in the "C" category and his was only 4.1 percent. So there are some rather large differences there.

If you look at the figure 386, which indicates the number of what we would classify as substandard risk backs for employment, you might assume that 386 applicants out of 2378 were rejected for employment. Actually, this was not the case.

Because of the influence of a rapid labor turnover and because of pressure to hire and intermittent short labor supply, it was just not feasible to reject 16.2 percent of all applicants strictly on the basis of an x-ray.

Therefore, some of these "C" category applicants were accepted for employment and they subsequently became a study group for comparison with applicants classified as normal or in the "A" and "B" categories.

(Table 3) This figure summarizes, or details, the two groups, that is, the experimental or high risk group of 209 subjects, all with category "C" backs, and a sampling of the so-called normal, or low risk subjects, totaling 664.

Table 2

SUMMARY OF X-RAY INTERPRETATIONS DURING THE PERIOD 1/1/67 to 1/1/71

	1/1/67 to 1/1/71		Comparison Study 1864-66[2]	
	No.	%	No.	%
Total Films Interpreted	2378	100.0	9593	100.0
Normal Backs (no defect)	1038	43.6	3743	39.1
"A" Backs	640	26.9	3311	34.5
"B" Backs	314	13.2	1321	23.7
"C" Backs	386	16.2	1218	12.7

BREAKDOWN OF CLASS "C" X-RAY FINDINGS 1/1/67 TO 1/1/71

	1/1/67 to 1/1/71			Comparison Study 1964-66[2]		
	No.	% of "C" Backs	% of Total Films	No.	% of "C" Backs	% of Total Films
Total "C" Backs	386	100.0	16.2	1218	100.0	12.7
C1, Spondylolisthesis	155	40.1	6.5			
C1, Spondylolysis without Spondylolisthesis	106	27.4	4.5			
C1, Combined	261	67.5	11.0	397	31.5	4.1
C2, Transitional Vertebra with Pseudoarthrosis	91	23.6	3.8	371	29.4	3.9
C3, Narrow Intervertebral Space	9	2.3	0.4	209	16.6	2.2
Other	25	6.5	1.1	281	22.5	2.4

Table 3

AGE AND DURATION OF EMPLOYMENT OF 209 EMPLOYEES HIRED WITH "C" BACKS COMPARED WITH A ONE-THIRD SAMPLING OF 1992 SUBJECTS WITH NORMAL BACK X-RAYS

	209 High Risk Subjects		664 Normal Subjects	
	Terminated	Still Active	Terminated	Still active
Number	132(63.2%)	77 (36.8%)	454 (68.4%)	210 (31.6%)
Average Duration of Employment	5.1 months	20.0 months	6.6 months	24.3 months
Average Age at Employment	26.9 years	27.7 years	26.5 years	28.9 years

In this detailing, it shows you that they were classified as to whether they were still working or had terminated employment at the time of the conclusion of the study and also as to average employment duration and age.

In both of these groups, approximately two-thirds had left employment by January 1, 1971, in the high risk group, 63 percent, in the normal subjects, 68 percent, with an average duration of employment for this two-thirds similar for both groups. In other words, it was five to six months.

The average age of employment was also very close in the groups.

(Table 4) To further verify that both the experimental and control groups experienced similar back stress demands, this table demonstrates the departments in which the subjects were placed and how long they worked there, and hopefully, it shows that the injury exposure risks were similar in the two groups.

(Table 5) I have detailed the x-ray diagnoses of the group of experimental subjects that were accepted for employment with substandard back x-rays.

If you add the first three categories, it comes to 156, just under the diagnosis of spondylolysis and spondylolisthesis. The next most common defect was the transitional vertebra with pseudoarthrosis.

(Table 6) In this table, I have listed the reasons for which the applicants with the "C" category x-rays came to be hired. Almost half of them were subjects in which spondylolysis was discovered and in many of these cases it was only on oblique views of the lumbosacral spine and where there was no associated spondylolysis. This condition appeared so frequently that from purely a practical standpoint it was decided not to consider it grounds for rejection, arbitrary but practical.

The period of observation covered four years. During that time subjects were added to and dropped from both experimental and control groups. Because of this, risk was figured in terms of person years. The injury experience was as follows:

(Table 7) There were six low back injuries among the 209 subjects in the high risk or experimental group. This amounted to an injury rate of 32.5 per 1000 person years.

In the low risk, or control group, there were 126 low back injuries out of 664 subjects. This represented an injury rate of 62.3 per 1000 person years at risk.

My conclusion at the end of the study was that for this population, given the conditions imposed upon the study, the back x-ray taken at the time of employment did not identify or predict the employee with the highest risk of injury. In fact, using the standard criteria for designating what we call high risk, those subjects expected to be most sus-

Table 4

PLACEMENT AND DURATION OF EMPLOYMENT OF 209 EMPLOYEES HIRED WITH "C" BACKS, COMPARED WITH A ONE-THIRD SAMPLING OF 1992 SUBJECTS WITH NORMAL BACK X-RAYS

	209 High Risk Subjects		664 Normal Subjects	
	No. Placed	Average Duration	No. Placed	Average Duration
Woods	46 (22%)	9.2 months	148 (22%)	9.5 months
Lumber	89 (42%)	10.2 months	343 (52%)	13.8 months
Plywood/Panels	55 (26%)	15.3 months	118 (18%)	12.3 months
Paperboard	7 (4%)	18.0 months	21 (3%)	14.5 months
Other	12 (6%)	3.4 months	34 (5%)	5.7 months

Table 5

X-RAY DIAGNOSIS IN 213 EMPLOYEES HIRED WITH "C" BACK

Spondylolysis without spondylolisthesis	99
First degree spondylolisthesis	56
Second degree spondylolisthesis	1
Transitional vertebra with pseudoarthrosis	36
Previous surgery	7
Evidence of old fracture or wedged vertebra	6
Narrowed lumbosacral interspace	4
Epiphysitis deformity	1
Rotary scoliosis	1
Moderate arthritic changes, lower spine	2

Table 6

REASON FOR HIRING 213 EMPLOYEES WITH "C" BACK

Spondylolysis without spondylolisthesis, not grounds for rejection	101
Defect borderline, applicant accepted	35
Job skill or other attractive feature overrides defect	18
Experimental placement in panels departments	13
Experimental placement in other departments	17
Hired temporarily without x-rays, defect discovered during subsequent exam for permanent hire	10
Hired for temporary period only or for part-time work	12
Placed in Class II-type job	4
Other	3

Table 7

SUMMARY

	High Risk Group (Experimental)	Low Risk Group (Control)
No. Subjects	209	664 (1/3 of 1992)
No. Injuries in 4 yrs.	6	126
Rate (based on person-yrs. of experience)	32.5/1000	62.3/1000
Percent entering and leaving the study in the 4 yr. period	63.2	68.4
Average employment duration of those who left	5.1 months	6.6 months

ceptible had an injury rate about half of that which occurred in the control group.

I believe the most critical factor in assessing the value of this investigation lies in the extremely short duration of observation afforded me in most of the subjects. Two-thirds of them worked only five to six months and it may be argued that it is not valid to draw conclusions on the basis of such short observation, especially in a population of which the average age was only 27 years at the time of hire.

But let me interject a practical note which indicates some value of this study. As a result of it, Weyerhaeuser Company in Springfield, Oregon, was able to ask this question, "In our hiring situation of high turnover and limited employment duration, is it worth the cost to x-ray every production applicant, particularly if he is young and stands a 66 percent chance probability of leaving in six months?

The answer, of course, lies in the predictive value of the x-rays applied to that one-third of the applicant population which became longer term employment prospects and at the present time, this is unknown.

The current practice at this plant is to x-ray the lumbosacral spines of only those applicants of 40 years or over and any younger subjects whose history or physical findings suggest such investigation.

In reviewing different articles about industrial back x-ray programs, it seemed to me that there were two popular approaches used by authors in justifying their various favorite programs.

The first was to show a strong association between certain abnormal x-ray findings and varying degrees of low back disability. My objection to this method was that the subjects are all selected by virtue of being injured and studying injured patients does not seem to me to constitute a true means of evaluating the x-ray as a predictive technique or as a screening technique.

The second method was to demonstrate a favorable trend in reduction of injury, frequency and severity and/or compensation costs following the adoption of a program in which x-ray used for pre-employment screening was one of the elements. My objection to this approach was that the x-ray is anything but a controlled variable in this situation because it is only one of several variables.

I chose not to use either one of these approaches because I was not trying to justify a program. My main interest was not to single out the x-ray defects associated with highest risk of injury which is what the IMA ad hoc committee was charged to do, but to demonstrate whether those criteria selected by the committee actually could be proven to have the high degree of association with low back injury which they claim. I chose the method I hadn't seen reported on, which was simply a comparison of the injury experience of two groups of employees doing heavy work, one with back x-rays findings assumed to represent high risk in this kind of stress and the other with normal back x-rays.

Hopefully, the subjects in my two groups are well enough matched as to age, duration of employment and heaviness of work to reduce the variables to a single meaningful one, that is, the x-ray, and this study may very well indicate that the conclusions can be made only for the population being studied with very limited application to industry at large.

It can still, however, be very useful to the company employing this group of subjects, as I have shown you. However, I would like to see this method of controlled observation of equal groups with the x-ray findings as the only variable reproduced in a number of industries in hopes that a general sense of the usefulness or the uselessness of selected x-ray criteria in employment selection might emerge.

DOCTOR ROWE: Our next speaker is Dr. F. J. Kelly, medical director of Mason and Hanger Corporation in Amarillo, Texas.

PANEL DISCUSSION CONTINUED

DOCTOR KELLY: The excellent presentations that we had from the radiologists and the orthopedists leave us with one conclusion, that regardless of what valuable information they can provide, as our late President Truman said: "The buck stops here." I refer to the fact that when we, the physicians in industry, get this information from the radiologist and orthopedist we must then make the final decision as to whether the individual can be hired in a particular industry and if so, what limitations must be placed on him, if any are indicated.

I would interject a reference to the legal aspect. Back in the early 60's, a California court said - and I think this is very pertinent to this entire subject - "It appears that both employee and employer in relationship, subject to the workmen's compensation act, will be well advised to be diligent in ascertaining at the very inception of the employment relations, all available or discoverable facts relative to the prospective employee's physical condition. This should subserve the interests of both employee and employer."

We began to collect our data in 1957. At that time we took what was commonly accepted as being "significant" back x-ray findings and used that as a guide for either rejection or hiring with certain limitations.

(Table 1) This first table serves to emphasize what the three previous speakers from industry have commented upon, that is, what we do in the preplacement examination depends upon the nature of the industry and each industry is different. Therefore, the requirements are going to be different. This must be taken into your considerations.

There are four general types of industry. (1) Chemical. This involves airborne or contact materials. (2) Physical. The primary concern would include ionizing radiation, noise, temperature and/or pressure. (3) Biological. This includes problems in the area of waste, sewage, food handling or insects. (4) Ergonomic. Heavy or repetitive lifting would be the hazard. Many industries could combine more than one or all four categories.

We have a medium-heavy ergonomic industry but also have extensive interest and concern in the other three types. These factors make a difference in evaluating statistics and certain criteria at the preplacement level.

In 1957, we had about 1100 employees and not only a sophisticated medical department, but all of our operations are highly automated and research oriented. We have a low turnover. These facts make a difference

Table 1

EXTEND OF THE PREPLACEMENT EXAMINATION
IS DEPENDENT UPON THE HAZARDS
NATURE OF THE INDUSTRY

A.	Chemical - air-borne or contact
B.	Physical - ionizing radiation, noise, temperature and pressure
C.	Biological - insects, waste and sewage, food handling
D.	Ergonomic - heavy lifting, repetitive motion, poor visual conditions

Table 2

REPORTED SERIES OF SIGNIFICANT LUMBO-SACRAL SPINE DEFECTS DETERMINED BY PRE-EMPLOYMENT X-RAY EXAMINATION

Reference	No. of Cases	Rejected or Restricted (%)	Considered abnormal (%)
Becker	7729	29	68
Gross & Coulter	207	26	70
Runge	4654	25.44	25.44
Reiner	1030	23.5	59.31
Crookshank & Warshaw	1927	22	22
Rombold	1000	20.3	66
Dively & Oglevie	6523	16.1	60.1
Allen & Linden	3000	-----	35
McDonald	9336	-----	41.85
Kelly	1087	9.8	44.2

Table 3

Defect (1087 Examinations)	%
Spondylolisthesis	3.4
Osteoarthritis	1.3
Lumbarization, unilateral	1.3
Lumbar scoliosis	0.6
Sacralization, unilateral	0.5
Posterior arch defect	0.3
Compression fracture	0.2
Asymmetrical facets and/or spina bifida occulta and/or transitional vertebrae	2.1

Table 4

STATISTICS CONCERNING BACK X-RAYS

Of the total sample (378) of persons having back problems,
82.3% had normal back x-rays
4.0% had insignificant back x-ray findings
13.7% had significant back x-ray findings.

in the statistics. Our records are extensive and complete with considerable medical data on the computer with monthly print-outs. All the back x-rays have been read by me and questionable films reviewed by our consulting radiologist.

Another important consideration is the activity of the medical department and the services it is capable of performing as far as initial treatment of non-occupational conditions are concerned. Do they use the medical department regularly enough and are controls sufficient so that accurate data can be obtained on the non-occupational back complaints? With about 35 people in our safety department and an employee population now of about 1800, the number of injuries should be and is kept to a minimum and this makes a difference in comparing results between industries.

(Table 2) This second table shows several authors' reports prior to 1962. In the last column the variance in "abnormal" backs ranges from 22 percent to 70 percent which may be an indication of how detailed you want to report the films. It may well depend on the industry. The range of those rejected or restricted is not as great - from 29 percent to our series, 9.8 percent. In this series we did use gonadal shields on most of them but unfortunately, I think, we discontinued the practice but are about to resume the shielding again.

(Table 3) This table indicates those conditions we felt in 1961 were an indication for either rejection or work limitations in the 1087 applicants. We are not as rigid with our criteria in recent years as we were at that time.

In 1971, we decided to take another look at the problem and we obtained the following data from the files of our 1800 employees.

(Table 4) We found that during the time these employees were working at our plant there were 378 individuals who had back problems. Then we referred back to their preplacement back x-rays and found that 82 percent of these 378 people had normal films. Four percent had minor defects reported and 14 percent had what most have considered probably "significant" findings. If you place that four percent in either the normal

Table 5

	X-ray Findings	
	Positive	Normal
a. Number of persons having had no back trouble	40	--
b. Number of persons having back trouble since employment	31	269
c. Number of persons having back trouble prior to employment	21	57
	92	326

Of the total sample of persons having back x-rays with positive findings,

43.5% had no instances of back trouble
33.7% have had no instances of back trouble since employment
22.8% had instances of back trouble prior to

Table 6

COMPARISON OF THE NUMBER OF INSTANCES OF BACK TROUBLE BETWEEN PERSONS WITH POSITIVE X-RAYS AND PERSONS WITH NORMAL OR INSIGNIFICANT X-RAY FINDINGS.

Xray finding	# of Persons with Back Trouble	Total # of Instances	Average per Person
Normal or Not Significant	269	496	1.8
Positive	31	59	1.9

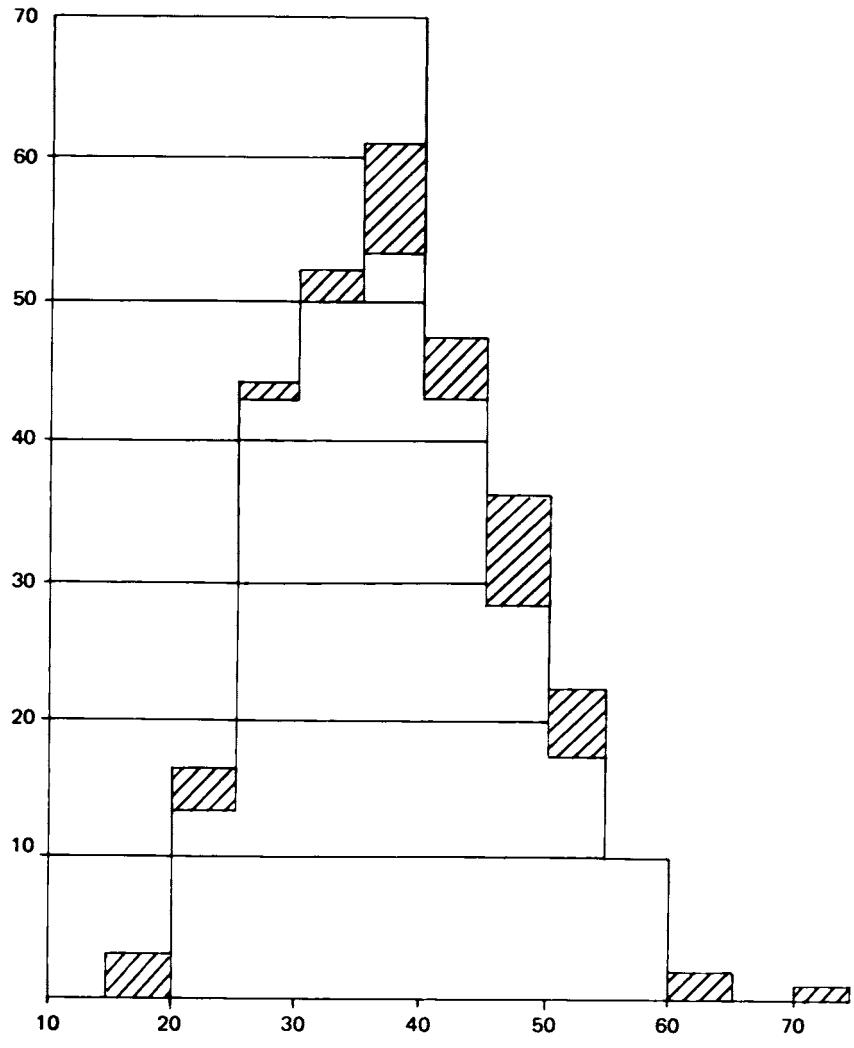

FIGURE 1. Histogram: age at first instance of back trouble since employment. Average=37.6; standard deviation=9.4. Sample back x-rays: ▭ Findings normal or not significant; ▨ findings positive.

or abnormal group or split the figure, you have 84 or 85 percent of these with normal x-rays who report back problems sufficient to see a doctor or lose time. These are not just occupational back injuries but include non-occupational problems as well. As I mentioned earlier, we do feel that we know close to 100 percent of the employees who may have had personal back problems because of our medical operation and reporting, so this 85 percent is minimal and we believe quite accurate. Another factor is that our plant is some 20 miles from town and it is much easier to come to us - most use car pools - and report to work for the initial treatment.

(Table 5) The first line of table 5 indicates the number of people (40) having no back trouble but who had "significant" back x-rays at the preplacement examination. We see that 43.5 percent had no back trouble and 23 percent had back trouble prior to employment.

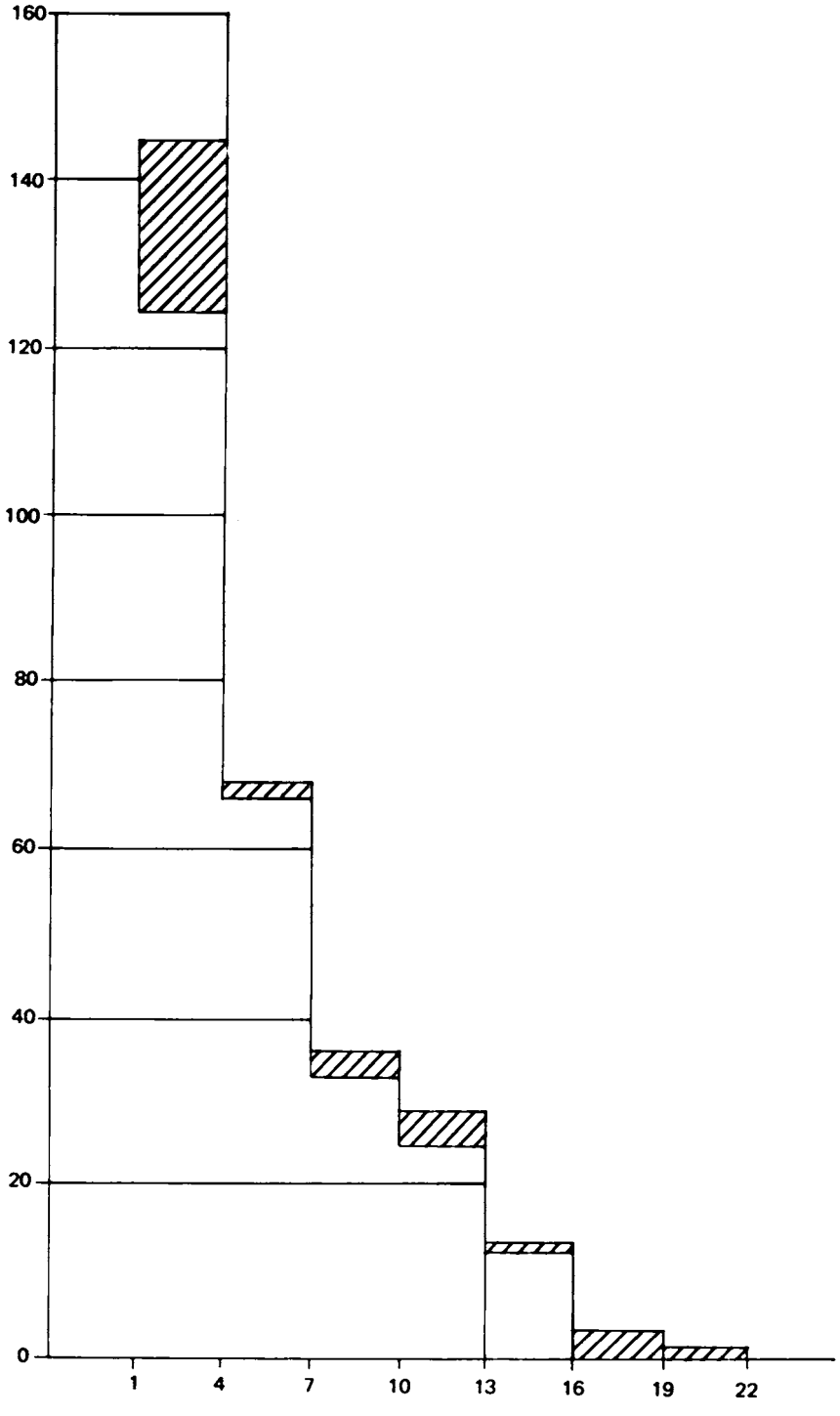

FIGURE 2. Histogram: years of employment at first instance of back trouble. Sample back x-rays: ☐ Findings normal or not significant; ▨ findings positive.

(Table 6) This table reveals that among the 269 people who had back trouble with normal x-ray findings, they had 496 separate occurrences of their complaints or an average of 1.8 per person. The 31 employees with positive x-ray findings had 59 instances of back complaints. Remember these are both occupational and non-occupational type cases. You will note that there are the same average number of separate instances of back complaints whether the x-rays are normal or have "positive" findings.

We found that for each instance of a back problem alleged to be occupational in origin, there were two instances of back complaints which were not related to the job.

Admittedly, the previous data are on a selected group, that is, some of the higher risk people may not have been hired but I am satisfied that there is considerable information to be gained since we do have areas for comparison. It would be most informative to followup on these people who have been rejected for employment on the basis of the back x-rays and really find out how much trouble they have had over a ten to 15 year span.

(Fig. 1) This histogram shows us the age of the employee when the first instance of back trouble occurred. Our statisticians indicated that it has a reliable bell curve. The hash marks indicate those people who had significant preplacement back x-rays. As you see, we do not have a mandatory retirement age so there are several over age 70. Also, this curve does not follow our plant population age, which is five to ten years older than these age groups. As this graph indicates, the highest incidence occurs between 35 and 40 - the greatest incidence of back trouble - but our average age throughout the plant is about 46 at this time. Notice, too, the comparitively large number in the 45 to 50 age group who had positive back x-rays at pre-employment and they have been working at least ten years and had no back complaints until this age. This graph also reveals that all who had significant preplacement back x-rays developed their back problem before age 55.

