Revaccination Against Smallpox

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REGULAR REVACCINATION against smallpox is necessary to protect persons with a higher risk of exposure than usual, such as hospital personnel. The necessity for maintaining a high degree of protection against the disease has been illustrated by several epidemics occurring almost exclusively among hospital employees.

However, regular revaccination of a group of employees induces several practical problems. The percentage of positive reactions, which strength vaccine to use, and the number and severity of complications are important factors which must be considered when a vaccination program is being planned and executed.

To determine the practical importance of these factors, a study was undertaken on the results of the continuous revaccination program against smallpox at the Hospital for Infectious Diseases in Stockholm. In this paper revaccination refers to vaccination of a person who has been vaccinated earlier. The term "repeat revaccination" is used for revaccinations when the first revaccination was unsuccessful.

Method

All persons employed at the Hospital for Infectious Diseases are required to be revaccinated once a year. The hospital employs about 390 persons, mainly women. As the annual rate of turnover among employees is fairly large, about 150 new employees with varying time periods since last vaccination are added to the regular staff which was vaccinated the previous year.

Smallpox vaccination during childhood is compulsory in Sweden, and unvaccinated persons are therefore only rarely encountered. No previously unvaccinated persons were included in this study. Persons in this study were vaccinated at the hospital from 1964 through 1967.

All vaccinations were given on the upper left arm with the multiple-pressure technique. Two vaccines with different potencies were used. One with the titer of about $10^{7.4}$ $TCID_{50}$ per milliliter is referred to as ordinary vaccine, and the other with the titer of about $10^{8.1}$ $TCID_{50}$ per milliliter is referred to as strong vaccine (*1*).

Immediately after the vaccination and before the vaccine had dried, the vaccination site was covered with a plastic film (*2*). The procedure did not influence the number of positive reactions as compared with the traditional gauze pad dressing. Either a staff nurse or I vaccinated all the persons in this study.

Generally, any person who had reacted positively within 5 years was vaccinated with the strong vaccine. If the vaccinee had had a strong reaction, or if the patient expressed some concern about the vaccination, the ordinary vaccine was used.

The results were read 4–8 days after the revaccination by the person who gave it. A revaccination was considered positive only if a crusta of at least 1 mm. in diameter was observed. Vesiculation or induration of the vac-

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cination site was not registered as a positive reaction. Repeated revaccinations were given all persons with negative reactions.

To study complications, the number of days absent due to smallpox vaccination was obtained from the payroll department. As no deduction from salary was made for absence due to vaccination, a strong motive existed for persons absent due to complications to report this diagnosis.

I saw all persons absent due to complications from vaccination. A detailed study of the vaccination history was made for persons absent in 1966.

Results

Of the 1,931 persons revaccinated, 1,894 returned for the results to be checked within the stipulated time. The remaining 37 persons (1.9 percent of the vaccinees) either returned at a later date or terminated their employment at the hospital.

The percentage of negative reactions to the ordinary vaccine was generally larger than the percentage of negative reactions to the strong vaccine (table 1). In the group which had been revaccinated 1 year previously, 30 percent of the persons revaccinated with ordinary vaccine and 15 percent of those vaccinated with strong vaccine had negative reactions. The group who had their last vaccination more than 5 years previously were revaccinated with the ordinary vaccine, and 26 percent of these persons had negative reactions.

The number of repeated revaccinations required to obtain a positive result is shown in table 2. The majority of persons with negative reactions required only one repeat revaccination although some vaccinees required up to four revaccinations before a positive result was obtained.

Of the 1,931 persons vaccinated, only 19 vaccinees were absent for a total of 85 workdays. The number of persons absent was very low compared with the number vaccinated, and no person was absent for more than 5 days. The proportion of vaccinations to absence days averaged 23 to 1.

When the case histories of persons absent in 1966 were studied, I observed that all absentees had been vaccinated with the ordinary vaccine and that their last previous vaccination had occurred during childhood. The reasons for the absenteeism generally were localized swelling of the vaccination site, headache, and fever. No serious complications were observed.

Comments

In this study the proportion of vaccinees with positive reactions was in general agreement with the observations during earlier investigations (*3*). The increase in the number of positive reactions observed in this study in relation to increased potency of the vaccine is also consistent with earlier reports.

Of special interest in this connection is that the percentage of negative results after vaccination with ordinary vaccine is about the same in persons vaccinated 1 and more than 5 years previously. The same was true concerning the strong vaccine if the persons vaccinated 1 year previously were compared with persons vaccinated 4 years previously.

Statistical analysis of results of repeated revaccinations show that although the majority of vaccinees had positive reactions after the first repeated vaccination, almost a fifth of the persons reacting negatively required two repeated revaccinations and about one-tenth required three or more repeated revaccinations. One person still reacted negatively when, after six revaccinations, she terminated her employment at the hospital.

The participants in this study were absent fewer days than the hospital employees in an earlier study (*3*). In the study I reported on in 1962, 11.9 percent of the vaccinees were absent as compared with 1 percent in this study.

The reason for this difference probably is that the study in 1962 included more persons who had not been vaccinated since childhood, whereas the majority in this study had been vaccinated the preceding year. This assumption could not be verified, however, because no histories of previous vaccinations were taken in the 1962 study. In a study of 2,417 persons reported by Smith and associates (*4*), the rate of absenteeism, 0.5 percent, was in accordance with the rate observed in this group.