(Fig. 2) Finally, this histogram relates the number of years of employment to the first back trouble incident. The columns represent three year intervals and clearly show that if the employee is going to have back trouble, the great majority will have their first episode during the first three years of employment. This appears to hold true whether they have a normal or abnormal preplacement back x-ray and whether the cause is occupational or non-occupational.

PANEL DISCUSSION CONTINUED

DOCTOR ROGERS: Our topic is a problem which is of extreme importance to industry throughout the United States. Further, it is a real honor to be allowed to present an aspect of this problem as it relates to a particular facet of heavy industry in the United States.

At the first meeting of a small group of men which was eventually to become the nucleus of this entire conference, I listened with interest to opinions expressed by our various members. I immediately was drawn to the fact that the discussion was centered entirely about the relationship of pre-employment back x-rays in industry to the workmens' compensation laws as they exist in the various states. After listening to this discussion, I presented some information which came as a surprise to most of the members of that original group. In the United States at the present there are over 544,000 employees in the railroad industry who are not covered under workmens' compensation laws but are covered under the terms of the Federal Employer's Liability Act. This act, commonly known as FELA, is actually a whole different kettle of fish. I would like to present the main features of this act and how it affects the railroad industry, since the terms of this act directly affect an attitude which has been established on the part of the railroad industry toward the use of pre-employment back x-rays.

In any discussion of the Federal Employer's Liability Act, we should take into consideration the conditions which existed prior to its enactment, both from a social and a legal standpoint. Our Anglo-Saxon forebears brought to this country a body of law which was originated, developed, formulated and administered in England as we know it now, as common law. Common law is best described as a body of rules and principles, written or unwritten, which are fixed and immutable authority and which must be applied to controversies rigorously and in their entirety and cannot be modified to suit the peculiarities of a specific case or colored by judicial discretion. Whether common law was just or unjust is a matter of conjecture but in the transition from a feudal to an industrial society, common law certainly served a good purpose. However, as the industrial revolution of this country expanded, there was a need to soften the harsh dogmas of common law in order to protect the injustices that common law brought to the working class.

Under common law, the employer had the duty to protect the employee from injury while he was engaged in the performance of his job, but at the same time, the employee assumed the normal risks inherent in the line of work he was engaged to perform. Also with common law, the liability of the employer arose only where it could be shown that the employer was negligent and that said negligence was the proximate cause of the injury or disability sustained by the employee. Under common law, injuries and

fatalities could not be compensated through the courts unless it was proved that the employer was negligent. Thus, the merest shred of evidence of negligence on the part of the employee precluded any recovery for injury or death.

For many years, the remedies for personal injuries for railroad employees engaged in interstate commerce were governed by the negligence laws of the various states. Congress, recognizing the difficulties under which the railroad employees engaged in interstate commerce labored in obtaining redress for injuries, enacted the original Employer's Liability Act of June 11, 1906. This act abolished the "fellow servant rule" and modified the contributory negligence rule. That law, by its terms, was applicable to all employees of railroads engaged in interstate commerce. However, the law was then held unconstitutional because, in the view of the Supreme Court of the United States, it transgressed upon powers reserved by several states.

Two years later, President Theodore Roosevelt recommended to Congress that the Federal Employer's Liability Act be re-enacted correcting the defects in the earlier law and so, in 1908, the Federal Employer's Liability Act was again put back on the books, thus bringing to bear an act which governed the employees of all railraods engaged in interstate commerce.

T he Federal Employer's Liability Act as amended has done away with the defense of contributory negligence and replaced it with a comparative negligence doctrine. Simply described, comparative negligence is that doctrine in the law of negligence by which the ordinary and gross negligence and a recovery is permitted notwithstanding the contributory negligence of the plaintiff, when the negligence of the plaintiff is slight and the negligence of the defendent gross, but refusing when the plaintiff has been guilty of a want of ordinary care, thereby contributing to his injuries, or when the negligence of the defendent is not gross but only ordinary or slight when compared to the contributory negligence of the plaintiff.

Also, under the terms of the Act, the "fellow servant" doctrine has been abolished which means that the railroad is liable regardless of who, within the scope of his railroad employment, caused the accident. Assumption of risk is also no longer a defense, not even in mitigation of damages, which means that when the injured railroad man can merely foresee the danger but negligently disregards it, he loses some of his claim under the comparative negligence doctrine. But, if he knew of the danger and willfully assumed it, he recovers fully. Stripped of their most powerful common law defense, particularly contributory negligence and assumption of risk, the railroads, under the Federal Employer's Liability Act, have less of a chance to prevail than ordinary defendants in negligence suits.

The original act has also been amended by the Boiler Inspection Act and the Safety Appliance Act. Under these amendments, it has been held that with any violation of these acts, there is absolute liability on the part of the railroad and, further, the problem of negligence may not be raised

and it is in error to charge the jury with the question in a Safety Appliance case.

When one puts all of these rules and regulations together, it can be said that the Federal Employer's Liability Act consists of federal statutes imposed on common carriers engaged in interstate commerce and it is used to provide remedies to railroad employees sustaining injury in the course of employment. However, it is quite different from workmens' compensation acts because, in the workmens' compensation act, there are fixed amounts of liability and amounts of recovery and that, actually, the FELA is like a workmens' compensation act without limits.

We in the railroad industry are faced with the problem that, regardless of how minor the injury is, under the FELA, we are faced with actual open-ended compensation claims and let it also be said that recovery under the FELA, by the carrier, when these cases come to a jury question, is extremely difficult. It has been shown that negligence on the part of the employee can only mitigate damages. It does not relieve damages even in the face of gross negligence on the part of the employee. Further, in the event there is the slightest alteration in the function of the equipment, under the terms of the Boiler Inspection Act and the Safety Appliance Act, negligence cannot even be brought into the case and we are daily besieged by claims of staggering proportions, as well as faced with staggering awards by juries when these cases are brought to trial. Under the terms of the FELA, an employee has a right to enter suit in even the most minute injuries, whereas under workmens' compensation, the statutes set forth very clearly a fixed fee for medical services as well as a fixed fee for redress to the employee, but this is not true with us. Therefore, it behooves the railroad carrier not only to work diligently to be sure that all equipment is perfectly functioning at all times but it also behooves the railroad industry to insure through its medical department that its employees are kept in top notch physical condition and, also, that the medical department provide the railroad industry with applicants who are as near perfect physical specimens as is possible for us to find.

In substantiation of this, I have just completed perusing a total of 795 back cases which occurred on American railroads during the year 1971. There exists in the set-up of the Association of American Railroads what is known as a Claims Index Bureau. Out of the 90-95 railroads in this country, approximately 60-70 of these railroads regularly report all of their personal injury claims to this Index Bureau. Records are kept of these claims for the purpose of analysis of trends, costs and so forth. I was furnished records of all of the back cases which were reported to this bureau in 1971. These totalled 795 cases. This total was further broken down into 292 cases of ruptured intervertebral discs, 57 cases of cervical injuries and all other back cases total 445. This immediately points out a rather interesting finding that of all of the back injury cases reported to the bureau during 1971, almost 40 percent of those cases were those involving a ruptured intervertebral disc. Now, let us take a look at these 795 cases as to what these cases cost the carrier in terms of settlement. The total cost of these 795 back cases was $18,515,539. This is a staggering figure. Further, to break this down,

it is shown that the disc cases cost a total of $9,494,089. The cervical injury cases cost $858,045. All of the other back cases cost a total of $8,163,405.

Then, to pursue this analysis just a little bit more, it is shown that the average of the ordinary back case, excluding the disc cases, was $17,971 per case in settlement. These cases were reported in the majority as being cases purely and simply of strain. On the other hand, the average cost per case to settle the employee with a ruptured intervertebral disc was $32,403. Therefore, it can be seen that it costs twice as much to settle a back injury case if a disc is involved than if it is an ordinary back injury.

I then attempted to take a look at some other interesting reports that could be derived from this inasmuch as in my particular company, in 1968, I included x-rays of the cervical spine as part of my routine, pre-employment back x-ray program. My total pre-employment back x-ray involves an AP and lateral of the cervical spine and an AP and lateral and 45 degree obliques of the lumbosacral spine. Therefore, I took a careful look at 57 cases of cervical injuries reported in this group. The age range in this group varied from 21-49 years of age with an average of 35 years. All of these cases were listed as so-called whiplash injuries or cervical strain. These 57 cases averaged $15,053 to settle each case. Now, to my knowledge, our company is the only railroad doing cervical x-rays. In 1971, I had no claims for cervical injuries. This raises the question, relating to a statement which has been frequently found in the literature, that a whiplash injury does not occur unless there is an abnormal cervical spine to begin with. Therefore, could these 57 cases have saved American railroads $858,000 had they been excluded from employment by pre-employment cervical x-rays?

I also took a look at 151 cases of back injuries all under 50 years of age which did not include any fractures or blow to the back resulting in direct damage to the bone but consisted mainly of diagnoses of spondylolisthesis, degenerative disease, spondylitis, spondylolysis or conditions which I felt could probably have been excluded by proper pre-employment back x-rays. In this group of 151 cases, the average age was 31 years and the total cost of this particular group was $2,153,686 with an average cost per case of $14,262.

Now, concerning my statement regarding the so-called case of strain, I would like to say that I am extremely interested and feel there is a direct relationship between an increased lumbosacral angle and the occurrence of disability and back strain as a result of heavy lifting or strenuous work. In fact, it is requested of all the radiologists who do pre-employment x-rays for the Southern Railway System that the lumbosacral angle be reported and measured according to the technique of Ferguson. In this regard, if a lumbosacral angle is above 45 degrees, it is considered to be disqualifying. I have discussed this problem with many radiologists and orthopedists and it is definitely the feeling of most of the ones that I have talked to that when the lumbosacral angle is increased above 45 degrees, when the line of weight bearing falls

far enough anterior, there is definitely an increase in the shearing force at L-5 and sacrum. In our particular industry, we have a large number of employees who are involved in jumping on and off moving trains constantly. When a man is riding the footboard of an engine and while it is moving, jumps off to the ground in a running position, he certainly is jolting and straining his lumbar spine considerably and, if the angle is markedly increased, or if there is a pars defect or spondylolisthesis or spondylolysis, I certainly think that he is headed for trouble. Therefore, I think it is important that we exclude these people from employment by means of pre-employment x-rays.

But to get into the financial side of this picture a little bit more, investigational claim records also reveal that in 1972, there were 93 cases which required settlements of over $100,000. This ranged all the way from $100,000 to $900,000 but there were 93 cases over $100,000 settlements. In addition to this, it has also been shown from the record that in the last three months of 1972, there were three cases in which the judgment was $1,000,000 or above.

To bring these figures a little closer to home, our own statistics show that during the year 1971, the year in which I reported a pay-out for the country as a whole by railroads of $18,000,000, my company alone spent $507,484 in settling back injury cases. Now, what can we prove from this? In the year prior to the institution of the back x-ray program within my company, back claims cost us a little over $300,000 in comparison with back injuries in 1971 costing $500,000. However, when one considers the marked escalation of jury verdicts, the escalation in salaries, medical costs, etc., I would certainly expect that we could have realistically expected a pay-out of triple the amount paid out in the year before the x-ray program was begun. After all, one would only have to have five cases with settlements of $100,000 apiece to equal the amount that we paid out for back claims in 1971. Without a pre-employment back x-ray program, it would be my estimate that back injuries would have cost us between $900,000 and $1,000,000 in 1971. However, our payout was only $500,000. In addition to this, my claim department advises me that the total number of claims for back injuries is decreasing, although the individual cost of each case is increasing.

Now, let us turn to another interesting aspect of this situation. 1971 was a big year for employment with the Southern Railway System. During that year, I processed a little over 5800 applicant files. Of that total number of applicants, approximately 90 percent of them received pre-employment back x-rays. Since my average cost for pre-employment back x-rays is in the neighborhood of $45, it is my estimate that, in 1971, I vouchered approximately $200,000 for pre-employment back x-rays. At first glance, this seems to be an enormous figure. However, when one takes into consideration the number of applicants processed and takes into consideration the average cost of settling a disc case, my total x-ray costs would be paid for if I could have saved six disc cases from employment. On the other hand, the total cost of x-rays could be borne by saving 12 non-disc cases from employment. Actually, the only conclusion that we can draw is that all of the x-rays could be paid for by just a very few expensive case settlements.

I have shown in these few minutes the problem which we are faced with in my particular industry. We are governed by federal statutes under which liability is almost absolute in every case and which allows for recovery on the part of the plaintiff with the sky as the limit with practically no defense whatsoever. I thoroughly realize that by means of a pre-employment back x-ray that we cannot possibly exclude from employment all of the potential back injury cases, nor am I naive enough to believe that we can accurately predict by a pre-employment x-ray all of the back injuries that will occur inasmuch as we know that there are people with spondylolisthesis, for instance, who go through life in a heavy industry and never have one minute's trouble and then there are those who suffer disabling back injuries with a perfectly normal back x-ray. On the other hand, there are those conditions which, although they may not be 100 percent in every case, we know are certainly apt to make an individual more prone toward a particular back injury. Therefore, in the face of a one time unconstitutional law and in the face of staggering claims and settlements, we feel we must do everything possible to exclude the potentially serious back injury.

CHAIRMAN PRESENT: Our next speaker is an orthopedic surgeon who will speak on "An Orthopedic Veiwpoint of the Industrial Problem."

AN ORTHOPEDIC VIEWPOINT OF THE INDUSTRIAL PROBLEM

John Schwartzmann, M.D.

DOCTOR SCHWARTZMANN: From a practicing orthopedist standpoint, the industrial implications of back problems, particularly with respect to pre-employment exams and pre-employment x-rays, is in just as much of a quandary now as it was before they were thought up and devised.

The chief value that I can see, and this is with respect to some heavy industry, mines and mining, is the ruling out of obvious disabling situations in low back and back problems. But insofar as employment and nonemployment are concerned, there is a considerable problem for the individual who applies for a job and is refused work on the basis of an x-ray or x-rays without examination, evaluation and so forth. He is pretty much put into a situation of not being able to get a job in many areas of Arizona and I think it is true probably in other areas, too, because once refused on a back basis, the problems of getting a job are nearly insurmountable in some instances.

I think that if nothing else, if this symposium comes out with a relative merit and value on pre-employment examination or pre-employment x-rays as one of the criteria for refusing individual employment, it would be very much worthwhile that it be modified to a useful and not a blanket or flat basis for employment or nonemployment.

I think that pre-employment examinations should not be limited to x-rays alone. Obviously, some x-rays rule out the employability of an individual but as you have seen, x-rays and work ability are not always a compatible parallel.

Working history is extremely important in those individuals who have a working history and if they have been working at the type of job for which they are being considered with a long working history of little or no time off, no history of backaches and so forth, they should be seriously considered in the face of some of the abnormalities or anomalies of the backs that are demonstrated by x-ray.

Physical examination, by the same token, can point up problems that x-rays do not. Posture decompensation, potbelly, swayback, limited motion and obvious signs that the individual may or may not attest to in history can many times point up the probability of problems with the back that x-rays again will not do.

In this area, we are confronted with rheumatoid arthritis as a big problem and x-rays, of course, eventually will show this but they may not show it early and certain physical examination procedures and laboratory work may be of definitely or infinitely more value than the initial x-rays.

X-ray deformities, as described, may bring up problems that require further study before the individual is employed or considered for employment. But classifying the job to the patient's physical and orthopedic and x-ray examination is the job of the doctor for recommendation and then it is the policy of the company to accept or reject.

I can see where the railroads have a little different problem than do the other industries because of the national responsibility rather than local or industrial responsibility.

Dr. Noer showed me an abstract on 2000 cases of compensation neurosis that were reported by Dr. Gormley in 1958. One-tenth of one percent of these were backaches. That was the lowest incidence of these 2000 case studies at the Mayo Clinic, the least common cause.

Of this one-tenth percent, 26 percent were adjudged osteoarthritic, 22 percent disc disease, 19 percent were undetermined as to the cause and the remaining percentages were various things such as spondylitis, coccygodynia, old injury, spondylolisthesis, Pott's Disease, osteoporosis and recent injury, and if an institution like the Mayo Clinic has one-fifth of these problems undetermined, certainly an initial x-ray or a cursory examination is not going to prove or disprove the potential presence or absence of back problems.

(Fig. 1) This is a scoliosis in a child 17 years old. She had no back complaints and was seen primarily for the curvature. The mother noted the problem. The pediatrician noted the problem and she has been fully active, athletic and so forth, without symptoms.

(Fig. 2) This is another lateral curvature of the spine in an adult 28 years old with no symptoms whatever. She is a housewife with two children and is carrying on daily activity and working as a secretary without any symptoms whatever.

(Fig. 3) This is a 42-year-old with absolutely the same story. She had no symptoms whatever.

These curvatures, of course, may preclude or obviate the expectation of appearance of back pain but not all of them do and this person is working as a cashier and doing housework, carrying on her daily activities without trouble.

(Fig. 4) This one is a 17-year-old who has an obvious defect, spina bifida, with a mild meningocele and is paralyzed from the waist down with a lateral curve. But this child has no pain and she is being trained for secretarial work. She is mostly a sedentary individual but she can walk with crutches and again has no pain. The problems here are, first of all, getting her employed with the disability she has plus the fact that certain job requirements, even in a sitting position, may run into problems of sores, pressure sores, decubiti and so forth in the lower extremities and the buttocks.

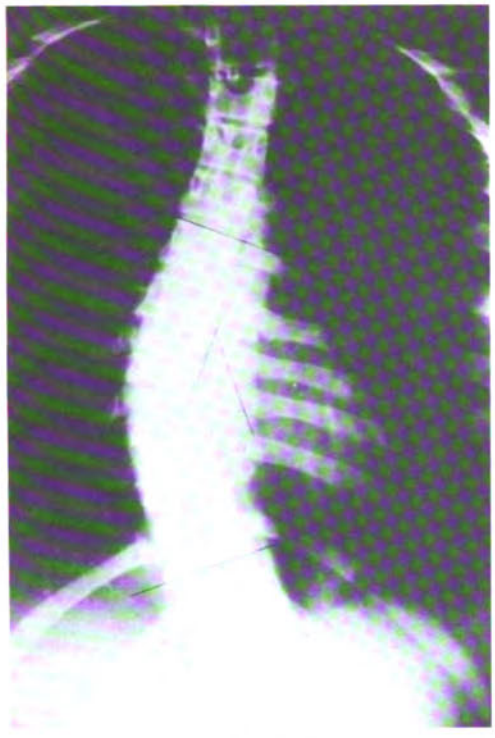

FIGURE 1

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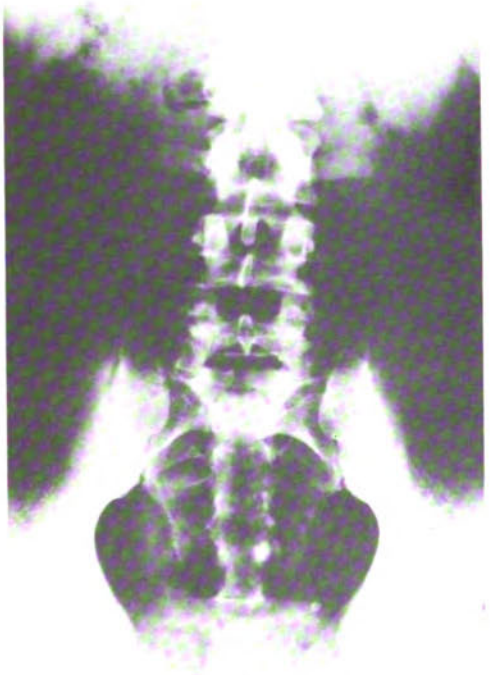

FIGURE 5

FIGURE 6

So even though she may well be trained for doing a job that she can do very well with her hands in a sedentary position, the employer must consider the potentials of problems that would come.

(Fig. 5) This is an occult defect with no symptoms whatever, absolutely no symptoms. It is a normal back. It was picked up in an urologic x-ray.

(Fig. 6) This one is a lateral view of the same person with a normal x-ray of the back.

(Fig. 7) This one, asymmetric facets, a lumbosacral joint and not much else. It is a perfectly normal back but this is the basis in some of the mining companies for refusing employment to an individual with an absolutely normal history and no back complaints. Normal findings and this is the basis for a rejection.

(Fig. 8) This shows a little settling of these same facets with sclerosis at the lumbosacral and L-4, L-5 area.

(Fig. 9) This is the same but no findings physically or on x-ray that would justify, in my mind, refusing employment to this patient.

(Fig. 10) This is another L-5 spina bifida occulta with asymmetry of

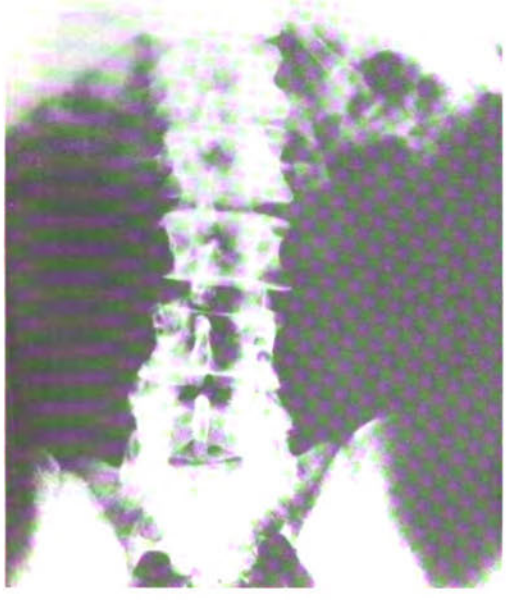

FIGURE 7

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FIGURE 9

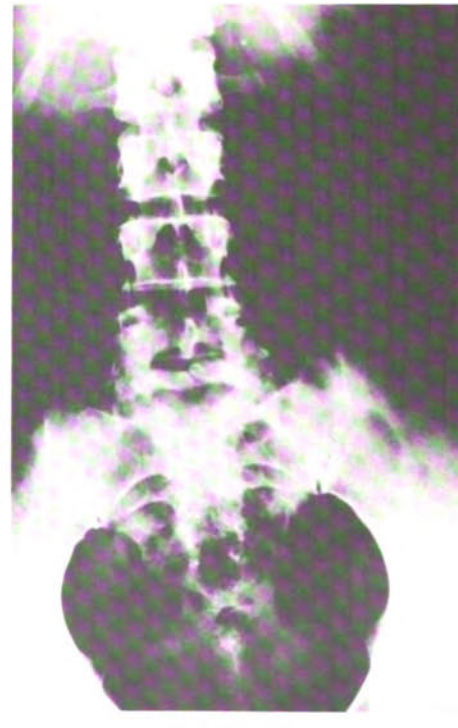

FIGURE 10

FIGURE 11

FIGURE 12

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FIGURE 15

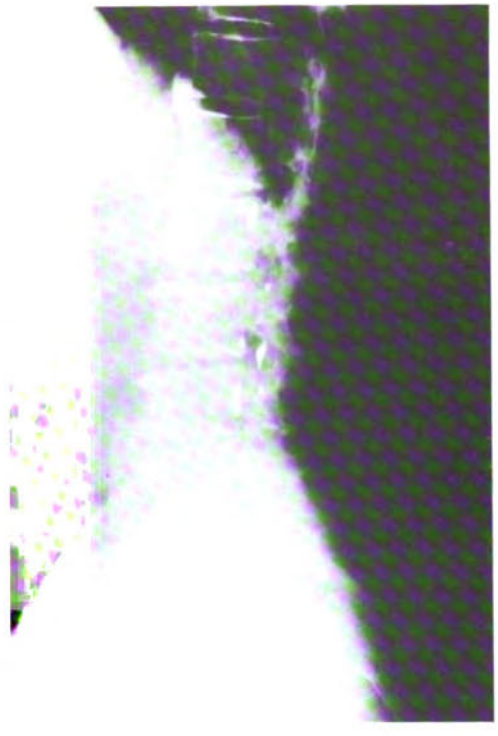


FIGURE 16

facets. The rest of the back is normal. This boy was refused employment and had trouble finding a job for two or three years because of the refusal that one time.

(Fig. 11) This is degenerative arthritis, very mild in degree, with no symptoms whatever.

(Fig. 12) This is the AP of the same individual and it may be a basis for refusing employment. This person was 28 years old.

(Fig. 13) Moderate degenerative arthritis with no symptoms whatever and no signs is shown here.

(Fig. 14) Here again is degenerative arthritis. This may be a basis for refusing employment to an individual in heavy labor and such as that, but without symptoms, without signs, without back complaints, it is probably not a basis for rejecting completely.

(Fig. 15) This man had a lumbar myelogram and considerable work-up. He has degenerative arthritis.

(Fig. 16) And here again, degenerative arthritis, but he was examined for a weak leg. His back does not look remarkable but he had two orthopedic and neurologic examinations. Amyotrophic, lateral sclerosis, but

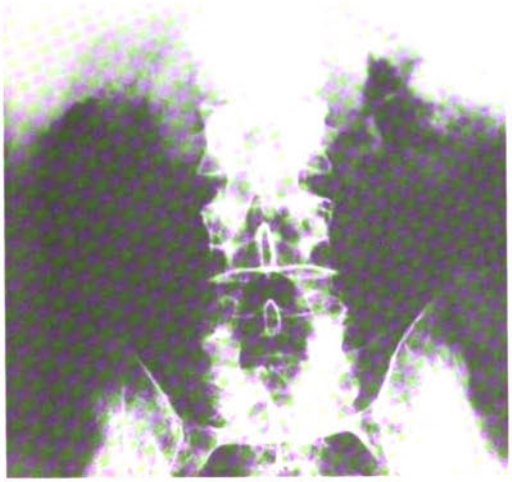


FIGURE 17

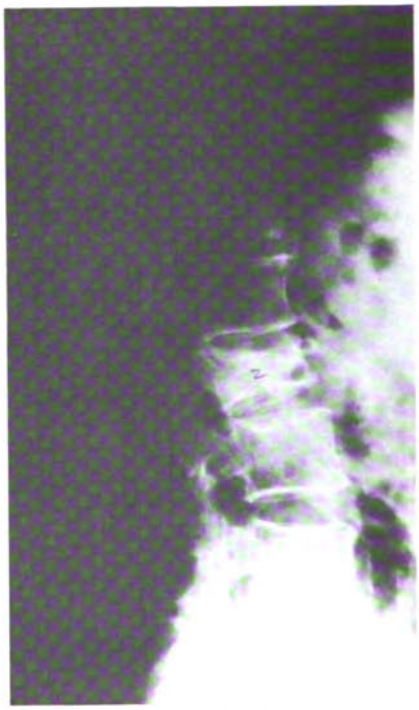


FIGURE 18

he was worked up for a disc and although without pain, there was a suggestion that he have surgery. When completed, the work-up revealed amyotrophic lateral sclerosis and his problem was not even related to his back. He did not have back pain.

(Fig. 17) Fractures. Here is a localized fracture of L-2 that has healed in a university professor who is digging in his yard, playing tennis, working regularly without problems.

(Fig. 18) This is a lateral view.

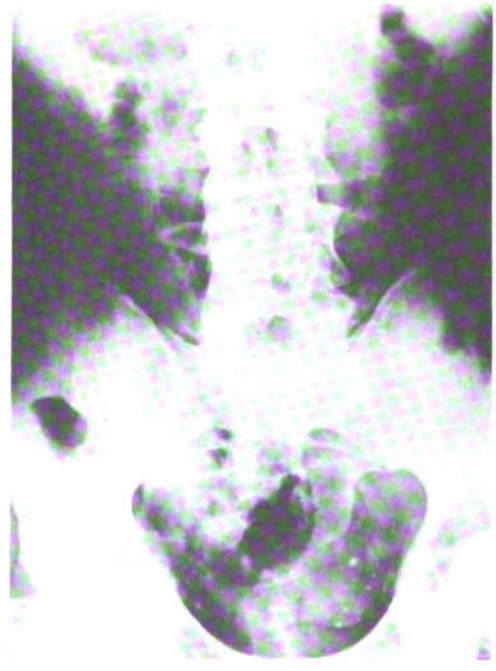
(Fig. 19) This is an individual who had a lesser fracture of L-2 and is totally and permanently disabled. As far as he is concerned, he will not and cannot find a job now. He will not look for a job aggressively and he has a better appearing back than the other one.

Motivation has as much to do with the working of these individuals and the appearance of back problems as do injuries.

(Fig. 20) This man was seen for back pain in his midback but he came in with x-rays of the lumbar spine. These show minimal degenerative changes but not much.

(Figs. 21, 22) There is a little thinning of the disc.

FIGURE 19



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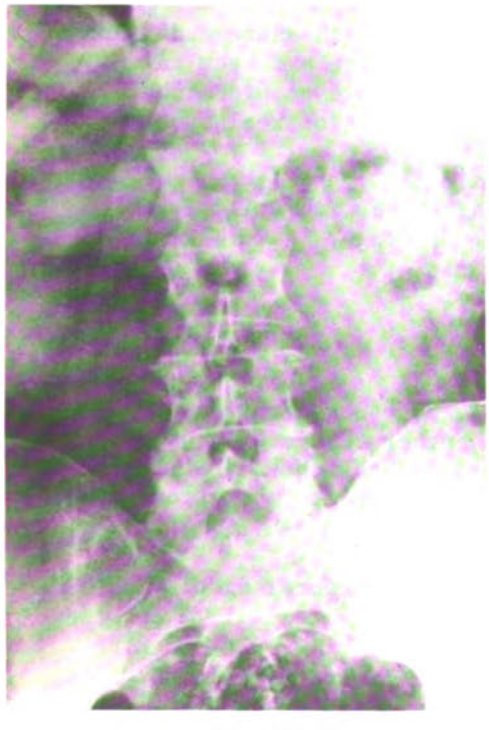

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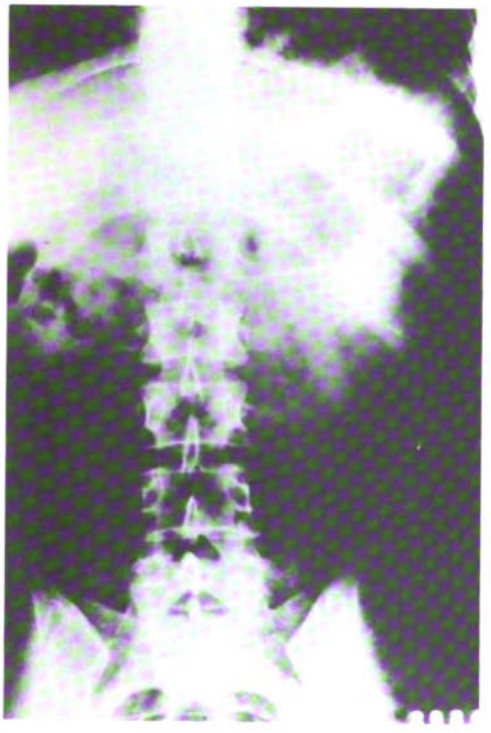


FIGURE 23

FIGURE 24

(Fig. 23) And here is the patient's thoracic spine with extreme degenerative arthritis, whereas, again if the lumbosacral spine had been taken, this could have been missed. He had symptoms referable to his midback, none to the low back and this could have been a source of real problem in certain types of employment.

(Fig. 24) This shows an individual who had backache with a little thinning of the lumbosacral disk but no other findings.

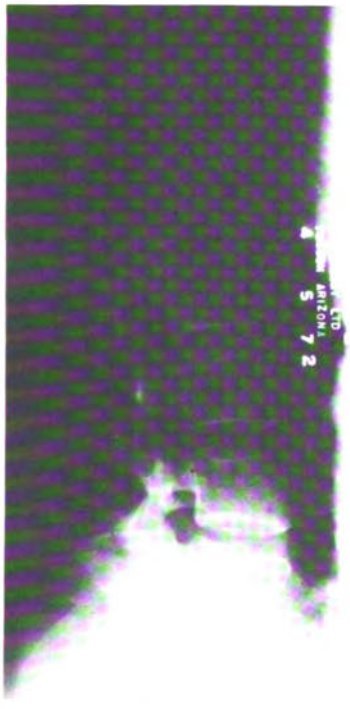
(Fig. 25) This shows the AP view of it.

(Fig. 26) This one is an AP.

(Fig. 27) This is a lateral with considerably more degeneration of the lumbosacral disc without neurologic findings, other than static or postural findings. Bending and stooping caused some backache and it responded to conservative treatments. She has continued to work frequently without loss of time with a narrow disc.

(Fig. 29) This patient has an extremely narrow lumbosacral disc. She had sciatica. Her disc was at L4-5, not at S-1.

This was explored at the time and was perfectly flat and normal, no pressure whatever, but the disc was at L4-5. It points up sometimes the



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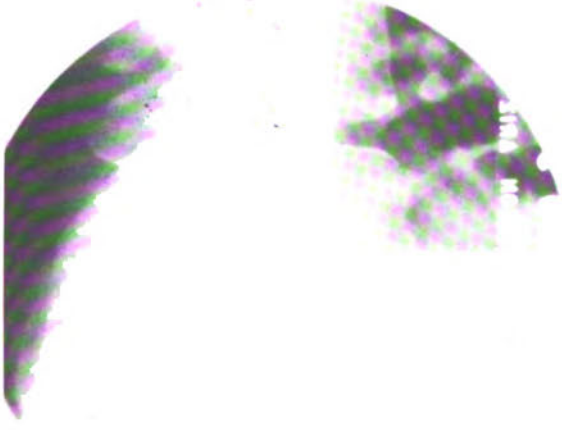

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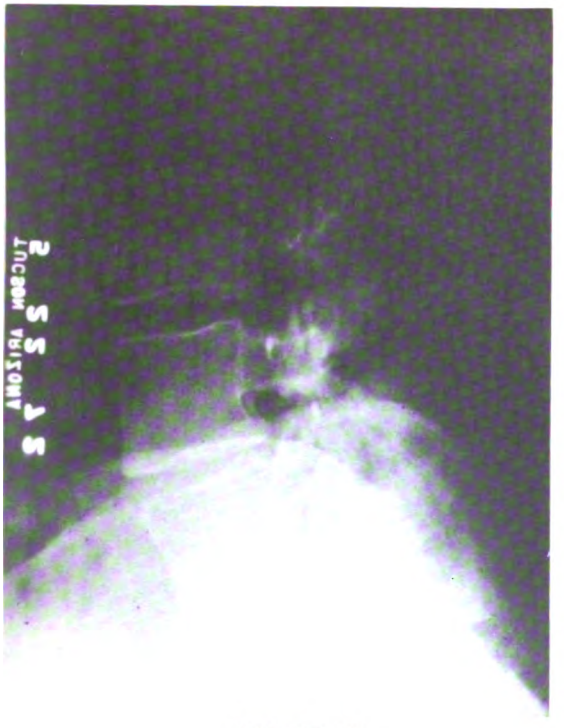
FIGURE 28



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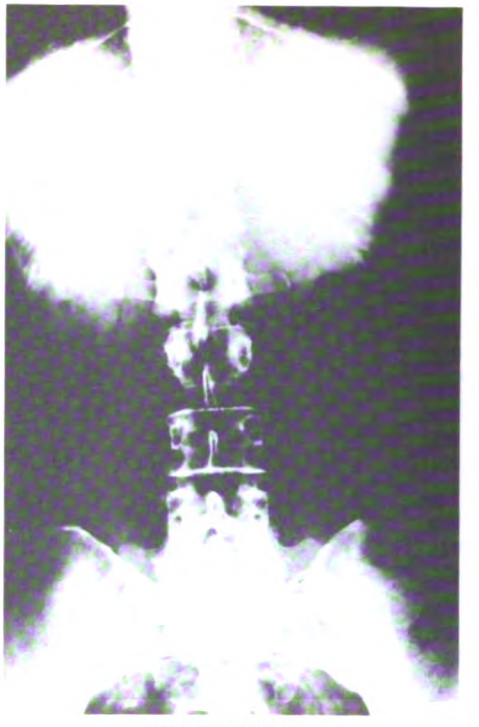

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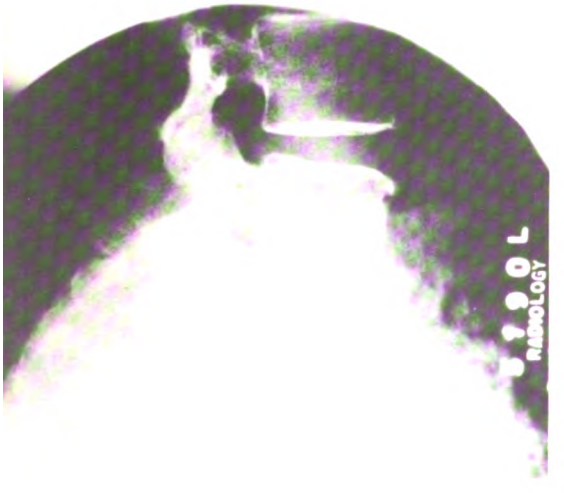

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FIGURE 32

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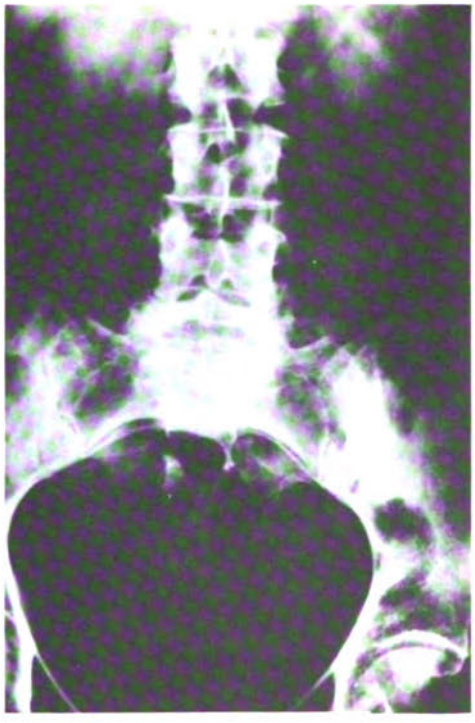


FIGURE 34

fallacy of reading into x-rays significance of narrowing of the lumbosacral disc.

(Fig. 30) This shows thinning of the disc.

(Fig. 31) This shows lumbar vertebrae but no other findings at the point of instability. One of the others showed four lumbar vertebrae.

(Fig. 32) This is an AP view of a spine on a patient who had considerable pain and discomfort, who was injured at work lifting a 15 or 20-pound box of papers. She has narrowing and a tendency to settling of the articular facets in the low lumbar spine.

(Fig. 33) Here is a pseudospondylolisthesis or the settling of spondylolysis. Hers responded to conservative treatment without neurologic signs.

(Fig. 34) Here is a patient who has a pedicle defect.

(Fig. 35) This is obviously a beginning spondylolisthesis with L5-51 defect, who had fallen. His tail bone was sore. He was 35 years old and had never had symptoms referable to his back but this is the way it looked at the time. He had worked as a carpenter and builder for ten or 15 years at the time he was first seen.

FIGURE 35

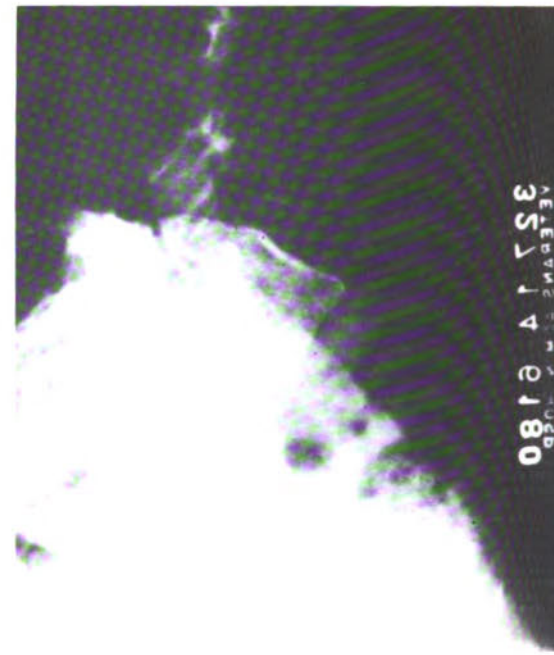


FIGURE 36

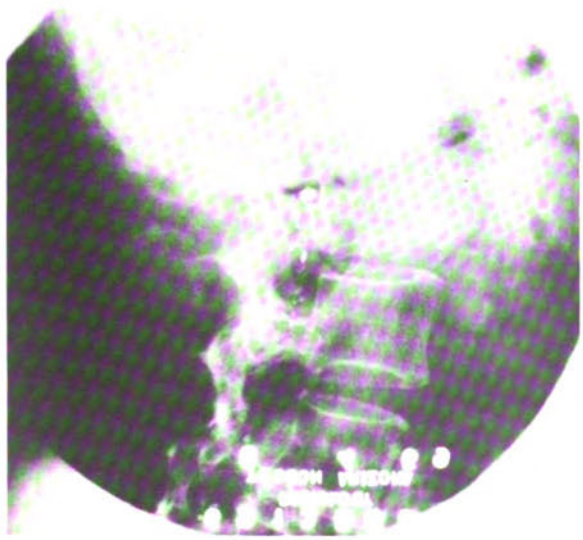


FIGURE 37

FIGURE 38

(Fig. 36,37,38) This lady was 45 years old and had worked as a waitress for some 20 years doing heavy work on her feet day-in and day-out in a busy bar. She had an altercation with one of the bar flies and was knocked down. For the first time she developed symptoms, both sciatic nerve, radiation of pain, and a severe spondylolisthesis, but for 25 years she had worked regularly on her feel all day long doing housework and so on, as well as working, and no symptoms, and then the precipitating factor was being knocked down, straining her back. She has been fused since this was taken and now is back at work two years later and is still going ahead working the same way.

Insofar as the value of x-rays, pre-employment exam and orthopedic examination are concerned, they are certainly of value in establishing confirmed disability. They are of value in anticipating incipient disability if the situation is right, if they have signs as well as symptoms. But the unknown surprised disability cannot be anticipated and injuries and unknown factors cannot be anticipated. I believe that there is a reasonable case for x-rays but not without orthopedic examination, in my own experience, to be fair both to the employer and the employee.

CHAIRMAN PRESENT: The next speaker comes from New York and will speak on the "Neurosurgical Viewpoint." Dr. Joseph Epstein.

A NEUROSURGICAL VIEWPOINT

Joseph Epstein, M.D.

DOCTOR EPSTEIN: On Long Island we have very few occasions to manage patients with industrial accidents related to heavy labor. Our practice is confined to the modest worker in this capacity. More than 50 percent of the patients include accountants who sit a great deal, stockbrokers, obstetricians, ophthalmologists and similar professionals who are constantly sitting bent forward to do most of their work. Similarly, secretaries and other persons fit into this pattern. There have been physiological studies made of the tension and pressures within the intervertebral disc. It is far higher in the seated position, especially when the person is bending forward, than it is when erect or reclining.

This, I think, plays an important role in the origin of disc disease unrelated to trauma or related possibly to minor trauma such as the simple act of getting up out of a chair or of lifting a piece of paper from the floor.

I have had little experience in evaluating pre-employment factors which form the basis of this discussion. Perhaps the knowledge gained by analyzing clinical experiences in the management of back derangement from the beginning to the end would be helpful in establishing a program that may have value. It is rare that we operate on anyone in litigation or in compensation without a positive myelogram to confirm the diagnosis. The diagnosis must be based initially on clinical values but confirmed by objective studies. This unfortunately may exclude patients with herniated discs and negative myelograms.

The surgical treatment of nerve root compression syndromes produces good results in 80 to 90 percent of confirmed cases, the target primarily being the relief of radicular pain. The back pain is managed more easily after disc excision than prior to surgery for neural entrapment.

There is a high salvage rate of 80 to 90 percent in patients with a herniated disc and a monoradicular entrapment syndrome. The other patterns relative to spondylosis, to narrowing of the spinal canal, to the superior facet syndromes and to arthrosis of the posterior articulations differ in that the salvage rate is never as high as it is in first category. However, there remains a significant salvage rate of from 60 to 70 percent in these patients.

In the presence of a transitional vertebra, one costotransverse process may articulate with the sacrum on only one side. In such cases, the apophyseal joint on the opposite side absorbs the major stress resulting in the development of severe arthrosis. Degenerative arthritis of these joints may cause neural entrapment in the lateral recess and foramen caused by osteophytic overgrowth. The foramen, which is normally funnel-shaped, becomes stenotic on the side opposite to and above the fixation

of the costotransverse process. The hypertrophic spurring is a result of the torsion and stress which is poorly tolerated.

Little evidence of spondylosis is noted in these spines, spurring being absent or minimal on the vertebral borders. (Fig. 1)

Most of the pathology is dorsal and more attention is now being diverted to neural compression caused by overgrowth of the posterior articulations and by the thickened lamina. Spondyloarthrosis involves a reorganization of the entire weight-bearing structure with remodeling of the vertebral segment.

The majority of these patients do now show restriction of straight-leg raising. Neurological changes may be minimal. There are well-defined radicular pain patterns with weakness and atrophy that can be conspicuous.

Electromyography has been helpful and in conjunction with radiographic findings and clinical evaluation, a correct decision to proceed with decompression can be reached. These patients are salvageable and radicular pain can be relieved.

In degenerative disc disease, the center of vertebral motion moves posteriorly, throwing more stress on the posterior articulations. The response is degenerative arthrosis with spurs projecting downward into the foraminal areas. Again, signs of root compression by dorsal intrusion of spurs may occur. (Fig. 2)

Myelography in some of these patients may show dorso-lateral defects caused by the tremendous enlargement of the apophyseal joints above the interspace level. A positive myelographic impression of this specific character aids in arriving at a decision to operate even though the neurological picture may be obscure at best. (Fig. 3)

In reverse spondylolisthesis, a late result of degenerative disc disease, an additional strain is directed to the posterior articulations. The resultant overgrowth and spur formation narrows the foramen dorsally as in the previous cases.

The defect in the myelogram caused by posterior facet changes is always higher than the intervertebral disc space. The surgical procedures may include complete facetectomy or simply cutting a tract through the dorsal boundary of the foramen over the course of the irritated nerve root. The nerve root shows signs of acute and chronic irritation. Complete decompression is mandatory, well out through the foramen of exit. The L4-5 vertebral level is involved with great frequency. (Fig. 3)

In these patients, there is no herniation of the intervertebral disc. The spurs in the floor of the canal are small and of no clinical significance. (Fig. 2) The major factor providing relief is the operation that removes pressure on the nerve root caused by overgrowth of the posterior articulations, particularly the superior facets.