The absence of severe complications among persons in this study probably is related to the large proportion of persons who had a recent

Table 1. Negative reactions of hospital personnel after revaccination against smallpox, by number of years after last positive reaction

Years since last positive reaction	Strong vaccine			Ordinary vaccine		
	Persons vaccinated	Negative reactions		Persons vaccinated	Negative reactions	
		Number	Percent		Number	Percent
1	1, 123	170	15. 1	96	29	30. 2
2	181	44	24. 3	28	5	----------
3	125	18	14. 4	27	6	----------
4	74	11	14. 9	12	3	----------
5	2	0	----------	16	2	----------
Over 5	0	0	----------	210	55	26. 2
Total	1, 505	243	16. 1	389	100	25. 7

successful revaccination. This observation is in agreement with the results reported by Bengtsson and co-workers in their study of 192 persons with complications after smallpox vaccinations (*5*). Among these patients were 68 who had been vaccinated for the first time, 90 who had been revaccinated more than 20 years previously, and only 16 who had been vaccinated within the preceding 10 years. Complications in these patients occurred at a time when approximately 300,000 persons in Stockholm were being vaccinated in a voluntary mass vaccination program in connection with the smallpox epidemic of 1963.

Conclusion

Revaccination against smallpox can be undertaken using a vaccine with a titer of about $10^{8.1}$ $TCID_{50}$ per milliliter without risking severe complications or absenteeism if the patient has reacted positively to vaccination within the past 5 years. Use of the stronger vaccine reduces the proportion of negative results, and hence reduces the workload of health personnel who give the vaccinations.

Complications can be expected mainly among persons vaccinated more than 5 years previously, and they will occur even when vaccine with a titer of about $10^{7.4}$ $TCID_{50}$ is used. Use of still weaker vaccine might be considered for these persons, even if the percentage of negative results should increase over the rate of negative reactions reported for the participants in this study.

Table 2. Repeat revaccinations required to produce positive reaction in persons with a negative reaction after revaccination with strong vaccine

Revaccinations	Years since positive reaction			Total	
	1	2	3	Number	Percent[1]
Negative reactions	160	33	8	[2] 201	99
1 repeat revaccination	115	24	6	145	72
2 repeat revaccinations	28	7	2	37	18
3 repeat revaccinations	11	1	0	12	6
4 repeat revaccinations	6	1	0	7	3

[1] Did not add to 100 because of rounding.
[2] 42 persons terminated their employment and hence were lost from the study.

Summary

Results from revaccination against smallpox were studied in 1,931 hospital employees given compulsory vaccinations 1964–67 at the Hospital for Infectious Diseases, Stockholm, Sweden. Vaccine with a titer of about $10^{8.1}$ $TCID_{50}$ per milliliter was used for persons who had reacted positively to vaccination within the preceding 5 years. The vaccinator observed and recorded the vaccinee's reaction. Formation of a 1-mm. crusta was considered a positive result.

About 15 percent negative reactions were obtained with the vaccine with a titer of about $10^{8.1}$ $TCID_{50}$ per milliliter compared with 30 percent negative reactions obtained with vaccine having a titer of about $10^{7.4}$ $TCID_{50}$ per milliliter. The majority of complications occurred among persons vaccinated with the less potent vaccine and those who had had their last

positive reaction to vaccination during childhood.

Use of the more potent vaccine for revaccination of persons vaccinated within 5 years is recommended to decrease the number of negative reactions.

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Decline in Births Slows in 1968

The National Center for Health Statistics has released provisional estimates on births for 1968. Births in the United States totaled 3,470,000, the fewest since 1946. Marriages continued to rise, reaching 2,059,000 in 1968.

Although the number of births in 1968 was 19 percent below the record total in 1957, it was only a little more than 1 percent lower than in 1967. This represents the smallest decline since 1963–64. The number of marriages in 1968 was the second highest on record and nearly 8 percent higher than in 1967.

The 1968 birth rate, 17.4 per 1,000 total population, continues the decline from the 1957 peak of 25.3. It is the lowest rate ever observed in the United States.

The fertility rate, the number of births per 1,000 women in the reproductive ages (15–44), was 84.8 in 1968. Although the fertility rate also has been declining since 1957, it is still well above the rates of 76–79 during the period 1933–39.

Presently, women 15–44 years old constitute only 20 percent of the entire population, as compared with 24 percent in the 1930's. As a result of the decline in this proportion, the substantially higher fertility rate of today's women is only large enough to maintain the birth rate per 1,000 total population at a level that is somewhat lower than that of the 1930's.

Another factor in the decline in the birth rate from 1957 to 1968 is a drop in the unusually high rates observed at the older childbearing ages, 30 and over, during the 1950's. These high rates were caused by the making up of births postponed by couples who were in the early childbearing ages during the late 1930's and early 1940's. The couples who followed them are now having lower birth rates at the older childbearing ages because they tended to marry earlier and have their children sooner after marriage.

Also, there has been a drop in birth rates among younger couples. This trend is believed to be caused partly by a tendency toward wider spacing of births and partly by a decline in the total number of children wanted.

Currently the number of young women is rising rapidly. In mid-1968 there were 14.3 million aged 20–29, the age group in which childbearing is most heavily concentrated. According to projections by the U.S. Bureau of the Census, this number will rise to 15.5 million by 1970 and to 18.3 million by 1975. Unless age-specific birth rates fall well below their present levels, the projected changes in the number of women will tend to raise the number of births. But even though the decline in age-specific birth rates has slowed down, it has still been sufficient to more than offset the effects of the increasing numbers of young women thus far, and it is difficult to determine precisely when the decline in the annual number of births is likely to end.

The marriage rate of 10.3 marriages per 1,000 population in 1968 was the highest since 1951. The current "marriage boom" is related to the high numbers of marriages and subsequent births during the period immediately after World War II. As a result, the number of youths moving into the marriageable ages has increased rapidly. In the U.S. resident population there were 4.9 million more persons in the age group 15–19 in 1968 than in 1960 and 4.3 million more in the age group 20–24.