In the superior facet syndrome, the inferior half of the facet lies horizontal and overhangs the lateral recess and canal at the foramen. Neural

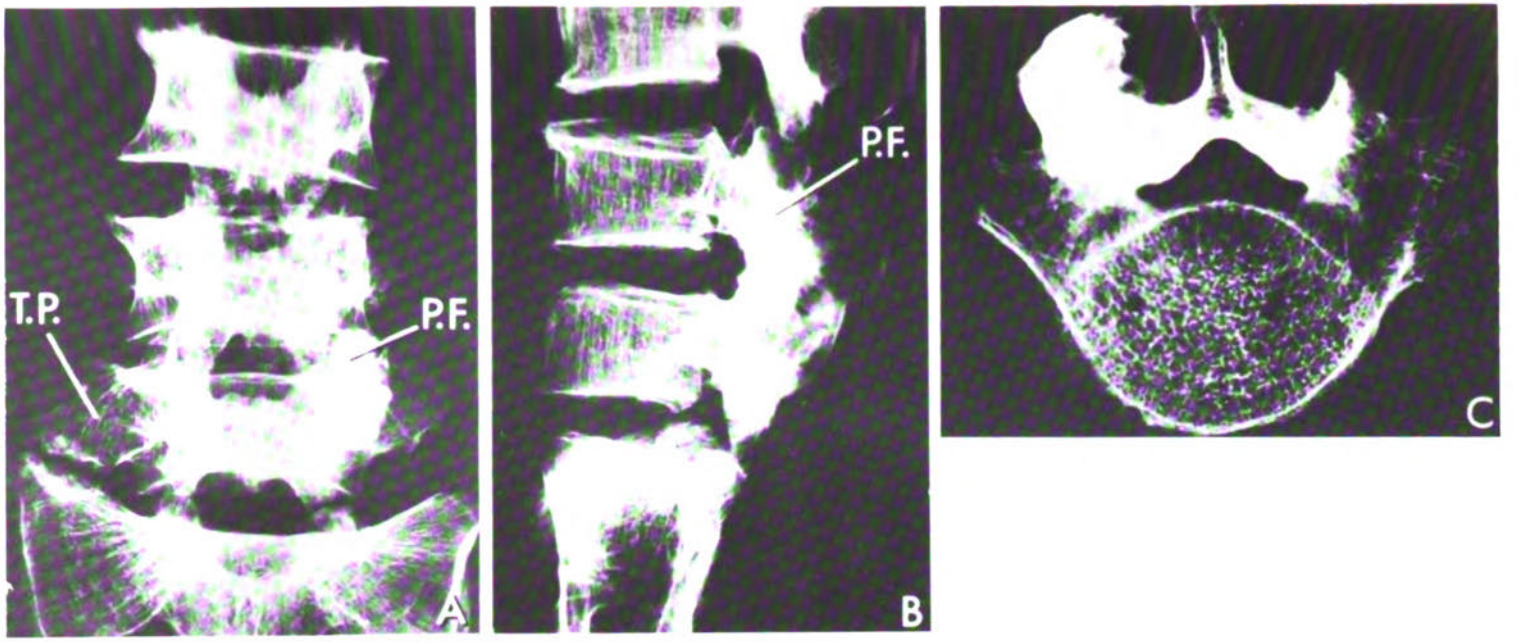


FIGURE 1. X-rays of a dried specimen of a lumbosacral spine with a sacralized L-5 vertebra, the costotransverse process on the left articulating with the sacrum (T.P.). The degenerative arthritis (arthrosis) of the posterior facets on the opposite side and one space higher in quite evident. The foramen in the lateral view B is constricted, the apophyseal joints dense and unusually prominent (P.F.). The alterations in the superior facet of L5 and the narrowing of the lateral recess and foramen are illustrated in the x-ray of the superior aspect of the fifth lumbar vertebra (C).

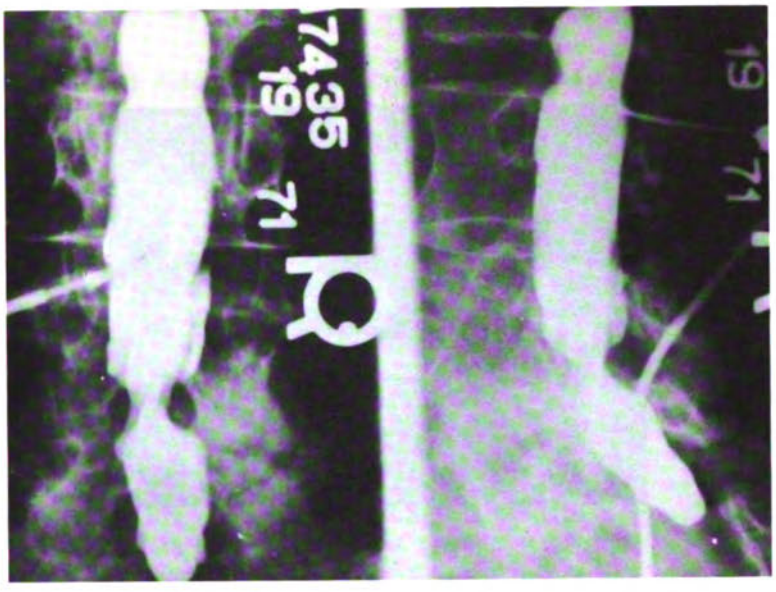
FIGURE 2. Spondyloarthrosis involving the sacrum with thickening of the lamina, osteophytosis of the enlarged hypertrophic facets and narrowing of the lateral recesses and foramens bilaterally. The black arrows point to the marginal osteophytes, the white to the foramen; there being minimal vertebral osteophytosis along the posterior margins.

entrapment can occur very easily beneath this portion of the facet. Minor disc intrusion plus developmental changes, such as thickening of tissues with spur formation and arthrotic alterations, can cause neural entrapment. While the ventradorsal diameter of the canal is normal, the lateral recess in the trifoliate canal may be seriously compromised. (Fig. 4)

These overhanging facets may be identified by means of axial tomographic studies of the spine made in a coronal plane. They are rarely identified on plane films and the myelogram is usually negative. The occasional relief of neural compression that follows a negative exploration for a herniated disc may relate to the large decompression during the search for pathology that requires removal of the medial portions of these facets with relief of neural entrapment in these areas. The procedure of choice surgically is a decompression of the lateral recess that requires partial removal of the inferior and medial border of the superior articular facet and foramenotomy.

The spinal canal of the achondroplastic dwarf is extremely narrow with large posterior facets leaving little reserve space in the canal and foramens for the cauda equina. A herniated disc occurring in an achondroplastic dwarf is a catastrophe. These people become paraplegic, or nearly so, and require emergency surgery with complete decompressive laminectomy covering multiple segments for relief.

Similar, but less severe narrowing may be seen in a great variety of so-called normal spinal columns. Not enough emphasis is being placed on



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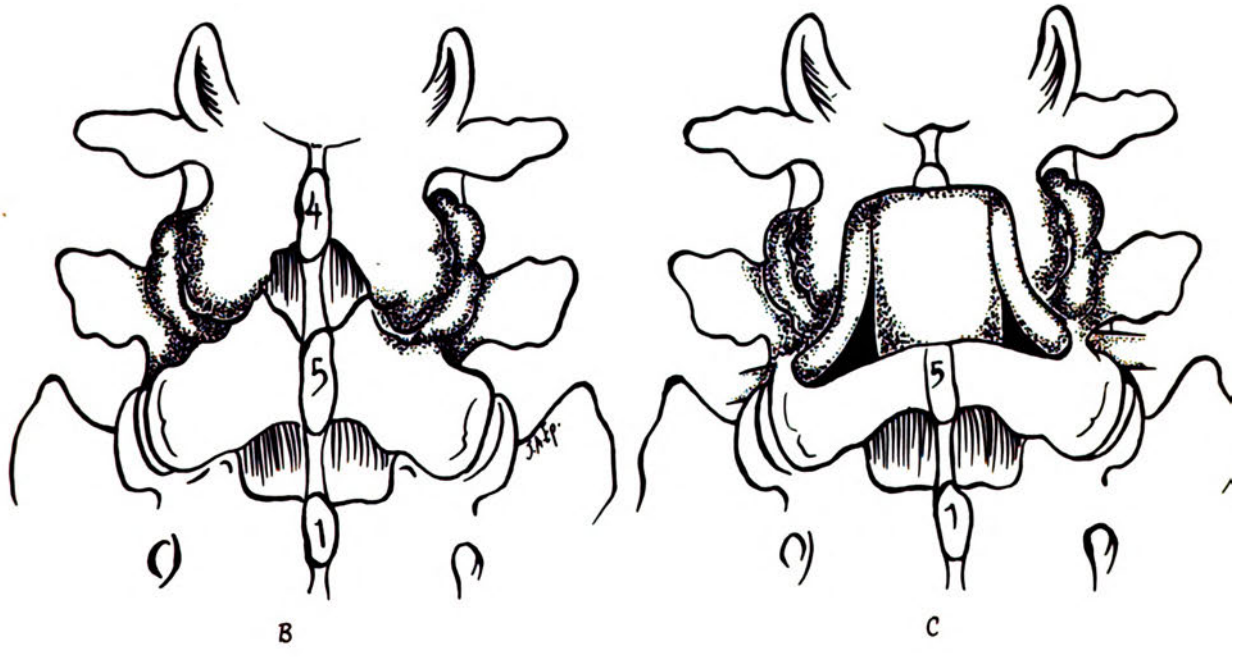

B C

FIGURE 3. Myelogram in a patient with arthrosis of the posterior facets and dorsal intrusions into the spinal canal and foramens bilaterally. The defects are immediately above the interspace at the level of the articular facets seen in the anteroposterior projection and dorsally in the oblique semi-lateral. The drawings B and C illustrate the arthrotic changes and the extent of laminar and foramenal decompression required to release the entrapped nerve root.

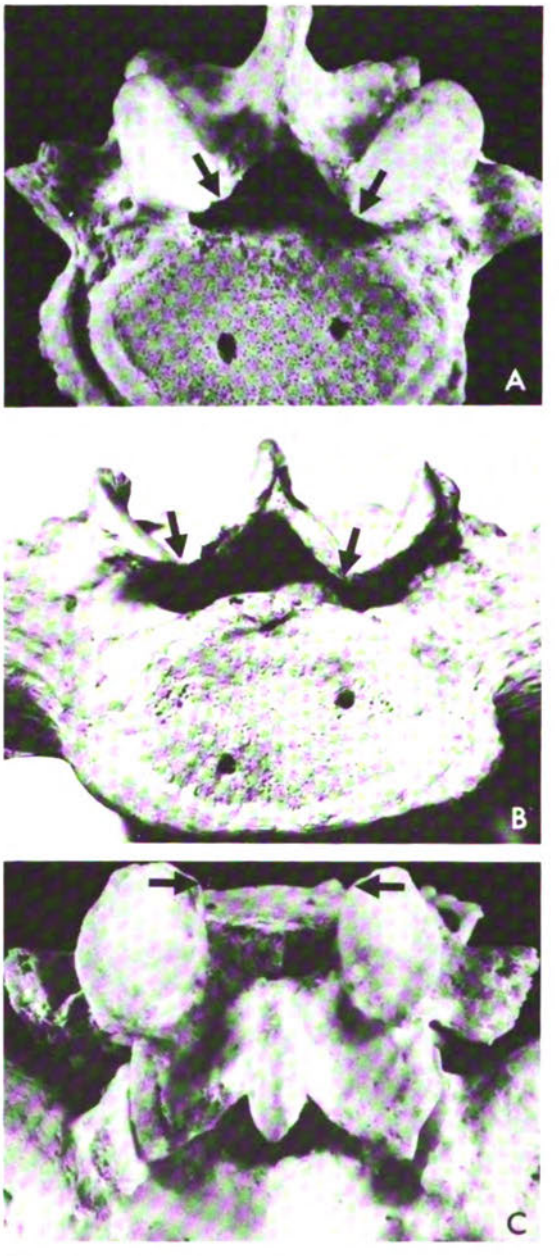

FIGURE 4. In the superior facet syndrome, the medial portions of the superior articular facets overhang the lateral recesses and entry zones of the foramens. This is more evident at the level of the sacrum B than at the fifth lumbar vertebra in A (black arrows). In C., the cranial extension of the superior portion of the superior facet overlies the intervertebral disc laterally where neural entrapment occurs. Since incarceration occurs laterally well beyond the confines of the dural envelope, the myelogram is usually negative.

these congenital and developmental factors. This is important in that the patient with a narrow canal is more vulnerable to discal herniation or to the effects of discal degeneration with osteophytosis primarily because of the absence of reserve space for the contained roots of the cauda equina. (Fig. 5) It is for this reason that it is difficult to do a myelogram in such patients. This may be the first clue indicating the presence of a narrow canal. With the injection of only 3 cc. of oil, the contrast medium may be distributed over multiple levels with a variety of defects often startling to the examiner. The ventrodorsal diameter of the canal narrows to produce a partial or complete block with segmentation often involving three or four segments. The L3-4 and L4-5 regions are usually the most seriously compromised.

The facets are enlarged and vertically oriented in patients with this pattern of stenosis. The lamina are thickened and overlap each other. It is almost impossible to get into the interlaminar space without removing large amounts of bone including portions of the facets which may be large enough to touch the spinous processes.

These are the patients who, if they are operated on without an awareness of stenosis, end up with foot drop or paraplegia, bladder and bowel dysfunction. The insertion of a rongeur or any other solid instrument into a canal that is stenotic and with nerve roots completely compromised can be catastrophic.

The patients may present a clinical picture suggesting intermittent claudication. Pain, weakness and numbness are noted as they walk. They have to stop and lie down or sit down for relief. No abnormalities of circulation are found. Similarly, a spinal cord tumor may be suspected because of bilateral complaints.

There are few neurological changes. Restriction of straight-leg raising may not be present, although it is the hallmark of disc herniation. This may relate to the greater involvement of levels above L4-5.

Surgical relief by laminectomy and foramenotomy will provide a 60 to 70 percent salvage rate.

In patients with spondylosis, similar changes occur because the canal is narrowed multisegmentally at the levels of intervertebral spurring. A washboard effect is seen in the myelogram with a bilateral type of defect commonly observed even though the patient may have an unilateral sciatic syndrome. The spondylotic spine often co-exists with the stenotic spine and with other anomalies such as tropism and changes in the superior facets.

In patients with scoliosis and spondyloarthrosis, symptoms relative to this abnormality of a disabling nature usually are noted at an advanced stage.

Severe neural compression occurs in the concavity of the curve where the nerve roots exit through foramens constricted by the spondylotic and the arthrotic changes in the vertebral bodies and facets. These patients can be helped by adequate surgical decompression.

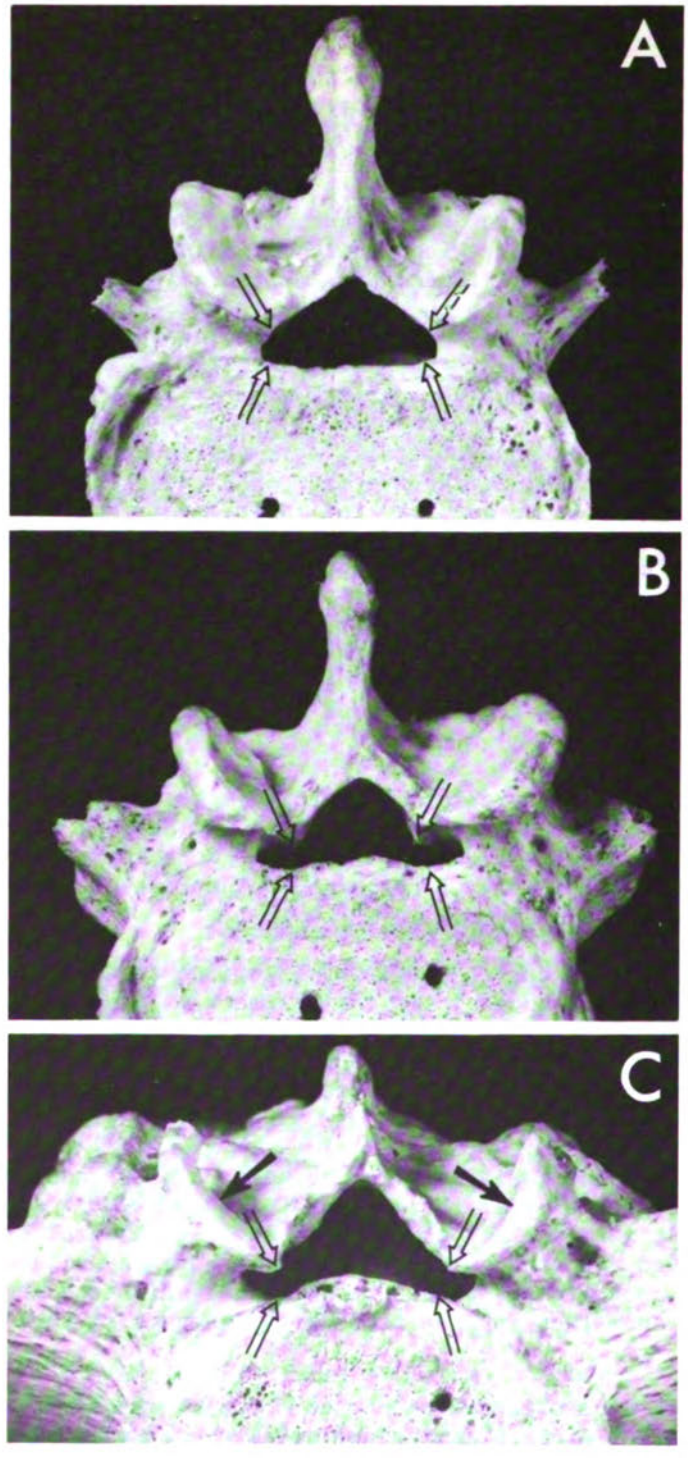

FIGURE 5. Stenosis of the spinal canal is evident in the fourth (A), fifth lumbar vertebra (B) and the superior aspect of the sacrum (C). The triangular canal is seen in A, the trifoliate in B and C (open arrows). The ventrodorsal diameter is narrowed, the transverse normal. Tropism is evident in the inclination of the facets of the sacrum (C) (black arrows). Developmental alterations are minimal.

An awareness of such abnormalities before placing a patient under stress may be significant in job placement both before and after symptoms occur.

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CHAIRMAN PRESENT: The next speaker is Dr. Robert Moreton from M.D. Anderson in Houston.

A RADIOLOGIST'S VIEWPOINT

Robert D. Moreton, M.D.

DOCTOR MORETON: My initial interest in the human back stems from service as a consultant radiologist for one of the large railroad systems. Later, I was a consultant for two other railroads, a helicopter company, and a division of a well-known telephone system. Only the railroad system furnished continuing information regarding injury and loss of man-hours.

It is well documented that low back pain has caused more lost man-hours in the industry than any other single condition. Judge Adlow stated that when he began serving on the bench some 45 years ago, accident litigation had attained overwhelming proportions. He stated that in a great many cases the court is called on to determine the extent of injury merely on the basis of subjective symptoms described by the plaintiff. Most frequent are those ailments about which scientific knowledge is none too certain in respect to both diagnosis and prognosis. Federal and state compensation laws are not in harmony. A man injured while employed by a local trucking company may recover $15,000, while a man who sustains a similar injury in a nearby freight yard may recover $140,000. Many of the operating problems of the present-day railroad stem from the frequency of minor injuries, increased time loss and increased disability compensation payments.

These increases were emphasized by Becker (5), who reported that from 1940 to 1950, Ohio had an increase in employment of 31 percent and during the same time, back injuries increased by 132 percent. For a similar time period, there was a seven percent increase in the industrial force of the state of New York and a 43 percent increase in the number of back injuries. He also cites figures from Minnesota which had a 57 percent increase in its industrial force and an 80 percent increase in back injuries during the same period. The seriousness of the low back injury problem was emphasized by a 12-month experience in Pennsylvania, with over 6900 back injuries reported and nearly $1,500,000 in related compensation payments. During this same ten-year period, back injuries were costing the American railroads over $100,000,000 a year (9) and the costs are increasing.

Because the greatest number of man-hours lost from work caused by back complaints occurred in a relatively small segment of railway employees, a program of preplacement x-ray investigation of the lumbosacral spine was undertaken by the railroad system for which I consulted. Similar programs by other railroads and industries dated back many years (5-10). The job applicants were applying for long-term employment. The work was not considered heavy but was rather hazardous.

Due to the wide geographic distribution of the program, a protocol was established for uniform patient positioning and radiological technique. This protocol was furnished as a guide to the radiological consultants to

obtain roentgenograms of uniform quality and to offer maximal protection from radiation to the prospective employee. Four views were made consisting of 14" x 17" anteroposterior and lateral films, as well as both oblique views of the lumbosacral area on 10" x 12" film. (32) The radiologist's responsibility was to interpret the radiographs correctly and place the condition of the spine into one of five classifications furnished in the protocol. (19-32)

The radiographic classification was only one of the determining factors used to reach a decision on the employability of the applicant, since no applicant was to be referred for x-rays unless he had previously given a medical history and passed a physical examination. All applicants referred for x-ray examination denied having had any back trouble.

After a careful review of the literature and in order to better appraise our problem, we studied the court records of approximately 150 relatively young men who had been employed in similar positions within the railroad system. These men had sustained minor injuries during their period of employment, had later separated themselves from service and entered claims suits for permanent disability. An analysis of all available records disclosed that 85 percent of the back conditions of these men had been present prior to the minor injury.

Zietlin has pointed out that there are at least eight congenital anomalies and variations of the human spinal column or supporting structures which are occasionally misdiagnosed as being due to trauma or fracture. These are rudimentary rib structures of the transverse process of the first lumbar vertebra, non-fusion (bone ossicle) at the end of a facet process that simulates fracture, non-fusion of the epiphyseal corners of a lumbar vertebra, occult spina bifida, the relatively flat fifth lumbar disc, butterfly-wing formation, interarticular defects simulating fractures, and spondylolisthesis. These congenital conditions have been well described and emphasized by Bailey (3) and Simril (28), as well as by many others. The importance of having pre-employment films of any of the first six of these defects cannot be over emphasized in case of subsequent injury to the employee. (27) There is medical disagreement as to the etiology of the latter two congenital anomalies. The etiology of interarticular defects in considered by some anatomical experts to be congenital (4) and by other experts to be of traumatic (21-30) or acquired origin. This condition, associated with spondylolisthesis, is a real medico-legal hazard. Flaxman reports that permanent disability occurs in one out of three patients with spondylolisthesis aggravated by trauma with or without surgery.

In studying the films of some 90 men, less than 40 years of age, who complained of low back pain following minor trauma but presented no compensation problem, we found that a great many of the films were interpreted as being essentially normal. The abnormalities found were all believed to be pre-existing conditions. These findings were similar to those of individuals who had entered disability claims in court. In contrast is the study made my Freedman, Fischer, and Van Demark of 100 soldiers with an average age of 26.6 years and with no history of backache or back injury. Most of the soldiers had been subjected to strenuous military training; some had been in combat. Using radiographic views similar to

those of railway employees, it was found that only 20 of the 100 soldiers showed no variation in the lumbar spine. In the remaining 80 men a total of 121 spinal variations was found. Similar findings have been reported by many physicians carrying out pre-employment x-ray examinations of the lumbosacral spine. (8-16-17-26)

We also studied x-ray films of the spines of 78 men with an average age of 40-plus years who complained of low back pain following minor injury. In this group we saw evidence of hypertrophic changes, narrowed vertebral interspace, slight scoliosis and minor congenital anomalies. There were no findings in these groups that would not be expected in the normal population. Splithoff studied radiographs of the lumbosacral spine of 100 persons with back pain and 100 persons without back pain who were 40 years of age or older. The incidence of abnormalities found in individuals without pain was essentially the same as that found in individuals in the same age group who experienced back pain.

Our own studies have been concerned with the objectives (32), radiological considerations (19) and value (20) of preplacement examinations of the lumbosacral spine. Our experience indicated that with very few exceptions, those employees who were not involved in major accidents lost minimal job time and presented no compensation problems. There was increased time loss by those in higher job classifications but no major compensation problems were encountered.

The following results were reported after an eight-year survey of our railroad program was made. Of 1256 men who had filed a report of back injury, 169 (13 percent) had received preplacement roentgen examination of the spine. Of this group, 22 percent were in Class I, 27 percent in Class II, 28 percent in Class III, 14 percent in Class IV, and 9 percent in Class V, as defined in previous papers. (20-32)

The 37 men in Class I averaged 28 years of age. Their average length of service in the railroad system was 41 months. Thirty-four of them had minor injuries (strain or sprain) and 25 of them lost less than five working days each, two lost ten days, four lost 20 working days and two lost 90 working days. One was awarded a $5000 settlement and all others settled for wages for the time lost. Three of the men were in major accidents and sustained injuries which were not referable to the lumbar spine.

The 46 men in Class II had an average of 27 years and had been in service an average of 49 months. Forty-one received minor injuries and 33 of them lost less than five working days each. Compensation for 40 of these men was not in excess of wages for time lost, except for one employee who alleged to have suffered a ruptured nucleus pulposus and caused a major area of disagreement in the medico-legal field. Five of the men in Class II sustained major injuries with greater loss of time per man and received wage-level compensation.

Forty-seven men, with an average age of 28 years and an average of 45 months of service, were in Class III. Forty-two claimed injuries which were considered to be minor. Twenty-seven men lost less than five working days each; eight others lost less than 20 days each, three lost less

than 30 days each and two less than 60 days each. All of these employees except one were paid their regular wages and manifested no malcontent. One filed a claim after he had been rejected from service following investigation of former employment. The other five received injuries not related to the low back area.

Twenty-three men, with an average age of 28 years and an average of 33 months of employment, were in Class IV. Twenty-one members of this group experienced minor injuries and 14 of them lost less than five working days each. One man in this class lost ten working days, two lost 20 working days, two lost 60 working days and two were dismissed from service. Only one presented a medico-legal problem and settled his suit for $5000. Two men suffered injuries not related to the low back area.

There were 16 men in Class V with an average age of 29 years and an average of 42 months service. None of these sustained a major injury. Twelve of the 16 employees lost five days or less each, while one lost 15 working days. Two each lost two months and one missed three months of work. None posed a medical or financial problem. There were no men in this group who had spondylolysis, spondylolisthesis or sclerosis adjacent to a narrow lumbosacral interspace.

There were many assets to the men and company as well. I believe that one important factor in consideration of job placement of men is that as the classification increased, the level of approval for employment increased. That is, the hiring officer approved men in Classes I and II, the superintendent approved men in Class III, and the general manager approved men in Class IV and V. This, therefore, instigated more pre-employment selection and investigation of the men in higher classifications.

Also of great importance were such findings as spondylolysis, spondylolisthesis, old fractures, residual lipiodal in the spinal canal and evidence of previous surgery. Runge (26) reported that injured employees with radiographic evidence of pre-existing spondylolisthesis and pre-spondylolisthesis represented a 50 percent increase in time loss over the group with negative radiographs. In the groups with disc space abnormalities, loss of time was doubled and in the group with prior surgical defects the lost time was 13 times as great as in the negative group.

Of those we examined, there were few applicants who had an interest in the radiological findings. These individuals were apprised of the findings and advised to seek less hazardous employment. In some instances they were referred to their physicians for advice and proper care. Many of them requested names of companies that did not have pre-employment radiological programs.

Another real asset of the program is the discovery of those individuals who had residual lipiodal in the spinal canal, evidence of spinal surgery or previous fractures and who denied knowledge of such conditions. These individuals either had very short memories or gave deliberately fraudulent information and would be potential liabilities, since once employed, management would be fully responsible for any aggravation of a pre-existing condition. The program also served as a check on the

thoroughness of the physical examination. Many times surgical scars were discovered on the backs of some men. These men should not have been referred for roentgen examination of the spine, as they should not have been considered candidates for job placement.

Centralization of all radiographs and careful cross-filing for quick reference revealed another small but important group of applicants who were eliminated. These were applicants who had been refused employment for a certain type of job and had applied at another division. These individuals had persuaded friends, who had passed the x-ray examination, to be radiographed for them. This is true fraud. We had anticipated some need for identification and required each applicant to sign the request for roentgen examination of the spine in the presence of the hiring officer and again in the radiologists' office, just as is done with traveler's checks. Bohart used a more direct method more than 45 years ago. He reports that if the applicant passed the physical examination, a serial number in indelible ink was placed in the scapular region and he was sent to the hospital for radiological examination. The number on the scapular region had to correspond to the number on the slip sent to the radiologist.

Another advantage of centralized control of radiographs was found when employees transferred to other divisions or returned to work after an absence. Returnees could be re-examined physically and have radiographs of the back as deemed necessary. Most indicated no injury or difficulty during absences. Several, however, were found to have pathology not present on the pre-employment radiographs. These findings were most valuable in cases of minor injury. Previously normal radiographs used for comparison revealed conditions which might lead to subsequent liability. In addition, correct treatment could be instigated before more serious damage could occur.

Last but not least is the importance of the discovery of asymptomatic pathological conditions of the applicant. In all instances where such pathology was found, the medical director was contacted by telephone and advised of the suspected problem. He, in turn, notified the hiring officer to have the applicant see his doctor. The private doctor was advised of the findings, furnished the radiographs if requested and given any other desired assistance on behalf of the applicant. I feel sure some individuals were saved future suffering and possible loss of life.

There is general agreement that pre-employment x-rays of the back are important to industry, both as a safety measure and as a means of reducing lost man-hours. Determination of the extent of injury is most important in treatment and for proper adjudication.

Redfield believed that the lumbosacral x-ray taken at the time of employment did not predict or screen out injury-prone applicants and was not worthwhile for short-term employees. As a long-term predictor, he believed it might be of more value.

Rose found lumbosacral radiographs of value in the proper evaluation of athletes for college competition. He believed that any candidate showing significant alteration of the lumbar region should be referred for spine

x-rays. He stated that for over ten years good results had been achieved with this philosophy.

Diviley (12) believes that a complete back examination should have wider use than as a means of evaluating the prospective employee. He believes each adolescent should have a careful back examination, including x-rays, to determine any serious congenital architectural defects of the spine. If such defects are found, the individual can be advised to prepare for a profession or trade utilizing brains rather than muscles. He found that most adolescents examined were not aware of any weakness.

Several things should be considered in the overview. First, it is the desire of industry to conduct safe operations without undue loss of man-hours. Therefore, as Winston pointed out, the preplacement examinations, whether physical, psychological, aptitude or radiological, are designed to bring about a more satisfactory utilization of all available manpower and to protect the safety, well-being and earning capacity of not only the employees and employer but of his fellow workers as well.

Flaxman points out that pre-existing pathological conditions of the low back are the most common of all anatomical conditions to be aggravated by trauma. About 90 percent of these are in the lumbosacral area. These defects can be demonstrated and recorded on preplacement radiographs of the low back. Most of the individuals requiring pre-employment lumbosacral radiographs are young. Rowe feels that trauma, as ordinarily defined, is only rarely the precipitating cause of an acute episode--that these attacks of low back pain characteristically begin in individuals between the ages of 25 to 35 years (11), reach a maximum frequency and intensity between the ages of 35 to 50 years, then decrease in number between 50 and 60 years. Episodes of low back pain are infrequent beyond the age of 60 years.

Backache is so common that it receives little attention until some sort of injury occurs which may be severe, minor or insidious. The discovery of a pre-existing lesion following rather than before some type of trauma produces a most difficult problem for both doctor and patient, as it is difficult for the patient to believe the trauma is not the cause of the spinal defect.

Willis notes that orthopedists like to ride hobbies especially in regard to backache and various anomalies of the spine. He states that his own particular interest is the separate neural arch. Willis further states that Badgley had debunked these hobbies. His findings are essentially the same as our own and others which reveal that these pre-existing conditions are present just as frequently in the spines of the controls as they are in those with backache.

Compensation (11-18) and liability patients who complain of low back pain and disability do not respond as satisfactorily to surgical intervention or other treatment as do private patients. Diveley (11) believes that this is probably due to the poor mental attitude they have toward recovery. One should remember that if the tort-feasor employs a person, and if, by reason of some pre-existing condition, the employee is more susceptible to injury, the tort-feasor is not thereby exonerated from lia-

bility. In many instances pre-employment radiographs play a major part in equitable settlement of many of these problems.

Thus, my conclusions are that:

1. Low back pain is one of the oldest and most common of human ailments. It is a leading cause of lost man-hours and compensation payments in industry.

2. Preplacement radiological examination plays an important part in job placement decisions, serving to reduce lost time and disability compensation payments.

3. Even though federal and state laws concerning compensation are not in harmony, the evidence of pre-existing lumbosacral pathology, demonstrated on preplacement radiographs, can be valuable in determining proper treatment management and equitable settlement.

4. The employer is responsible for the health and safety of the employee once the employee is placed on the payroll. Radiological examination of the lumbosacral spine is only one part of the total pre-employment examination that should be conducted for proper placement of an applicant not only to ensure long safe productivity for him but for those with whom he works.

CHAIRMAN PRESENT: Our last speaker is Mr. Harlan Amandus who will speak on "Statistics of Industrial Low Back Injuries."

STATISTICS OF INDUSTRIAL LOW BACK INJURIES

Harlan Amandus, M.S.

MISTER AMANDUS: The following is a statistician's eyeview of whether or not there is sufficient evidence in the literature to accept or reject the following hypothesis: Is it possible to predict future low back injury from a pre-employment x-ray?

I shall approach this in the following manner:

1. What is an ideal statistical design needed to answer the question posed?
2. A brief description of various studies and/or designs employed.
3. An evaluation of the various studies and/or designs in terms of statistical inferences and control of extraneous factors.

Ideally, a study may be approaced in two ways: Retrospectively, random samples of injured and uninjured employees would be selected, stratified or matched for age, amount of weight lifted, duration of exposure to stress and/or any other extraneous factors which may relate to low back injury. The percentage of abnormalities on the pre-employment x-ray could then be evaluated within both groups.

Prospectively, samples of employees, with and without abnormalities on the low back x-ray could be randomly selected, matched for the aforementioned extraneous factors and after a long period of time, the percentage of injuries recorded within both groups.

Obviously, this is quite over-simplified. Many other factors at the time of hire need to be considered. A prospective study in which a high risk individual would have to placed in the same controlled setting, i.e., matched for age, activity level and so forth as a normal employee would be economically unfeasible. A retrospective study also has its difficulties in that it is not easy to adjust for extraneous factors in an ever changing working population.

Retrospectively or prospectively, the design is a chi-square analysis, a statistical test of association between the presence of symptoms on a pre-employment x-ray and the future development of low back injury. This is analogous to comparing the respective percentages derived from the aforementioned prospective or retrospective studies.

With the proper design in mind, the following pages are a brief outline and statistical evaluation of the majority of studies comprising the literature.

Of the approaches taken by those advocating the reliability of the x-ray, the most popular is to show decreasing compensation, time or days lost and/or disabilities over approximately three to five years after the addi-

tion of the x-ray to a pre-existing pre-employment program or after the addition of a program which included the x-ray as one of its components.

A second method, attempted by Runge in 1958 and Connell in 1968, was a retrospective design in which the authors demonstrated a higher incidence of anomalies from pre-employment x-rays in an injured group than in a non-injured group.

Crookshank (1961) demonstrated a lower injury rate in a group put through a pre-employment program in which the x-ray was instrumental than in a group not having been through the program. He then projected the amount of medico-legal costs which would have been saved if the non-screened group had undergone such a program.

Several differing designs have been employed to discount the use of the x-ray. The most popular is to extract two samples, the first having no history of back pain, and the second, either having a history of pain, or were in the process of or were receiving compensation, or having been disabled, were referred for orthopedic opinion but no diagnosis had been made at the beginning of a long term study. The procedure is then to x-ray both groups and show no difference in the number or percentage of abnormalities on the x-rays between either. This type of procedure has been done by Splitoff (1953), LaRocca (1969) and Rowe (1969).

Redfield (1971) published a prospective study in which he found a lower injury rate in a high risk group than in a low risk group. The high risk was defined to have more serious abnormalities on the pre-employment x-ray than the low risk group.

The following discussion is an evaluation of each design described above in terms of its statistical validity in the inferences one may draw and the control of extraneous factors.

When one x-rays a group after injury and compares it to a normal group, one cannot evaluate the predictability of the x-ray before injury, as done by Splithoff, LaRocca and Rowe. Our inferences could only be upon the abnormalities seen at the time of injury as opposed to a normal group. Splithoff's inferences are questionable in that he imposed no control of extraneous factors. He simply selected 100 patients complaining of back pain and 100 with no such history from hospital records. LaRocca and Rowe, on the other hand, had somewhat controlled studies, in that LaRocca, restricted his sample to heavy laborers with a minimum age of 35. Rowe followed his two groups for 10 years, matched for age and activity level.

Although each found similar percentages of the same type of abnormalities, Rowe found more disc degeneration within those injured, attributing most back pain to disc abnormalities. Rowe's impressive ten year study certainly demonstrates strong evidence to support cause and effect of low back pain upon or after its onset but neither his nor any design of this nature can evaluate the predictability of future injury from the x-ray.

In Redfield's prospective study, he found no differences between his high and low risk groups, including no differences in disc degeneration. As

he admits, his paper has several drawbacks in that his time of observation was very short (four years), his average age quite young (28 years), and he eliminated approximately 45 percent of his high risk backs, which may have accounted for a higher time loss in this group. Therefore his inferences upon the use of the x-ray, even in a young and changing working population, may be questionable.

Conclusions from Connell, Runge and Crookshank's publications may be questionable in that Connell and Runge, although having valid retrospective designs, do not control for age, activity level or any extraneous variables. Runge mentions he x-rayed his injured group either before or shortly after injury. Again, the effect of this may lead to an invalid estimation of the predictability of injury from the x-ray. Crookshank's method of making inferences from a lower injury rate in a group having undergone a pre-employment program creates the same probelm as in Redfield's publication. It does not allow a comparison of the potentially high risk back to the normal in similar levels of activity.

The most popular approach of showing decreasing compensation after the addition of a back program is not a controlled experiment in which the effect of the x-ray can be isolated and evaluated, i.e., when it is part of an entire pre-employment examination where past history and physical symptoms are considered in the patient's evaluation. It is a very appealing and convincing argument and until further investigation shows otherwise, is the most honest recommendation to management.

In conclusion, I feel there has not been a controlled long range study which answers the question completely. As Rowe states in his article (1969), studies based on short term observation of patients with low back disability have yielded tunnel-sighted information. I feel the need for a controlled study to be done before any inferences become a household word.

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The following pages are a brief outline of an ideal retrospective design to answer the above hypothesis.

Design

The diagram below is the fundamental part of the entire design.

Presence of Symptoms on Pre-employment X-ray

		With	Without		
Development of Low Back Injury	Injured	X_1	N_1-X_1	N_1	$P_1 = X_1/N_1$
	Not Injured	X_2	N_2-X_2	N_2	$P_2 = X_2/N_2$

FIGURE 1

The question "whether one can predict low back injury from an x-ray?" is statistically stated as there is no association between the development of low back injury and the presence of symptoms on the pre-employment x-ray. This is analogous to saying the percentage of symptoms within injured employees is the same as in those not injured ($P_1 = P_2$). If the percentages are similar, one may infer that injured patients can not be predicted from these symptoms more or less frequently than normal subjects. Thus the x-ray is a very poor tool to predict future injury.

The design is simply a matter of selecting a sample of injured and non-injured patients, reviewing their pre-employment x-ray for presence of symptoms and proceeding as explained above.

Sampling to Remove Extraneous Effects

The task of selecting such a sample must take into account the various extraneous factors which may cause low back injury. The problem then is to identify whatever extraneous factors are deemed important. It goes without saying that the more one considers, the less likely that one will be able to sample adequately. It is recommended to limit the design to age, activity level and possible length of exposure to such an activity level or a small number of the most important extraneous variables.

After having been selected, the extraneous variables must be classified. For example:

Variable	Mode of Classification	Classifications
Age	# Years	<20,20-30,30-40,40-50,50-60,60-
Activity Level	Ad Hoc Criteria	Job classes: I, II, III, IV
Duration to Activity Level	# Years	<1,1-10,10-20,20-30,30-40,40-

FIGURE 2

The method of sampling should be randomly within cross-classifications of extraneous variables, of injured and uninjured employees. For example, samples of injured and uninjured employees would be selected from each of the populations at Level C in Figure 3.

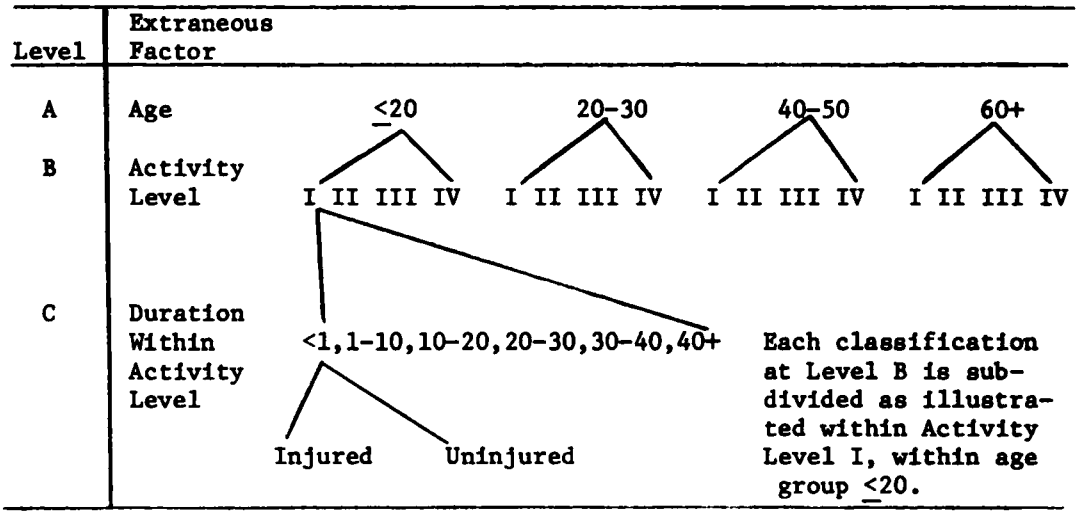

FIGURE 3

Each level of age is classified into an activity level, each of which is classified into a period of duration to that activity level.

It becomes quite apparent that as one increases the extraneous factors, the populations which must be sampled increase. There are 144 such populations at Level C above. With a larger design, it becomes very difficult, if not a little ridiculous, to select a sufficient sample size from each of these cross-classifications.

Analysis

After completing the sampling one can analyze the data in a variety of ways.

A table as in Figure 1 can be derived:

1. In general, i.e., all patients sampled can be classified as in Figure 1. From this we can make the inferences previously stated.

2. A similar table can be generated within each age and activity level classification. We can test if injury can be predicted within a certain age and activity level.

Reservations

I would take some reserve in saying the above design will completely answer the question. This is for the following reasons:

1. Ideally a sampling structure as in Figure 3 should be constructed. Then any differences in the percentage of employees with symptoms in either the injured or uninjured group would be attributable to the groups and not any extraneous effects. The sampling structure should, in theory, incorporate all extraneous variables which may contribute to low back injury.

This is where the design may fail. More than three or four variables may enlarge the sampling structure to such a degree that it would be nearly impossible to derive samples large enough upon which to make statistical inferences.

But for practical purposes, the design is not completely invalid. For the most part, the three factors mentioned (Figure 3) are probably the most important; any others could be related to these. Thus, the removal of the most important factors may remove the effect of the lesser ones.

2. Obviously before one samples, one must know the extent of the population. Though the dimensions of the populations in Figure 3 are theoretically unknown, an industry-wide sample incorporating a host of different occupations is probably "representative," though not theoretically random.

A similar objection arises in that all employees of the sample mush have pre-employment x-rays. Whether or not his subset of the working population is "representative" of it is in question. This could be determined by comparing statistics from census figures of the nation to those derived after sampling. If the descriptive statistics from our sample were similar to the general population we may, for practical purposes, infer in generalities.

Variations in the Design

The design in Figure 1 can be expanded in both the rows and columns to answer more relevant questions. The uninjured group could be partitioned by the severity of the injury. The evidence or lack of evidence or symptoms on the x-ray could be sub-divided into past history of back injury as well as physical symptoms at the time of hire.

Thus, from these variations in the design, one could by comparing the percentages in the injured groups to the normal, evaluate the relative risks of developing various types of injury from pre-employment findings. In particular, one could identify those findings which are the most helpful in predicting the respective injuries.

Of course, the previously stated reservations may become more pronounced. As one expands the sampling structure, obtaining sufficient sample sizes becomes difficult. Variation among physicians in the interpretation of physical findings and recordings of past history may present difficulties in evaluating these components of the pre-employment program.

Conclusions

The extraneous variables and partitions of the injured population discussed are, of course, speculation on my part. As a statistician, I am constantly aware that extraneous factors should be removed by a randomized design. Since I am not a physician, identifying and/or classifying such, for the most part, is beyond the realm of my experience.

This design and sampling procedure is just one of many approaches to the question, although in my opinion is the most practical. Theoretically, employing any approach, it may never be answered. I personally cannot put faith in any inferences unless the effect of my reservations with the design are evaluated, i.e., a few extraneous variables can for the most part account for most low back pain and a sample derived from an ambiguous population which is restricted to employees with pre-employment x-rays only, is representative of the entire working population.

Even though these reservations may prove slight, the percentages obtained would not be theoretically correct. But for practical purposes they may serve as crude measures which could contribute more to answering the question than any study done to date.

SATURDAY LUNCHEON SESSION

January 13, 1973

CHAIRMAN PRESENT: I would like to introduce Dr. Forrest Rieke who was a member of the now defunct, but recently very active, AMA Council on Occupational Health.

DOCTOR RIEKE: During this conference, we have brilliantly explored the anatomy, functions and socio-economic vagaries of the human back. I am grateful for this opportunity to be instructed by many of the nation's outstanding radiologists, orthopedists and occupational practitioners. It has not been dull. You have vividly etched your current clinical methods, precautions, innovations and medico-legal frustrations. Because of the intensity and clarity of your expositions, it is possible that the conference may feel its job is accomplished and lose momentum. From my seat on the academic periphery, a community level industrial clinic, it seems imperative that you finish strongly. Let me review with you the park and league in which we play; among the spectators are some highly critical partisans, a few unscrupulous bookies, some scouts for next year's opponents and the usual gaggle of poor but honest referees.

Our discussions are not far removed from the noise and oft-times abrasive review of medical services currently popular with labor, business, politicians, the media and even our medical peers. Self-examination is not a new experience for medicine but seldom has it been so vigorously espoused as a device to press for change in the medical delivery system. It is gratifying to be granted attention from consumers of our services. We can only hope they will approach our shared problems with a desire for quality as well as a concern for cost containment. There is much talk among health planners about cost effectiveness and wide use of preventive measures that will hopefully reduce both the human toll of disease and the great cost of sickness care.

Politicians and private citizens ask for better health strategies, more accessible community level medical services and a safe, clean environment. These requests are music to the ears of those who labor in occupational medicine. We seek to conserve and promote the health of 84 million U.S. workers, scattered in nearly five million shops, factories and service establishments. During and since World War II, we have been honing medical skills, often empirical, which guard the individual, repair personal damage and improve ability to function. Like biblical prophets, we now wander through the medical and industrial wilderness crying to colleagues and workers, "Try prevention, it works; try it, you'll like it!"

At long last one large segment of the industrial audience has joined the cause of prevention. Labor bought the package and embedded our percepts in the Occupational Safety and Health Act of 1970. The new laws ask medicine to "come back" to the work place, to put our skills on the production line. Physicians, employers and workers are challenged to shape-up, with obvious rewards if we succeed and cash penalties if we fail. National policy has been asserted. It is time to develop blueprints for implemen-

tation. We are short on skilled clinicians and technicians, some methods are known and validated, others suspect. Thus this conference on the valid uses of x-rays of the lower back was developed.

The goals and needs of those we serve have been reset and redefined. Social concepts and planners have evolved new rules. Rights and privileges are being restated in legislatures and the courts. Male dominance in business and industry will be reexamined; phoney sexual restrictions are threatened. The rights of property are in decline; the rights of children and women ascendant. In both occupational and community medicine we are challenged to find ways to assist men and women in adaptation to a rapidly shifting milieu, one which baffles them even more than it does us. Let me offer a partial list of the more obvious changes which complicate life for workers, their employers and those who provide health and safety services to both.

1) The community is changed

Small communities are wiped out by urbanization. The constraints and supports of neighborhood are gone. City workers are heavily dependent upon constant employment, an unfailing pay check and group security in sickness and injury. If money, food, transport or garbage removal fail, we are quickly in serious trouble. In spite of great improvements, and indeed because of their complexity, our changed medical services are having trouble keeping up with mobile families and surging suburbs both in appropriate personnel and in location of services. Customary health and environmental services provided by local and state governments are under-financed and undermanned.

2) The work place has changed and workers are changing

Physical labor has been much reduced by the addition of automation, palletizing, lift trucks, hole diggers and tractors. Such machinery can be controlled with ease by men or women. Technologic advances have introduced exotic and unfamiliar chemicals and new methods of melting and fusing metals. Ionizing radiation is used in many industries. Employee units tend to be very large, very impersonal and well-equipped, or small, humane and poorly equipped. There is a recognized need to build in a sense of creativeness and usefulness for individuals - qualities easily lost in any big organization. Within the U.S. economy there is a rapid expansion of service trades and professions but we have not managed to create or preserve a sense of worth among those who serve. Medicine can, if it tries, provide a working model for this much desired goal.

3) Women have widened their occupational and social goals

Many factors contribute to the changing aspirations and goals of U.S. women. Universal education, an amazingly productive industrial base, labor saving technology and control of pregnancy have removed long present constraints. Women are now justifiably insistent upon equal protection under the laws, equal access to work and full use of

their brains and skills. In many ways women's liberation is a peculiarly U.S. phenomenon. Other nations match our statistics, 32 million American women at work outside the home, nearly 40 percent of the U.S. work force, but few western nations are as exercised about "equality under the law."

World War II provided the opportunity to prove that women could do so called "man's work." We have long known that women can and will do many jobs that men are either unwilling or unable to perform. Women are going to work in changed roles and this presents new responsibilities to them and to medicine. Protection of women at work, whether about to be pregnant, pregnant, post-pregnant or menopausal, requires reexamination of our preventive methods and strategies. We are obliged to protect both women and men in unfamiliar and different job assignments, to protect the fetus from damaging chemicals and radiation, identify any sex-linked variation in response to environmental carcinogens, and to assure that men and women balance their limited energies with the load imposed by endeavors in occupation, family and the community.

You'll be interested to learn that the American Medical Association, the American College of Obstetrics and Gynecology and others have initiated conversations with the Women's Bureau of the U.S. Department of Labor in a long overdue review of the health implications of employment for women. These will, of course, be keyed to changes in work assignments as well as verifiable sex related considerations. The deliberations and recommendations of this conference are of great interest to those conducting this dialogue.

3) Occupational Safety and Health Act of 1970 (OSHA)

The federal Occupational Safety and Health Act has supplied renewed impetus to a long existent commitment to protect workers--all workers, wherever employed. This was one of the primary purposes of state workmen's compensation laws, long since lost in a thicket of conflict over claims, blame and rewards. The new national law directs the U.S. Department of Labor to establish and enforce regulations about worker protection and gives punitive powers to the enforcer. It assigns research on physiologic and health effects of on-job hazards to a scientifically oriented National Institute for Occupational Safety and Health (NIOSH). It anticipates that physicians, hygienists, engineers, human factors experts and many others will combine their skills to set realistic standards for safety and health and to monitor the results of their recommendations. As never before, the new OSHA law has aroused demand for special medical examination related to protection of workers--measurements of sight, hearing, pulmonary function, enzymes, blood levels, pulmonary and bone changes, and more to come. As a profession, we shall be hard pressed to create and maintain the kind of records that will reveal injury or assure that workers are not receiving work-connected damage.

5) The maligned health delivery system

On many fronts and for various reasons the disease oriented U.S. medical system is under attack. Depending upon one's bias and discipline, critics are certain that skillful planning, changed organization of financing and staffing and better training of the consumer will result in better health of all citizens. A well educated and indoctrinated younger generation is sure that an attack on ignorance, poverty and an adverse environment will improve the health of all. They grow impatient over the failure of medical practitioners and associations to march at the head of their crusade. We all hope for improvement but remain gently skeptical. Experienced medical workers remember too many gaps between plans and performance in both fallible human systems and inconstant human beings.

In those industries where skilled environmental monitoring and employee safety programs prevail, morbidity from job hazards has been sharply reduced. Careful medical examinations and health instruction have stimulated individual self-restraint and better use of private medical care. These successes have occurred mainly in large, well-organized companies or quasi-military agencies. They give credence to proposed health maintenance organizations which could focus on distribution of community level physicians and new varieties of allied health personnel to interview, inspect, instruct and route citizens into a complex health system.

Those who propose legislated national health or sickness plans place great faith in consumer education and use of preventive strategies. In a few European countries with high educational and economic attainments, these goals have been partially realized. These countries and a few others have developed nationalized occupational health programs based on factory inspectorates or factory medical officers and centralized occupational medical clinics. Financing, staffing and technical out-put vary widely in these programs; nationalization of medicine has not guaranteed effective guarding of the health of workers.

6) Ionizing radiation-diagnostic, therapeutic and occupational

One can debate whether politicians and media of public information have created or responded to widespread public awareness and concern about ionizing radiation. Attention has focused on nuclear testing, fall-out and possible environmental contamination from the use of nuclear fuels. State and national public health officials have been equally concerned over a steady increase of exposure to radioactive sources used in medical diagnosis and therapy. Organized medicine has been aware of these problems but singularly reticent about their import. It is time for an expression of responsible concern by the American College of Radiology and all of medicine, not in the quiet of the clinic and hospital, but skillfully and appropriately in public places. This meeting is a part of the planning for such an expression in a legislative year in which consumers are waiting to drop the other shoe on clinicians and industry.

7) Rehabilitation of the impaired worker

Several speakers at this conference have pointed to widespread failures in rehabilitation and reemployment of the injured, the aging, the impaired or the "painful back" case. In occupational circles, physicians are aware that the employer who hires such an impaired person may be saddled with undeserved costs of medical care and time-loss compensation if the worker suffers a relapse, whether from chronicity or an aggravating second injury. Such costs may rise sharply in "second" injury to the diabetic, the post-coronary, the arthritic, a worker with a faulty lumbar spine or a variety of other stationary conditions.

The impaired person needs to work, often more urgently than the healthy, and deserves a chance to be self-sufficient. Rehabilitation will be implemented if we arrange legislative protection of the humane employer. This can be guaranteed by modification of the Second Injury Fund provisions of workmen's compensation laws. Of course the injured worker must receive full benefits but the employer who accepts a person with a defined impairment must be relieved of all excessive costs resulting from a second injury or aggravation by inadvertent circumstance. When the employer can be sure that his good citizenship will not be financially disastrous, he will more willingly join the rehabilitation team. At that point, x-ray of the lumbar spine will cease to be a medical cause for rejection of the aspiring employee and become another useful tool for successful counseling and placement at tasks within the competence of the applicant.

CHAIRMAN PRESENT: At this time, we ask the chairmen of the small groups to summarize their recommendations, their activities and their ideas.

GROUP SESSION REPORT

Sydney Thomas, M.D.

DOCTOR THOMAS: Railroads are anachronistic, incorrigible and distort our problems. They have anachronistic laws. Their position in this field is distorting a clear look at pre-employment low back x-rays. The weight of their dollar is high. Their problem is large but they are giving it a negativistic approach and not a positivistic one.

Did we have a positive approach? I think we did because we as a group felt that mandatory pre-employment x-rays for everyone are not realistic. The plan for doing these is completely management oriented and is not in the best interest of the individual.

What is in the best interest of the individual? A very careful examination of the patient is necessary. If there is a problem, x-ray, certainly, has a place. It is a part of the total examination but not a routine factor.

We considered techniques and the ability to produce these films and decided upon a more complicated examination. Even six films, which obviously have the highest radiation dosage, was at the one extreme. A few felt that two films were adequate for a screen. Everybody, except Dr. Ford, would take two films as a starter if we had to. However, some negativistic things were also brought out.

We all think that the material is available for using x-rays in this field but it hasn't been used properly and we need help from the statisticians. We need help from the people who are in industrial medicine to bring industry into an investigative approach.

What is the investigative approach? We weren't very certain of this but we all felt that prospective studies with retrospective studies of continuing large series, Eastman Kodak and the like, were essential for the future, that we had to get a large body of statistically significant numbers to convince people, and that we couldn't just say: "Well, I am not going to employ a guy with spondylolisthesis. How can I find it if I don't take an x-ray?"

Ninety percent of the spondylolistheses are going to have a back problem so these are the kinds of things that do not solve the problem. Industry should take these people on. They should live with them. They shouldn't dump them. They ought to give them jobs that fit their spondylo.

GROUP SESSION REPORT

Max Rogers, M.D.

DOCTOR ROGERS: In our group there was considerable discussion and interest in the gonadal irradiation effect of pre-employment back x-rays. This was stimulated largely because we had some of the best minds in the country on gonadal irradiation there. Finally, this was tabled with the proof, as presented by our biostatistician, that actually there is no more, and probably less, harm in gonadal irradiation from pre-employment back x-rays than there is with a GI series or a barium enema.

Also, there was some discussion on the psychosociological aspect of pre-employment. There is not a great deal that can come out in a concrete way as a result of this but the important thing is that it points out that we, as people handling pre-employment problems, are thinking more and more of the psychosociological effect on our applicants.

The pre-employment low back x-ray examination has not been shown to be of predictive value in determining the future disability status of an employee. However, there are certain industries in which this examination may be of medico-legal or socio-economic significance and this aspect warrants further investigation.

GROUP SESSION REPORT

John McClenahan, M.D.

DOCTOR McCLENAHAN: Our interdisciplinary session included four radiologists, three industrial physicians, three orthopedic surgeons and Dr. Walter Hoover, a representative from NIOSH.

We brought no more unanimity to the question of the validity of the pre-employment x-ray examination than already exists in a rather snarled literature. We did, though, identify a few problems and in general, although there were digressions, agreed on several concepts.

First, x-rays are only one, and perhaps a minor criterion in the selection of job or applicants. Less workers are being screened under a stringent program.

There are two very distinct requirements in ordering a pre-employment x-ray examination. One is the legal requirement, the second, the scientific. These two do not always overlap. A film, for example, that may be of relatively limited medical or scientific value, such as a large Schmorl's node, may look huge in the eyes of a jury.

We were concerned to some extent with not only outright disability incurring after a person is selected for a job but with the idea of aggravation as well.

It was generally agreed that a clinical history and examination are probably more important than x-rays in gauging the suitability of an applicant for a job. The age of the candidate, his coordination and above all, his psychological constitution and motivation are of fundamental importance.

Third, the nature of the job is as strong a consideration as the health of the candidate. Factors such as weight lifting, heat, repetitive motion and other environmental variables vary so widely that the term "pre-placement" was to be more desired than "pre-employment" examination.

Factors of supply and demand for labor and industry influence strictness of criteria for selection of an applicant to some degree.

We wondered what society is to do with the job applicant, particularly the one who is willing to work, who is turned away from a job for whatever standards have led to his rejection.

We suggested that an applicant's suitability is sometimes determined by chance events such as technical factors, position, competence and attitudes of attending physicians, that is, the keenness of the eye, the haste or the hangover.

Fourth, data from reported series of examinations is of limited statistical value because control figures are seldom cited and specific criteria for naming and identifying spondylo anomalies vary to a great extent. Job turnover, requirements of minority representatives, senses of security and participation in an industry reflect themselves in the number and intensity of compensation claims.

Fifth, in terms of x-ray technique, the need for safety, economy and uniformity of examination and interpretation was recognized. In general, four films with added obliques, bending views and tomograms should be ordered when indicated, together with bending views. Collimation and gonadal shielding were thought to be indispensable. The need, when examining films, to consider not only anatomical detail but the mechanics as well of motion, function and stance was stressed.

Finally, we agreed that each patient should be individually considered in interpreting films. The role of one or more specific anomalies is hazardous in determing whether or not he is qualified for a job.

Disqualifying findings would probably include stress spurs, unstable joints on flexion and extension, spondylolysis, spondylolisthesis, degenerative hip disease, retained contrast or indications of surgery as well. These last were findings which would strongly incline one toward rejection.

GROUP SESSION REPORT

Clinton Compere, M.D.

DOCTOR COMPERE: Our panel this morning was an exceptionally well-balanced group of experienced individuals. We had four orthopedic surgeons, three radiologists, four representatives from occupational medicine, Dr. Erikson and a NIOSH representative, Dr. Purdy.

We had much open general discussion with regard to what a pre-employment examination actually is. Is it ever indicated or necessary in a large industrial program? We commented upon the special situation of the railroads and upon Dr. Rogers' statistics. We were fortunate to have with us Dr. Davison from the Chicago and Northwestern who presented his statistics.

There was no one in our group who felt that the pre-employment x-ray low back examination had been established, particularly, as being of significant value.

We realized in our group that there were special industrial situations where x-rays were a necessary part of an over-all history, physical evaluation clinically for a patient, for possibly hiring, employment, and certainly for certain job placement routines.

We reviewed the conditions of job class suitability drawn up by Dr. Bond and his ad hoc committee previously. Obviously, we are not accepting it. No one is accepting this outline of conditions to be used except where it is put into a clinical evaluation program and is a guideline for intelligent interpretation of x-ray findings.

We think our little modification might be of some value but only when correlated clinically and this was specifically true of certain sections of it which are valueless the way they are listed unless clinical correlation is included.

We agreed that x-rays in a pre-employment examination are indicated only as part of a pre-employment workup including history and physical examination. The x-ray determination must not be the sole cause of rejection for employment but must be part of the coordinated history and physical.

We agreed that there is a variation of importance for x-ray evaluation possibly in the pre-employment programs of certain industries such as railroads, logging and so forth as compared to an accounting firm but that all of these must be individually judged and we are certainly encouraging an appropriate total clinical evaluation.

It was brought into the picture that even a pre-employment medical examination should be really just a part of the ongoing medical care of the citizen, of the individual laborer.

DOCTOR THOMAS: I would like to bring up one point that we haven't discussed in the summary so far. This is a soft tissue structure we are dealing with. It is the soft tissue that goes wrong and not the hard bony structure. You are not going to be able to get as much out of your x-ray as you would like to get. Therefore, it will either depend upon the geneticist or the chemist for a real definitive look at what makes up a back.

SUNDAY MORNING SESSION

January 14, 1973

CHAIRMAN PRESENT: Dr. Jend, president of the Industrial Medical Association, would like to say a few words to us.

DOCTOR JEND: I want to congratulate the American College of Radiology on arranging such a successful and thought-provoking conference. I think that when we were first approached about this conference we didn't know if we were going to be conned into giving a rubber stamp to what the College of Radiology had already made up its mind to do, but needless to say, that was not so.

I would also like to bring you the official greetings of the Industrial Medical Association. Many of our members are represented here.

My colleagues in occupational medicine and I have been very gratified at the breadth of viewpoint that has been expressed here. It has been truly a multidisciplinary approach, far exceeding any expectations or hopes that I might have had and it is a recognition of the complexity of the problem that we have discussed.

What makes it so important is the changing employment scene where the emphasis is on ability of people to do something rather than disability and where we are evaluating people in terms of their ability to perform the work for which they are being considered rather than seeking reasons to exclude them.

This is not to ignore the many pitfalls that are in our way in terms of workmen's compensation laws, malpractice threats, regulations, pension considerations and other things that have been true from the past, some of which are quite antiquated, but out of this is coming a very healthy and constructive approach to placing people at work.

We want to make full use of the deliberations and summaries of this conference in our own "Journal of Occupational Medicine" and to other industrial physicians who may not be associated with our group. It deserves that kind of attention.

This is a base on which further discussions should be built. NIOSH is certainly looking to us for guidance and we owe it to them to provide it.

So again, thank you for inviting us to participate. This has been an excellent conference. We will do our part in the Industrial Medical Association to see that the ideas that have been expressed here are examined fully and used fully in our own work.

CHAIRMAN PRESENT: We now come to the part of the discussion called soundoff. This is an opportunity for anybody who feels that he has not yet fully expressed his opinion to speak.

DOCTOR KERR: I seriously question the validity of pre-employment examinations, including those taking low back x-rays. We have little or no documentation that the preplacement examinations have yielded any satisfactory results insofar as the workers are concerned. There is little information to authenticate the value of low back x-rays. There are no controls on materials put forth so far and there is no solid epidemiology on which to base any conclusions. I am opposed to the preplacement examinations as well as the low back x-rays.

Another reason for my opposition is the fact that there are no criteria that have been developed as to the quality controls as well as the reading controls of these x-rays. It is doubtful even if we had these controls that they would be of any particular assistance insofar as low back pain is concerned. This is in contrast to the dust diseases in which you have a slowly developing and eventually progressive disease which can be monitored with high quality films. While not all of the dust opacities lead to disability, there is yet a fairly high proportion. There are no comparable figures insofar as low back pain is concerned. There is also no provision for the confidentiality of these x-rays.

It is obvious from all of the information made available to date that management is desirous of having these films because of the major cost of workmen's compensation.

In view of these and many other problems, it is my feeling that these x-rays, if indicated, should be a part of the total medical care provided the worker and his family. This would be equally true of the pre-employment examinations.

The continual emphasis on low back pain, as well as other aspects of pre-employment examinations, detracts from the major endeavor which should be preventive medicine. The general attitude of the physicians involved with the x-rays of the back is comparable to the episodic medical care provided by many physicians. Until the focus of attention can be on the prevention of the illnesses and the injuries for which it is thought the back x-rays are an important measure, there is little justification for this continual exposure to x-ray.

DOCTOR BOND: It seems to me that what we have seen and heard the last few days and what we already know about the low back indicates that we cannot prevent all, and in my opinion, even a significant number of what are called low back injuries in industry. Low back injury may or may not be an injury in the usual sense of the word. It is low back pain that is attributed to injury. I don't blame the man for thinking his job caused it. Neither do I think the safety people in industry are going to prevent a significant number of low back injuries. They have carried on training in our big companies for years, telling people how to lift and how to stand and one thing and another. I don't believe this makes an awful lot of difference, though it helps some.

I don't believe the physicians nor the safety people are going to prevent what is called under workmen's compensation or other kinds of compensation laws in our society, low back injury. Maybe the human factors, the engineers, can help, not by telling us how to lift, but by designing our work places and our machinery and equipment in a way that is a little more compatible with the way people are put together.

One thing the medical profession can do a lot better than it does is to properly handle the patient that comes with a low back injury that is compensable and is the responsibility of the employer.

In all the articles that we have read we have heard about the serious problem cases. You can point to problems that occurred that were not recognized early. We should recognize that possibility in any patient we see with a low back compensable injury.

We should be very careful and thorough in our examinations. Do this as soon as possible.

We should explain what we find to the patient in real doctor-patient language and tell the employer what we think and what we find.

We should get acquainted with the patient. We should get to know him. This is assuming it requires more than one or two visits. Find out what sort of guy he is, what he thinks about his work, about his family and about himself, too. Find out if he has any hangups.

If you think that this man's back is going to continue to fail under the kind of job he is doing or other heavy work, tell him that, tell the employer that and tell them right away.

If this man will not be taken back by his present employer because of company rules, union rules or some other rules, then get on with it and get him over to the rehabilitation facility and stick with him and keep explaining to him that he is going to be all right, he is going to live, he is going to have some kind of job. Don't let him develop what may be called traumatic neurosis or neurotic fixation on his symptoms or whatever you want to call it. Certainly try to keep this man at work because otherwise he will deteriorate.

Certainly, we should be alert to the signs of these problems that I am talking about. Most of our patients respond to our treatment and do not develop these problems but some do. These are the ones that the articles from Toronto, Oregon, California, New York and every place describe, the serious problem cases. It is only a few that cost $10,000 to $100,000 and we all know this.

We should be alert as we are treating a patient. If our patient does not respond like we think he should, that is one of the first clues. Certainly if you get mad at the patient or if he gets mad at you, that is a clue that there are a lot of factors other than the back involved here.

We all recognize when there is something bizarre about the story the patient tells you during the course of your treatment. We must not get so busy that we do not have time to notice these things. Perhaps this is the greatest role for the medical profession.

We can hopefully, by proper placement, prevent some of the serious problems but we have a greater role in preventing the complications than in preventing the low back pain itself.

DOCTOR SNOOK: As a point of information for those of you who have some influence in the design of tasks, industrial or otherwise, there is some information available concerning weights, maximum weights which people can handle, maximum forces of push and pull, carrying, walking and so forth.

We have spent the last ten to 12 years developing this information in the laboratory. It is expressed not as maximum weights but as a percentage of the population that can handle particular weights or that can exert particular forces when pushing or pulling.

If you have new factories that are being built or new jobs that are being designed, here is some information that may be of some help in designing the job to fit the individual.

Thus far, this work has been done on males only. We are in the process of collecting data on females. We have 16 subjectes completed and it will probably take us about a year more to complete the female comparisons.

The work on males is available in the Industrial Hygiene Journal.

We were seomwhat surprised at our initial information about the ability of the female as compared to the male. When you examine the literature, you find estimates of from 60 to 80 percent, this percentage being what the female can do in relationship to the male. The female can lift perhaps 60 to 80 percent of what the male can lift. Our results, based on 16 subjects over a period of about two months show that it depends on the type of task the female is doing. Our females are only showing us around 45 percent for the lifting, lowering and carrying tasks but in terms of pushing, it goes up to 60 percent. Comparably, in terms of walking, it rises to 80 percent.

The distinction has to be made between the maximum forces or the maximum weights of lift. An individual may be able to lift it once but he or she cannot maintain the task. We call the first, strength and the second, endurance. When we speak of fatigue, we speak mainly of endurance, but when we talk about strength, we talk about whether the individual can pick up the weight initially regardless of the pace that this individual has to maintain.

We are not getting back x-rays on these subjects. I haven't mentioned lower back here because I am not sure of the relationship. The relationship is not that clean-cut between the forces that these people have to exert and the incidence of low back pain. There is some indication that

it may be a bimodal distribution and we are overstressing some of these people and understressing the others.

Certainly our data from our own southern division is significant. In one chart which showed the incidence of manual handling accidents, 90 percent of these were low backs. When you are handling 100 pounds plus, the incidence really rises, then dips and when you get down to the lower end around 20 pounds or 30 pounds, it comes up again, but not nearly as much.

We started studying the capacities of men in doing these manual handling tasks without regard to the lower back pain or the incidence of lower back pain but you cannot study this too long without becoming concerned about that.

DOCTOR BROWN: The thing we haven't touched on is the ingenuity of man to solve his problems. All the approaches we have talked about here have been explored and found wanting in our hospital setup. Now we are going to what we call the lift team approach. The lift team costs about $20,000 a year in a hospital. It is given mechanical aids. We have about two years' experience in California in three hospitals. I am happy to say that the nurse injury claim rate has dropped to zero under these circumstances.

It is premature. It is early but there are some avenues in particular situations that offer some hope that we can resolve at least the financial difficulties where our total claim rates in these hospitals were on the order of $500,000 a year with an average of about $50,000 a year for the surgical cases.

DOCTOR SCHWARTZMANN: Referring an individual to vocational rehabilitation for replacement was mentioned earlier. An individual who has injured his back and may well never return to his regular work could be trained by vocational rehabilitation a month or two after the evaluation is made and be ready for a job when he is ready to go back to work, if he is retrained.

In my state, however, vocational rehabilitation will not pick up an injured patient until he has been discharged from medical care and that means sometimes a year or a year and a half plus another year of studying and psychometric evaluations and all the rest toward trying to retrain him. By that time, he is firmly ensconced in the idea of not working and collecting pay checks without work. Thus, the quicker an individual can be placed or returned to work, the shorter is his claim on the injury itself. The disgruntlement and frustrations of the individual become greater as time goes on.

In rehabilitation, an individual is evaluated and trained for a given job and in my locality, particularly, they will train 25 or 30 people for the same job. There are no jobs available. They are injured. They are recovered to a degree. They are well-trained but unable to find work.

We as an organization can try to get vocational rehabilitation to step in as soon as the individual is ready for rehabilitation and be trained by

the time he is ready to return to work, rather than a year or two after he is completely ready.

These individuals should be trained realistically. If there is a pool of jobs available in the community, they should be trained toward that pool of jobs and not trained for a given job for which there is no outlet and no employment available. That again is another factor that the rehabilitation system must change if it is to justify the money expended and actually rehabilitate some of these people.

DOCTOR NOER: I am an orthopedic surgeon and associated with the National Orthopedic Rehabilitation Hospital. My comments are on this locational rehabilitation and rehabilitation, in general.

At least in our area this is a dying field, though no fault of the medical profession.

When I came to National Orthopedic Hospital, we had retraining shops, a sheet metal working shop, a machinist's shop, a printing shop, a carpenter's shop, a plastic working shop and four or five others which were placed in our buildings by the respective unions to be used for retraining the injured worker.

The unions provided instructors who were themselves back at work but who were themselves handicapped. We had a monoplegic printer in charge of the print shop. We had a bilateral A-K amputee carpenter in charge of the carpenter shop and so forth. These people were taken down to the shops and retrained and sent back to work under the aegis of the Virginia Rehabilitation Program.

At the present time the print shop is the only one that exists. All the rest are gone. There is no money to run them. The unions provided people but we couldn't get money.

We had the same situation in rehabilitation of patients not concerned here. We were doing a lot of work with the patient with multiple sclerosis, the patient with stroke, that sort of thing. I believe that if you are going to take a stroke patient and teach him how to walk and take care of himself and you are going to send him to physiotherapy in the morning and physiotherapy in the afternoon and activities of daily living in the evening and occupational therapy in between, you are putting such a load on his cardiovascular system that the possibility of having another stroke or a coronary attack is significantly heightened. Thus, we do not rehabilitate these individuals as outpatients but we find that the insurance carriers call this physiotherapy and will not fund it on an inpatient basis. So now it is the rich that are getting this kind of retraining and not the poor.

In my state it is a little bit different from the examples cited by Dr. Schwartzmann. We get vocational rehabilitation as soon as possible. There is not a time lag. As a matter of fact, a very recent male patient who was injured when his car was rear ended was a carpenter and could not work. He came to the office for two months after his injury and was won-

ering where he was going to get the money to pay his rent.

I took him by the hand down to vocational rehabilitation and they arranged to buy him a brace and pay his rent. He was two months from the date of injury and not ready to go back to work.

So this is a state-by-state affair, I submit, but rehabilitation is a problem.

DOCTOR HOOVER: Prior to my present position with NIOSH, I was engaged in small industry research and was involved with small industry programs for a period of five or six years.

I am making a plea to this conference to reduce their recommendations to the lowest common denominator. That is, are these things applicable to small industries? Are we making impractical recommendations?

Very often we are asked for advice, mostly by industries without medical departments. The things in the literature are not actually applicable. They are much too sophisticated.

If we are going to go on record for or against anything at this conference, these things should be understandable to nonindustrial physicians and other people that are involved in small industry care since 70 or 80 percent of the employees in the country are probably in these industries with a very minimal medical coverage.

The motivation of money is rather important. In my small industry group in New York and Brooklyn, we had an incidence of back injuries of less than four percent. There was a good reason. These people didn't get paid for the first week before they started getting workmen's compensation. A lot of them were medium and medium heavy industries and actually the incidence of reported compensable back injuries was less than four percent. I can't help but think that the monetary loss involved induced these people to keep on working.

DOCTOR F. J. KELLY: We should keep in mind the complexity of the problems that small and large plants have in reference to regulatory situations. This relates to the preplacement evaluation that has to be kept in mind by the industrial physician representing his company and remembering such things as the unions and their rights and their responsibilities and also the ability of the company to deal effectively with them.

In my area, we are required to have a minimum of 11 percent minority working in our company. That is derived because we have 11 percent minority in the Amarillo, Texas area. So when we are looking for new hires and the ratio has come down to ten percent, it means that our top management immediately says that the next people we hire are going to be minority. If this conference tightens down too much on what is required to employ these people in the way of rules and regulations and then on top of that, the company has to go only to a small labor group to get this one percent and this would include also regulations in reference to the ration of females, or at least they are looking hard at this, it obvious-

ly is going to put our industries in a bind and particularly this 80 percent that Dr. Hoover mentioned of our labor force who are in the small industry.

The secretary who comes to work today may well bid out a year from now to some strenuous job that she feels capable of doing and if the industry has hired her without taking certain precautions medical-wise, they are in difficulty because she has a right to bid out on it and it is pretty late and not quite fair to her to then do extensive testing to see whether or not she will qualify.

We have weights that we incorporate into our preplacement examination program to get some idea as to what men and women, all applicants, can do as far as lifting, pushing, pulling and so forth are concerned.

Finally, let us consider the big area of legal aspects. This is unscientific perhaps. It is a way of life as these other things are and it is a tremendous problem particularly when we see the real activists in the legal profession making a tremendous business but it is a way of life, a fact of life, that goes back to the preplacement that we as industrial physicians have to take into account in the preplacement evaluation.

Thus, the recommendations that come out of this should be not too restrictive to the small plant because I can envision a conference next month with the internists and industrial medicine and they will come up with electrocardiographic requirements in the preplacement and the month after that the dermatologists will meet and so on.

DOCTOR RIEKE: We have to recognize that any socially feasible system has to allow time for injured or troubled workers to fall back and regroup. The back provides that sort of safety valve.

Secondly, the work group will usually adapt to a minor impairment if you give them a chance and do not set too many clinical limits upon it.

The third point, totally fundamental to the rehabilitation discussion, is that the employer, if he is not protected from unrealistic liability and subsequent claims, simply will not re-employ the impaired person, particularly in the low back category.

We do encourage immediate changes in state workmen's compensation laws which will remove the penalty and the potential penalty of the employer who does hire or place the impaired worker, whether it be from the back or other causes.

DOCTOR BOSHES: We have referred to immediate care and avoiding the latency period between the time the diagnosis is made and the man is back at work. What the man cannot do is of little importance in the rehabilitation process. Immediately, it is discovered what he can do and he is trained toward that with a programs course. This is disastrous. Western man is notoriously dependent no matter how tough his exterior may be or how tough he may be after he has had a few beers. This is the nature of western man.

In experience in war, this was the largest traumatic experience in our era. In World War II, after Dunkirk, England had very few men left. At the Oxford head center they couldn't have a man lie around for three months. They had every man out by the end of the sixth day with severe head injuries. The incidence of post-traumatic neuroses was zero. All men went back to work unless they were paralyzed.

In the area of the peripheral nerve, found in Her Majesty's publication on peripheral nerves, the incidence of recovery in rehabilitation centers, not physical therapy centers, was high but every man that was sent home for rehabilitation ended up with a permanently injured limb. I point out that when we had lieutenants up in the front who were unsure of the diagnosis and were sent back for extensive laboratory studies, there was a 90 percent loss but when we had lieutenant colonels up in front with an immediate, definitive diagnosis of a plan for rehabilitation, 90 percent of the men were back on the line within a few days.

The lesson is identical here. If you don't program a man immediately, you lose him.

CHAIRMAN PRESENT: Shortly, we will hear reports and conclusions from the various intradisciplinary groups. What I am hoping these reports will reveal is a degree of unanimity of opinion or at least a unanimity of verbiage, terminology, so that we can publish a conclusion which has not only facts upon which people may rely, but might well imply directions in which further efforts may be made. We will start with Dr. Marcus Bond from the industrial medical group.

DOCTOR BOND: This is a report of the 15 industrial physicians in the group and there was a rather good consensus among them.

1. Occupational physicians are called upon regularly to make recommendations about placement of persons in jobs, these recommendations to be based on health factors. These procedures are called preplacement medical evaluations.

2. a. X-rays of the low back may be of value in the preplacement medical evaluation of persons for certain types of work.

   b. Low back x-rays should not be used as a primary or isolated medical screening procedure for job placement.

   c. There is not agreement among experienced physicians as to the value of low back x-rays used in the preplacement medical evaluations in the prevention of low back injuries.

3. Low back x-rays should only be done with the use of proper x-ray techniques based on current knowledge to insure good quality radiographs with the least radiation exposure.

   Gonadal shielding should be used for both males and females and the international ten-day rule should be used for females in the child-bearing age.

4. Because of the lack of knowledge about the value of preplacement low back x-rays in preventing low back injuries, it is recommended that NIOSH design and implement a prospective study of this subject with the assistance of the Industrial Medical Association and other appropriate resources to determine if information learned from low back x-rays is, in fact, useful in predicting low back pain and/or injuries.

That is the substance of our report. I have a couple of addendums that our group felt should be included which are:

A. There are barriers to employment and to rehabilitation and re-employment of persons with low back injuries. Due to workmen's compensation laws and certain federal and state laws and regulations as well as industry management and union rules and procedures, certain of these nonmedical factors will influence the use of low back x-rays as a preplacement screening procedure.

B. Medical science would be benefited if there was greater knowledge available of the physical requirements of various jobs. This might be accomplished through systems design techniques using the resources of radiologists, orthopedists, occupational physicians and human factors engineers.

   The objectives of such might be to develop a "performance requirement data sheet" for management and unions and a "performance capability data sheet" for occupational physicians and human factors engineers.

   The results would hopefully improve the objective of matching the employee with the requirements of the job.

C. This group also wishes to emphasize the importance of proper group job training and continued safety instruction in the role of prevention of low back injury.

I have another brief addendum.

In the course of discussions on the use of low back x-rays, it has become apparent that in rehabilitation and re-employment, the worker with an impaired back is often refused employment on the basis of his x-ray and the fear of future injuries. Current workmen's compensation practice does not completely protect the humane employer from this situtation. Such protection of the employer can be accomplished through changes in second injury fund, provisions of state workmen's compensation laws. We hope this conference will endorse this principle.

CHAIRMAN PRESENT: Dr. Ford is reporting for the orthopedic group.

DOCTOR FORD: I took the liberty of deferring the chairmanship of the orthopedic group to my more senior and very respected colleague, Dr. Clinton Compere.

We had 15 orthopedic surgeons and one neurosurgeon and to have this group come to agreement and conclusions on a number of different subjects is remarkable.

Our group took the guideline for interpretation of x-rays of the lumbo-sacral spine with all due respect to Dr. Marcus Bond and suggested some changes in some of these items. Our changes have been inserted in parentheses in the following guideline.

CONDITIONS AND JOB-CLASS SUITABILITY

1. Mild scoliosis (of 15 degrees or less)
   All
2. Mild increase or decrease of lumbar lordosis
   All
3. Moderate increase of sacrolumbar angulation
   All
4. Narrowing of 5th lumbar interspace when unaccompanied by other findings.
   I, II, and III (All)
5. Spina bifida occulta of sacral segments (or lower lumbar segments)
   All
6. Complete symmetrical sacralization, 4 lumbar vertebrae [Last lumbar vertebra is completely fused.]
   All
7. Complete symmetrical sacralization, 6 "lumbar" vertebrae [First sacral segment has become a separate segment and has the appearance of the last lumbar.]
   All
8. Lumbar ribs [or ununited transverse processes]
   All
9. Evidence of minor epiphysitis
   All
10. Incomplete ossification of epiphyseal line in individuals under 25 years of age.
    All
11. Minor anomalies of transverse processes or articular facets
    All
12. Centrally located Schmorl's nodes
    All (should not disqualify a worker for any occupation)
13. Laminectomy
    I and II (III, Occupation)
14. Fusion with good result
    I, II, and III
15. Fusion with mobility demonstrated (without symptoms)
    I and II
16. Radio-opaque material in the spinal canal
    I and II (III and possible IV)

17. Marked scoliosis with rotation of vertebrae
    I and II
18. Kyphosis of lumbar spine
    I and II
19. Marked increase of lumbar lordosis associated with increase of lumbosacral angulation
    I, II, and III (IV)
20. Marked decrease of lumbar lordosis, flattening of lumbar spine [poker spine]
    I and II
21. Marked narrowing of intervertebral joint space at lumbosacral joint (with sclerosis with or without arthritic changes)
    I and II

(In numbers 13 through 21, we feel that the classification of workers should be correlated with the history and physical examination.)

22. Transitional vertebrae
    (a) partial fusion of last lumbar vertebra with sacrum
    (b) separation of 1st sacral segment, with unilateral fusion
    (c) Unilateral or bilateral articulation of transverse process with sacrum, asymmetrical
    I and II
23. True spina bifida
    I and II (should be related to the history and physical examination)
24. Spina bifida occulta including lumbar segments
    I, II, and III (omit completely)
25. Advanced arthritis of any type
    I
26. Moderately advanced osteoarthritis if in excess of average usual findings in relation to age
    I and II
27. Spinal deformities due to old fracture of vertebrae or old [healed] infectious diseases
    I, II, and III
28. Spondylolisthesis
    I and II (III)
29. Defect of pars interarticularis without "slipping" forward [pre-spondylolisthesis, spondylolysis]
    I and II (III)
30. Marked variations of apophyseal joints [unstable facet structure] (omit word "marked")
    I and II (III and possible IV)
31. Multiple Schmorl's nodes when eccentric or associated with an undulating appearance of the surfaces of the vertebral bodies
    I, II, and III
    (omit completely)

(31(a) Stenosis and other deformities of the spinal canal
I and II)

32. Marked deformities due to residual epiphysitis
    I and II
33. Bone or joint lesions of destructive or formative nature, e.g., osteoporosis, osteochondritis, osteitis cystica, spondylitis,

tumors, other pathology suggesting fragility and weakness of osseous structure, and infectious lesions of vertebrae
Such conditions are often progressive and require treatment; therefore, individuals with any of these conditions should be referred to their own physician for care. Employment in any job class may aggravate the condition.

In conclusion, then, our committee makes these recommendations:

1. No prospective employee should be rejected on the basis of x-ray interpretation alone of the low back.

2. Pre-employment x-rays should not be done except as part of an evaluation including a competent history and physical examination.

3. This pre-employment evaluation may be done for Class I and II prospective employees but should be carried out on all who are considered for Class II and Class IV work.

4. Low back x-rays should not be done routinely, but rather on indication in those examined for Classes I and II.

5. X-rays should certainly be taken on indication and may be obtained routinely for those considered for Class III and IV work.

6. We are cognizant of the hazards of x-ray exposure and these shall be minimized on the advice of the experts in the field of radiation safety.

7. AP and lateral views constitute a basic screening exam but on indication, additional views should be taken.

8. Lastly, we recommend the continuation of ongoing studies and further studies in this field of both pre- and postemployment examination of the low back to try to help solve this trying problem with its many implications.

CHAIRMAN PRESENT: Dr. Reynold Brown will speak for the radiologists.

DOCTOR BROWN: We had 15 radiologists and we were blessed with some other disciplines of neuropsychiatry, radiation protection and radiation physics. We did not arrive at a unanimous opinion but I do believe that this in general was the consensus.

1. Radiologists can perform a variety of examinations to demonstrate the anatomical structure of the low back.

2. Radiologists should not be used as an administrative resource. They should serve as radiological consultants. As consultants they reserve the right to refuse consultation in individual cases, but in general, they recognize the right of the attending physician to arrive at the decision to request the examination. The radiologist reserves the right to design and perform the examination to answer the questions raised by the patient or the attending physician.

3. The conduct of the examination will be according to the state of the art to produce good quality radiographs and will include pertinent aspects of radiation protection.

4. The radiologists will prepare a written report of his examination and consultation.

5. Radiologists believe they are the most competent specialists to interpret the radiographs.

6. The radiologists in attendance by a vote of eight to three came to the conclusion that on the basis of the information presented at this conference, there is no medically predictive value in pre-employment or preplacement low back x-ray examinations that can be related to work assignments. This is not to imply that back anomalies are not associated with an increased rate of impairment during the patient's lifetime. This question was not thoroughly explored at this conference.

7. There may be some job situations where job stress may be important, such as certain railroad categories. The radiologists endorse the concept of a research project to determine the facts of this possibility. In the meantime, there are socioeconomic and medico-legal problems encountered by employers and employees that justify the continuation of pre-employment low back x-rays as part of a complete medical evaluation in these special industries and sub-classification. These programs should continue until research supports the discontinuation or modification of the practice.

DISCUSSION

CHAIRMAN PRESENT: Our three leaders will lead the discussion. If any one of them would agree to express one point which he feels common to all three reports, we might present it for your consideration and your response as a group. Dr. Brown, as the last speaker, summarized the radiologists' viewpoint and in so doing, crossed over all lines and had some ideas that were common to the two previous reporters. It was obvious that you said, and everybody else said, that pre-employment x-ray examinations as a routine procedure without patient history or physical examinations are common. Was this not true or in words to that effect?

DOCTOR BROWN: Not exactly. We said that we would like to see if they are common but we are not sure that they are. I think this is the most important question of the conference.

CHAIRMAN PRESENT: The statement I have just made was common to the other two. Is this not correct? Is this acceptable to radiologists to the best of your knowledge and not inconsistent with anything you discussed?

DOCTOR BROWN: Yes.

CHAIRMAN PRESENT: You have heard the remark that pre-employment low back x-rays are not by themselves total criteria for placement but are to be combined with an adequate history and physical examination.

DOCTOR TROUT: You used pre-employment and preplacement in the same sentence and in my mind there is a difference. I think one of the most important things to come out of this meeting is the idea of preplacement rather than pre-employment.

CHAIRMAN PRESENT: Let me rephrase it. Preplacement examinations by x-ray alone are inadequate but should be combined with an adequate history and physical.

DOCTOR NOER: I am perhaps a little parochial but we fought with semantics at some length in our group. I suggest perhaps that you go over the seven points suggested by the orthopedists and I think you will find the agreement you are looking for and hopefully the terminology.

CHAIRMAN PRESENT: The chair accepts this suggestion.

DOCTOR FORD: We concluded that no prospective employee should be rejected on the basis of x-ray interpretation alone of the low back.

DOCTOR KELLY: That statement somewhat implies that if an individual with a normal history and normal physical is examined and the x-ray examination is abnormal and the individual is rejected for employment, he is being rejected on the basis of the x-ray alone.

MEMBER: I agree because if a person had an x-ray of the spine that yielded a carcinoma or metastatic disease and his history and physical were completely negative, you would not be allowed to reject him on the basis of the x-ray alone. Thus, that terminology cannot really be used.

CHAIRMAN PRESENT: I don't believe we said that in the terminology. Repeat it, Dr. Ford.

DOCTOR RIEKE: The physical examination should be included in that sentence.

DOCTOR FORD: The wording is: No prospective employee should be rejected on the basis of x-ray interpretation alone of the low back.

CHAIRMAN PRESENT: Why can't we add the rest of the statement now and make it one statement? "A history and physical should be included in any adequate preplacement examination."

DOCTOR FORD: In No. 2 we stated: Pre-employment x-rays should not be done except as part of an evaluation, including a competent history and physical examination.

CHAIRMAN PRESENT: Why can't we combine them into one statement? Will that satisfy your objection, Dr. Kelly?

DOCTOR KELLY: No, because you say you are not going to reject an individual on the basis of x-ray alone and he is accepted on history, the physical and psychiatric findings and then you take an x-ray and change your mind from accepting him to rejecting him, you have rejected that individual on the x-ray findings alone.

DOCTOR COMPERE: You are leaving out totally the interpretation part of it. The pre-employment examination or rejection must be based upon interpretation of all facets of the examination and laboratory data including x-ray. That is the standard table. We call it pre-employment x-rays. We want the rejection or the acceptance to be based upon a medical evaluation of all data. The x-ray is part of the medical data. It is not normal. It is all put together and the patient is rejected after the diagnosis is made.

DOCTOR BROWN: Dr. Kelly is saying that in most programs this is actually practice. In order to save money, you go through the physical history and laboratory data and do the x-ray on only those people who have qualified up to that point.

DOCTOR BOND: Our group says in part (b) of No. 2.: Low back x-rays should not be used as a primary or isolated medical screening procedure for job placement. Does this help any?

MEMBERS: Yes.

DOCTOR BOND: There is a semantic problem. It came up in our mixed group yesterday that really what we mean is that we would not do an x-ray

and reject somebody without having done a physical and history and then interpret what we think of the whole picture.

DOCTOR MORETON: I think that what he is saying also is the fact that the man should not be rejected from a job but I don't think he is saying that if, after these things are done and one particular job he is applying for would appear to be hazardous, he could not be placed in a suitable job for his finding. If it is preplacement, then you are really trying to put the man in the job that all of these things together fit him to qualify for.

DOCTOR KELLY: That is true.

DOCTOR EYLER: Can we simply say that the radiographic examination is one portion of the entire evaluation? The spine with destructive lesions from metastatic carcinoma might well be equivalent to the urinalysis showing many red cells. Each item is a part of the total evaluation.

CHAIRMAN PRESENT: If I gather the consensus, we would like to say that in a preplacement examination, not a pre-employment -- this implies that we are placing this individual -- that preplacement examination should include a history, physical, laboratory studies and x-ray examinations, where indicated, without putting the phrase in that they must be taken or that they must not be taken. Is this not in essence what we are saying across the board? Is there objection to a phraseology close to that?

DOCTOR FREDERICK WILKINS: I suggest you use the term "the evaluation of persons for employment" because you are saying here that some are thinking preplacement and others are thinking pre-employment. We have restrictions as to whether we will give them the job or whether we will send them to another job. We are evaluating patients or persons for employment only, whether it is placement or whether it is restriction to job.

DOCTOR FORD: Our second conclusion was that pre-employment x-rays should not be done except as part of an evaluation including competent history and physical examination.

No. 2. No prospective employee should be rejected on the basis of x-ray interpretation without such history and examination.

CHAIRMAN PRESENT: All who feel that a statement of this type is warranted as a result of this conference, please raise their right hands. Those who feel opposed to such a statement. Let it be noted that everyone seems to favor it.

Now, the second statement that seemed common is a statement corollary to it. There is at the present time no agreement as to the value of the pre-employment examination as a means of predicting the work history of an individual, in all instances, at least. Was this not more or less common to all three?

DOCTOR BROWN: I am not sure it was common to the orthopedists.

CHAIRMAN PRESENT: The orthopedists had some type of comment along that line.

DOCTOR COMPERE: We were all in agreement that the state of knowledge, the current work that is reported in regard to the predictive value of a pre-employment low back x-ray examination, the data, statistics and so forth prove nothing really, are not significant in establishing whether the examination has predictive value or no predictive value. Our position is that there is not enough data one way or the other that is properly controlled. There is no follow-up on any of them.

We know that there are conditions that do cause by attrition and later on are more prominent but this has not been established statistically in the various job occupations.

MEMBER: The degree of predictability is certainly in grave question but there have been several occasions when individuals have expressed the belief that there is no predictive value.

With deference to the orthopedists' report today, they spent considerable time giving us revisions of the standards in the AMA tables. The very fact that they have made revisions in this table would certainly indicate that they do feel there is some predictive value. Otherwise, they would not have bothered making these revisions. They obviously feel that there are certain job categories that would seem the orthopedic complaints are incompatible data. Hence the revision of our tables here.

CHAIRMAN PRESENT: Would it be fair to say that as Dr. Compere implied, in the present state of our knowledge, there is no certainty that a pre-employment low back x-ray is a source of predictable job experience in the future?

DOCTOR LaROCCA: We as orthopedists do feel that there are certain problems which in our experience are associated with some degree of disability but that is feeling along. The issue is that there is no hard, concrete, statistical evidence in the literature to support the predictive value of a pre-employment x-ray in determining whether an individual will become disabled. So the differentiation I would like to call attention to is opinion versus statistically proven data.

DOCTOR FORD: I have to disagree with my colleague in that the changes in criteria, all of them, tend to liberalize the acceptance of people for employment. We added classes and we felt that there were too many conditions that we cannot predict will cause trouble in the future. Every change we made was one that was more liberal that Dr. Bond and his committee had made originally.

DOCTOR BOND: The problem is that when you say that it has not been shown that they are of value, it is not the same as saying that they have been shown to be of no value.

DOCTOR COMPERE: That is true. But I would like to comment on this revision. We said this because we had some knowledge of it. We were asked by Dr. Bond to go over it and we were interested in doing it and we

did it again in the orthopedic group for one reason. This was to use the knowledge that we had to develop this from our experience purely as a guideline that could be used but only in the spectrum of a complete physical and complete history and a medical evaluation applying to its use when pre-employment x-rays were taken on a medical prescription.

CHAIRMAN PRESENT: In an effort to compromise, would it be fair to say then that at the present state of our knowledge, it is evident that all pre-employment low back x-rays are not necessarily indicative of the future work habits or work abilities of the individual?

MEMBERS: No.

DOCTOR NOER: I think we are foundering on a difference between fact and opinion. What the orthopedists are saying is that we have some opinions as to what certain things may bring with the future. It is vital and we included a clause of basic research. It is vital that this be moved into an area of statistical fact and that has yet to be done.

Sometimes when you move opinion into fact, you find out what you thought you knew wasn't so. I doubt that very many of us are doing much cupping anymore but that was once standard medical practice. I think it is perfectly all right for us to go ahead on the basis of the expertise assembled here and to state what our opinion is just so long as we do not confuse the reader into thinking of it as fact.

CHAIRMAN PRESENT: Is anyone willing to draw up a statement relative to this, just a simple, one-sentence or two-sentence statement about the applicability to the future working habits of an individual out of a low back x-ray?

DOCTOR RIEKE: There is disagreement about the predictive value of the lumbosacral spine x-ray as to the future work performance or morbidity and we are concerned about both, not just the work performance. Most feel that there is empirical usefulness of the procedure in selected instances.

CHAIRMAN PRESENT: Do you like that wording or would you modify it, gentlemen?

DOCTOR COMPERE: I would like to say "lack of agreement" rather than "disagreement."

CHAIRMAN PRESENT: Are there any other comments relative to this? The principle is obviously well embossed on your minds so you all know what we are aiming for. It is just a question of stating it so that it is in agreement with your thinking.

If you agree with this, will you show me by raising your right hand, or a hand. Is there anybody who disagrees with this? You don't agree?

DOCTOR BROWN: No. Nobody attacked these papers as they were presented. We spent a day and a half listening to a gamut of papers representing the experience. I did not find them statistically invalid. They are

the best that have been done and the conclusion remains that on the information submitted to this conference, in these two days, we find no medically predictive value in pre-employment back x-ray examination relative to work assignments. No, that is a simple fact that you would have to draw from the material we heard at this conference.

If the orthopedists want to say that in spite of this they still have the opinion that they are work related or there is a strong possibility that they still are and they recommend research, that is fine. But I think to revert back to the opinions we brought when we came here destroys the day and a half we spent working here.

DOCTOR LaROCCA: I would endorse Dr. Brown's statement even though I am an orthopedist because I do not think that there is sufficient evidence to provide the information to suggest that these are predictable.

DOCTOR COMPERE: This just establishes the value of the motion that has just been carried.

DOCTOR KELLY: What was the second sentence in that motion? Didn't it say that most feel that there is some value?

MEMBER: There is lack of agreement about the predictive value of the lumbosacral spine x-ray films as to the future work performance or morbidity. Most feel that there is empirical usefulness of the procedures in some instances.

DOCTOR BROWN: The orthopedists believe.

CHAIRMAN PRESENT: Dr. Noer suggests a substitute.

DOCTOR NOER: We concur with the opinion that pre-employment, or pre-placement, x-ray evaluation may be very useful but recognize that such x-rays have yet to be proven clearly to be of statistically predictive value.

MEMBER: I have another minority opinion from the orthopedic group. I would agree with Dr. Brown and Dr. LaRocca. I would ask the chair to submit Dr. Brown's statement to the group.

DOCTOR BROWN: My colleague and I have been looking at my statement and possibly it does bring us together.

We came to the conclusion on the basis of the information submitted at this conference that we find no medically predictive value in pre-employment low back x-ray examinations relative to work assignments. However, this does not imply that back anomalies are not associated with an increased rate of impairment during the total life experience. This question was not explored at this conference.

In other words, we heard all of the problems related only to the work assignments but there was not a single paper presented that mentioned the rate of impairments in the total life experience of these people compared to the normal back.

DOCTOR NOER: I disagree with the last part of that statement. It is quite true that there was no formal paper on the first day. There was a great deal of discussion involving seven different discussion groups and much of the discussion in the two groups I was associated with did revolve around this precise point, so I cannot say that there was no data presented here, point one.

Point two, you are trying to write a standard or a state of the art statement and when you do that you have to take the outside case as well as the inside case.

I do not think anybody here would disagree with the cases that were presented the first day where the patient was shown to have a metastatic carcinoma lysing half the body of the vertebrae.

This was not a statistical predictive value. You know what is going to happen in metastatic carcinoma within the next five years and I don't think we have to have any long studies on this but unfortunately, that is the outside case. You can not say there is no predictive value overall without qualifying it.

DOCTOR SNOOK: Could we hear Dr. Noer's statement again?

CHAIRMAN PRESENT: "We concur with the opinion that pre-employment, or preplacement, x-ray evaluation may be very useful but recognize that such x-rays have yet to be proven clearly to be of statistically predictive value.

How many favor this statement over anything we have had to date?

MEMBER: I think we might add as a corollary the other statement that we recommend that further epidemiological and pathophysiological findings be done.

DOCTOR FORD: We said that in our conclusions in much simpler language.

CHAIRMAN PRESENT: I think this is the direction in which we are going. I envision this and I am not sure I am the one who should say this, that we are going to make a statement about whether it should be a universal procedure or not. We have done that.

What is the state of the art at the moment? How should we do it, if we do it? Should we take shielding and things of that sort into consideration? I am not trying to put words into these gentlemen's mouths. I am listening to them. In what direction should we go in the future if we have not answered the question completely now? Where do we go for help? In what direction should we recommend that we go? If we do no more than that, this meeting will have been more than worthwhile and I am sure that the committee will be more than satisfied and NIOSH, too.

It is extremely difficult to get a group of individuals to agree on words but it is easy to get them to agree on opinions. I think if no one person, including the chairman, tries to shape your ideas as to what your opinion should be, then we will be successful.

I think there is no agreement about being good and right and proper in the way in which an examination is taken and a statement seems to be common to all and certainly readily acceptable by the radiologists, that any radiological examination should imply minimal exposure to obtain the proper information and that that exposure should be made with adequate protection to the patient in all respects, including gonads, obviously.

That statement is very cumbersome.

DOCTOR BOND: I will read ours again if you would like.

Low back x-rays should only be done with the use of proper x-ray techniques based on current knowledge to insure good quality radiographs with the least radiation exposure.

DOCTOR BROWN: I think we might add to that to be perfectly acceptable, "including pertinent aspects of radiation protection."

CHAIRMAN PRESENT: All those in favor signify by raising a hand; those opposed to such a statement. (Consensus)

What other common ground do you gentlemen want as the fourth statement? We have made three now.

DOCTOR BOND: We should recommend a prospective study.

CHAIRMAN PRESENT: I think this is our last statement.

DOCTOR FORD: May I read again our statement No. 7 from the orthopedists? AP and lateral views constitute a basic screening examination but on indication, additional views should be taken.

I think you have already covered the matter of films of good quality in your statement. I was going to suggest that we state AP and lateral views of good quality but that would be redundant if that is in conclusion No. 3.

DOCTOR LaROCCA: The point is not to dictate to the radiologist in any way. The point comes from consideration of all of those things tabulated in the handout as being concepts of findings which would be in some way inimical toward hiring an individual for an occupation and in looking over that list, every one of those could be appreciated from AP and lateral. This would, therefore, make additional exposure unnecessary, except perhaps spondylolysis.

CHAIRMAN PRESENT: Do you think this could be a corollary to the third point in our conclusions, namely, that AP and lateral examination might well be considered adequate in most instances.

DOCTOR FORD: No.

DOCTOR BERNARD EPSTEIN: I think for the preliminary examination the AP and lateral is perfectly adequate but it should be within the province of

the radiologist, armed with clinical information as to just what the problem is, to supplement these views wherever he thinks it is necessary at the time he is examining the patient and this will vary from patient to patient.

The thing that the radiologists will object to will be a request slip stating: "Got a low back pain. Therefore, I want flexion extension turning them to the 10°." I think most radiologists would object to that.

We feel we are conducting a physical examination using roentgen rays. Therefore, it is not a technical process except that our technologists do it. The planning of this matter is a radiological matter. This should be done in conjunction and in consultation with our orthopedic colleagues to answer a question that they may have.

DOCTOR NOER: The reason for the terminology that we employed I think is important. I think once this is understood, the roentgenologists will have no objection.

We are caught between a couple of "potential legal traps." On the one hand, if you state that you are going to have a complete back series and in your area that comprises six films and all you are doing is a screening study with two films, you may find yourself in court because you didn't get an adequate series.

Hence, we stated that the minimum screening was an AP and lateral. The individual who does this for routine screening has something to fall back upon.

Then we hasten to add, without specifying, that for indication one does other studies in the individual case. For example, maybe the man had a back AP front to see whether he is stable, with bending films, or because the roentgenologists sees a lytic defect of the pedicle and wants to do tomograms, we have then gone on to say that for indication, one does what is necessary, in essence.

That is the reason why both of these things were stated. It is to protect the roentgenologists or whoever else is taking the films. In many cases he is not going to be a roentgenologist.

DOCTOR BROWN: When we meet with you in your conferences, we don't prescribe the method of your surgery. We don't want you prescribing the method of our consultation.

We want to reserve the right of the individual radiologist, even in his screening program. If he wants to use the flexion films that we saw yesterday that demonstrate the movement of the vertebral bodies, that is still a permissible thing at the screening level. We don't want this tight prescription at all.

Leave the conduct of the examination as previously stated that this would be a good quality film according to the state of the art, according to the needs of the program, and leave it in the hands of the man who is conducting the examination. We are not going to work by prescription.

CHAIRMAN PRESENT: I am a radiologist and I am thoroughly convinced that Dr. Brown is right, so the prejudice of the chair is quite obvious. On the other hand, I do know that radiologists like the shelter and protective attitude of Dr. Noer and his colleagues.

I would hope, frankly, that we wouldn't state the number of films and positions in any general report such as this.

DOCTOR FORD: Do you object to saying that a AP and lateral are the minimum number of films to be taken?

CHAIRMAN PRESENT: I do, personally, but that is out of the chair.

MEMBER: May I ask, how does the radiologist plan to recommend the screening x-ray for industry. What would they recommend to the medical director as to what x-rays should be taken? What information would you want to know?

DOCTOR BROWN: I would imagine that it might differ in Dr. Rogers' situation and it might differ in Eastman Kodak and I don't think in view of the time, we really want to go that far. I only wanted you to respect the expertise of the radiologist in his field as we respect your expertise in the conduct of your procedure and leave it in his hands to make that design.

It is very likely that the minimum will come out in AP and a lateral. This I don't deny and this is not the point at issue. It is the nature of the advice which we are receiving which we think is inappropriate to our consultation.

CHAIRMAN PRESENT: You are implying that if you state that it should be a proper and adequate examination with adequate protection, that this covers the matter without indicating the number of films.

DOCTOR NOER: One of the suggested wordings in our group was that of Dr. Marchisello who said, "biplanar x-rays." But I think it would be of more value to all concerned, however you use the terminology, to indicate that the single 14 x 36 film is not an adequate screening study.

CHAIRMAN PRESENT: I think that is accepted generally.

DOCTOR EPSTEIN: There is one medico-legal point that I would like to stress and that has to do with the danger of prescription.

If we receive a request slip notice,—I avoid the word "order"--if we receive a request slip that says do so-and-so and so-and-so and we do not do it and anything should turn up later, we become medically-legally liable because we did not follow the prescription sent to us by the referring physician. Consequently, the wording should be an adequate and a thoroughly adequate examination.

Nobody objects to that, but there are times when adequacy becomes superfluity and we should be able to determine that.

DOCTOR BOND: Wouldn't it be useful to the radiologists who aren't at this conference, and I suspect that this is an unusually competent and ethical group here but that may not describe all of your colleagues back home--would it be useful to them to have some kind of general statement because I don't think every place in the country works the way your client here does. The x-ray technician looks at the note he gets requesting an x-ray and does it, and then the x-ray man comes along in the afternoon and reads the film. This is probably as common as the way you are describing here.

So it might be useful, and I am just asking you if it would, for those people who will be doing them that aren't here to have some suggestion as to what your opinion is of a screening film. No symptoms and so on, just for job placement if, in fact, you agree with two films -- not one, not six--but two as the initial screening.

I think there might be some use for it, but again, if you disagree after that, I won't argue.

CHAIRMAN PRESENT: What other items of common ground would you like to present to this group before we get the the question of projection?

DOCTOR BROWN: We think the next most important one is the one we talked about, the socio-economic and medico-legal problems that govern our society today.

There are some socio-economic and medico-legal problems encountered by employers and employees in some industries where pre-employment low back x-ray examination should continue, on this justification.

DOCTOR BOND: We had a statement. This was one of the addenda in our group. There are barriers to employment and to rehabilitation and re-employment of persons with low back problems due to workmen's compensation laws and of certain federal and state laws and regulations as well as in management and union rules and procedures.

Certain of these nonmedical factors will influence the use of low back x-rays as a preplacement screening procedure.

CHAIRMAN PRESENT: That is a good statement. Is there anybody who objects to it?

Let's put it on the negative now. Is there anybody who objects to including this as a portion of our conclusions?

If not, we will include it as the fourth item. It also implies, and I think importantly, that modification of these compensation laws and rehabilitation programs as John Schwartzmann and others spoke to the matter, might well be indicated and it might be a good thing if this conference stresses such an objective as one of its points.

DOCTOR FORD: On that same line, our items 4 and 5 stated it a little more simply but were not as all inclusive.

We stated: X-rays should not be done routinely, but rather on indication in those examined for Classes I and II.

And I can combine this into one statement and simply say they may be obtained routinely for those considered for Class III and IV work.

CHAIRMAN PRESENT: I am wondering if you aren't cluttering a little bit, Dr. Ford, when we have said before that, where indicated, they should be used, and if we want to expand further on what is already in, and we have that statement already in. Perhaps that can come out in a future publication relative to this.

DOCTOR NOER: We had a worry which I will invite your attention to. I don't know how you are going to solve it. That is how we solved it.

Very few of us conduct histories and physicals and mandatory back x-rays on the girls we hire to be our office secretaries. But suppose NIOSH takes this thing home. It becomes incorporated in Department of Labor practices. It is picked up by state legislatures and do you suppose maybe five years from now because of the deliberations of this meeting we find ourselves required to examine the 16-year-old daughter coming to work in the summer in mom and pop's grocery? Are we going to have to examine our secretaries?

I am getting out of business, don't you see? This may very well snowball. This is why, at least, I advocate stating that the physical examination is optional, whatever term you want to use, in Class I, Class II employment.

I can't see that physical examinations are vital except for reasonably heavy or heavy laborers. If you say otherwise, you may very well find that you are conducting physical examinations on all the people that you employ in the future and that I think might be more than the medical profession in the country could handle because there are an awful lot of them.

DOCTOR A. RUSSELL HOOVER (NIOSH): NIOSH is not so susceptible as to include all of these things immediately into a material document.

DOCTOR NOER: We all know how these federal things grow.

DOCTOR HOOVER: So far, the results of this conference have been kind of a parochial squabble on some mandates and there really isn't anything specific to help some of the people that I have encountered who have asked for help in the low back problem.

I really find it rather confusing so I think that maybe we should confine ourselves to recommending the direction in which we should go in research if we can't agree more closely on what we are saying.

MEMBER: I thoroughly agree with the spirit of what Dr. Ford said. We in industry have to use such criteria regularly but to put this in a recommendation specifying classifications has great hazard to us as brought

out by one of the speakers earlier this morning. Our employee populations now are not categorized in these classifications permanently. As has been brought out so dramatically, the young girl who is a switchboard operator may be up the telephone pole and on your TV set next.

We have similar things in our industry and all other industries are having the same. So to categorize, as such, the spirit is right, but to be specific on our recommendations, I think we would have difficulties in living with them from a practical point of view.

DOCTOR NOER: If you make the physical examination for Class I and II employees optional, then that provides you as the company's physician saying: "All right, in our firm we opt to examine all of them." It doesn't take it away from you but it permits the hospital, for example, which is hiring a secretary, to opt not to do it. That is precisely why we said optional.

It doesn't keep you from examining everybody if you want to but I think it is important that it be specified, whatever terminology you want to use, that for those desk and/or light labor, physical examination is optional.

You actually represent a very small segment of the labor market. We are talking here about heavy industry, railroads, mines and so forth and so on.

I have left out the farm laborers. We have left out the government workers. We have left out the mom and pop firms of all varieties. We have left out all the small businessmen. We have left out the largest occupational group which is the housewife and I think that when you start writing regulations, it had better not be tailored to General Electric.

CHAIRMAN PRESENT: Could I have a reaction? How many people feel that we should make a statement as to the application of physical examinations to specific classes of work. All those in favor; those who are opposed to it. We will omit it.

It seems we have come pretty much to the recommendations for further activities on the part of NIOSH or whatever agency should do it and there were some pretty good statements as to the direction in which prospective studies might be done.

DOCTOR BOND: Because of the lack of knowledge about the value of preplacement low back x-rays in preventing low back injuries, it is recommended that NIOSH design and implement a prospective study of this subject with the assistance of the Industrial Medical Association and other appropriate resources to determine if information learned from low back x-rays are, in fact, useful in predicting low back pain and/or injuries.

CHAIRMAN PRESENT: Comment on that phraseology, that idea? Did you wish to accept it as stated?

DOCTOR FORD: We recommend the continuation of ongoing studies and further studies in this field of both pre- and postemployment examination of the

low back to try to help solve this trying problem with its many implications.

CHAIRMAN PRESENT: You have heard two different opinions relative to the proper phraseology for future work. One was specifically directed toward NIOSH.

DOCTOR ALAN PURDY: I think if you are serious about getting some government help on this, funds are very hard to come by right now. If you specifically name us, this will give us a tool to work with to break loose some funds. That is all.

I think a general recommendation would probably be fine under other circumstances but if you want the money from us, let us know.

MEMBER: The suggestion that Dr. Ford just made was very similar to one that was made by Dr. Bond's committee nine years ago, very general, and we can see where we are nine years later. We haven't been able to shed that much more light on it. I would be in favor of being much more specific about who we recommend to help us out on this.

CHAIRMAN PRESENT: I have one other item that I want to bring to you, if I may. I don't know whether it belongs in here or not because we were defined as trying to find out something about pre-employment low back x-rays but much comment has been made about the human side of this thing and the future of the rejected individual. Does this belong in here in any way? I don't think so, but I wonder.

I am going to ask Dr. Loop to speak relative to a project of the College's.

DOCTOR JOHN W. LOOP: I just want to make you aware of a project that the American College is undertaking in looking in a very broad way at some of the more specific problems that have been dealt with in this conference. That is, is it possible to estimate by sampling and across the whole spectrum of x-ray examinations, why x-ray examinations are performed on the one hand and what radiology contributes to patient care on the other hand? Within the context of this very broad problem, the pre-employment back becomes only a small segment.

In order to manage the present program, which looks only at the possibility of dealing with the problem, we have chosen some areas of the body or general kinds of examination to investigate.

One of these is the lumbar spine and Dr. Reynold Brown has agreed to head a task force to look into the methodology by which these broad questions might be defined and investigated.

I call this study to the attention of the group only to hope that some of you might choose to help us, to cooperate in both the design of data collection instruments and in pilot studies to explore problems in communication and problems in preliminary data handling.

CHAIRMAN PRESENT: Mr. Gitlin has some ideas about designing a program.

MISTER JOSEPH GITLIN: Since I am with the Bureau of Radiological Health and the direction that this group has taken is to say to NIOSH that future work might be sponsored by that organization, it may be a little out of order for me to speak to the subject, but let me take off my hat and talk only as a statistician.

During the discussion, and I was very impressed with the data available and the possibilities that they provide for designing future studies, it occures, at least to me, that a future study can be designed specifically to answer the single question as to the predictability of the low back examination related to future work experience or back injury.

It is not an easy problem. It will, if it is done in a traditional controlled experimental fashion, require some intercession which may not be acceptable to the necessary participants but at least intellectually and theoretically, it can be done.

I will offer consultation to the interested group on behalf of myself, and I think Dr. Cole, and I think the Bureau of Radiological Health, and certainly we will expect to work as closely as we have with the NIOSH people if anything does come of this proposal.

CHAIRMAN PRESENT: It couldn't be better and I assure you if any good is coming from it, we are going to have to go to you and look for your help.

DOCTOR PURDY: If you would care to modify that bureau request for help to include the Bureau of Radiological Health, this would be great. We work with them all of the time. We have joint contracts and so on. There is no problem.

CHAIRMAN PRESENT: I can see no reason to object to it and I assume that I voice the feeling in this group.

DOCTOR THOMAS: There might be some objection to it on the basis that immediately the emphasis would be converted to the radiation aspects, and the radiation aspects are well known, whereas, the clinical and applied and future aspects are not. I don't object to cooperation but I would object if this produced a change in the emphasis of the program.

DOCTOR LOUIS B. ARNOLDI: I am greatly impressed with the way the whole program was conducted. I feel that we should not lose the momentum of this conference. There are certain extrapolations brought out that are required to really get into the heart of the problem. We should utilize the skills and the ability of the people who participated with a continuing committee to bring together the radiologists, the orthopedic surgeons, the industrial health physicians, the human factors people and the statisticians to take the projection that this conference has implied and then incorporate that into some kind of a feedback group so that all of you should get this information back again and not lose this momentum.

CHAIRMAN PRESENT: I am wondering how we could ever do that if we really want to. There are a lot of us who have felt that quite a bit of energy was put into this meeting, whether it has produced great results or not,

but perhaps we can contact one another through the organizations involved and see what projection there might be for future activities.

We certainly accept your suggestion, Dr. Arnoldi.

Now it is my pleasant task to thank Otha Linton whom you all know has worked very hard, and his staff, and to thank the medical organizations who referred you to us and those of you who accepted the invitation. I want to call your attention to the fact that our aims were awfully high. Our objects were high. It is quite obvious that this is a many-faceted problem. It is one that nobody even anticipated solving and I think we have gone as far, and certainly further, than we had hoped for.

The time is always too short and yet if it is any longer than this, it is too long. So there is no balance; there is no happy medium. Maybe the future with a carryover from this and a combined activity, perhaps a liaison of a close type, will provide us with an opportunity.

CONCLUSIONS

1. Radiologic examinations of the lumbar spine may be an appropriate part of pre-employment or preplacement physical examinations for prospective employees where company policy or experience indicate their value. Such x-ray studies should be made in conjunction with proper histories, physical examinations and other appropriate diagnostic procedures. They should not be utilized as a sole screening method in the absence of other clinical modalities.

2. The incorporation of an x-ray examination of the lumbar spine in a pre-employment assessment of an individual is valuable in assessing the current status of the individual's spine but less positively valuable in predicting the possible trauma or disability which might result from that individual engaging in a physically stressful occupation.

3. The feelings by many physicians that lumbar spinal x-ray examinations can have a predictive value in assessing the reaction of an individual to physical stress are based primarily upon clinical observation, rather than statistical or other documentation. There is a need for the development of appropriate clinical and statistical studies to demonstrate the presence or absence of correlations between x-ray findings and subsequent development of spinal disabilities.

4. On the basis of clinical judgment and experience, it is possible for an industrial organization to devise protocols for its own use in determining the physical characteristics of prospective employees which appear to be useful both to the prospective employee and to the organization. However, there is little in the literature to indicate that x-ray findings should be given more prominence than other basic procedures in such assessments. There is need for much further study of the entire problem.

5. While parameters of the extent of lumbar spinal x-ray examinations can be suggested by physicians seeking consultative assistance, the final determination of the optimum execution of the procedure should be left to the radiologist or other physician responsible. In no case should the x-ray examination involve fewer than antero-posterior and lateral projections.

6. The physician responsible for the performance of lumbar spinal x-ray examinations should be cognizant of the imperative need for good radiation protection practice. Gonadal shielding should be used, particularly for male patients.

7. The extent of the problem of low back ailments, injuries and disabilities in various types of occupations and industries is sufficient to warrant the continuing attention of the medical profession and of responsible public agencies, particularly those charged with public health responsibilities for occupational programs.

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