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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

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HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 75-151-259

WINCHESTER HOSPITAL
WINCHESTER, MASSACHUSETTS

JANUARY 1976

I. TOXICITY DETERMINATION

An environmental survey was conducted at Winchester Hospital in Winchester, Massachusetts on September 29 and 30 and October 1, 1975 to determine the concentrations of waste anesthetic gases and vapors to which operating room personnel were being exposed. The toxicity of waste inhalation anesthetic gases has been demonstrated in animal experiments and from epidemiologic studies. Present technology does not allow anesthetic gases to be completely eliminated from operating room air without compromising safe anesthetic administration practices. However, the health hazard can be minimized by ensuring that specific work practices be followed to reduce leakage of gases, and by establishing scavenging techniques to collect and dispose of waste anesthetic gases. It has been reported that concentrations of 30 ppm of nitrous oxide and 0.5 ppm halothane are attainable during the routine use of inhalation anesthetics, where the anesthesia equipment is free from leaks and scavenging techniques have been established which collect and dispose of the waste gases. At Winchester Hospital scavenging is accomplished by allowing the waste anesthetic gases to pass through a charcoal canister. This would adsorb the halothane vapors but not the nitrous oxide. On the basis of environmental sampling, it has been determined that concentrations of nitrous oxide measured in the operating rooms greatly exceed 30 ppm. It has been further demonstrated that concentrations of halothane are usually in excess of the 0.5 ppm level, and recommendations for effective control of both of these anesthetics are included herein.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are available upon request from Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

a) Winchester Hospital, Winchester, Massachusetts
b) U.S. Department of Labor - Region I
c) NIOSH - Region I

For the purposes of informing the approximately 80 "affected employees" the employer shall promptly "post" the Determination Report in a prominent place(s) near where exposed employees work for a period of 30 calendar days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, U.S.C. 669(a)(6) authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health received such a request from the Chief of Anesthesiology of Winchester Hospital regarding exposure of operating room personnel to waste anesthetic gases in the operating rooms. There were no specific alleged health problems at the time that the request was generated. The recognition of the potential health hazards associated with chronic exposure to anesthetic gases was primarily responsible for the health hazard evaluation request.

IV. HEALTH HAZARD EVALUATION

A. Conditions of Use

Winchester Hospital is a 200-bed private hospital built in 1912. The surgical suite was built in 1952 and enlarged in 1961. It includes four rooms for major surgery and one for minor surgery as well as several scrub rooms, storage areas, lounges, and a recovery room. Approximately 25 operations are performed each day. The staff includes 28 nurses, 5 anesthesiologists or nurse anesthetists and about 50 surgeons, and on most days there are about 35 persons working in the operating rooms. Five categories of operating room personnel may be present during an operation: the surgeon, the anesthesiologist or nurse anesthetist, scrub nurse, circulating nurse, and surgical technician. The number of people on any given surgical team depends on the operative procedure being performed.

Halothane (2-bromo, 2-chloro, 1,1,1-trifluoroethane) and nitrous oxide are the general anesthetic agents currently in use at Winchester Hospital. Nitrous oxide and oxygen are piped in from outside the rooms at controlled flow rates. These are combined in approximately a 50:50 ratio, but this may vary up to a 70:30 ratio of nitrous oxide to oxygen. Halothane, which is a liquid, is vaporized in the anesthesia machine to form a mixture in the range of 0.75% to 3% halothane in combination with the nitrous oxide/oxygen mixture. This entire anesthetic mixture is then delivered to a face mask or endotracheal tube at a rate varying from 4 to 8 liters per minute. The exact concentrations of anesthetic gases are varied during a procedure, with higher concentrations required during induction than during maintenance of anesthesia. Exposures of medical and technical personnel depend not only on the concentrations of gases used, but also on the individual anesthetist's technique, the length of the surgical procedure, type of operation, and on their proximity to the anesthesia equipment. The principal source of exposure is leakage from the anesthesia equipment.

The anesthetic circuit is composed of the anesthesia machine and the breathing system. The gases and vapors are combined in the anesthesia machine, then are delivered to the breathing circuit, consisting of a soda lime canister (to absorb exhaled carbon dioxide), breathing bag or ventilator, valves for assuring unidirectional gas flow, flexible hoses and a Y-piece terminating in an endotracheal tube or face mask. The anesthetic gas mixture is delivered at a rate greater than the patient's metabolic need. Where a breathing bag is used, excess gases are vented out of the breathing system through the pop-off valve. The volume of gases and vapors escaping through the pop-off valve are highly variable, as they depend on the patient's breathing pattern and metabolic rate, as well as the flowrate of gases from the anesthetic machine. While a ventilator is in use, the pop-off valve of the anesthesia machine is closed, and the ventilator assumes the function of the pop-off valve. The pop-off valve and ventilator are the major sources of leakage of waste anesthetic gases. Other sources are the face mask or endotracheal tube, cracks or holes in the hoses, through fittings and seals, or from spilled liquid halothane. Scavenging systems can effectively reduce the amounts of gases and vapors escaping into the operating room air. At Winchester Hospital, the pop-off valves were connected with canisters of activated charcoal to adsorb halothane vapors. These were attached via lengths of rubber hosing and hung to floor level. Canisters were reportedly changed twice each week. Nitrous oxide is not adsorbed onto the charcoal and therefore is released into the operating room air.

Separate but similar ventilation systems serve the operating rooms built in 1952 and those added in 1961. Fresh air is brought into each room from the outside at the ceiling level and is exhausted from a wall vent close to floor level. There are reportedly four air changes per hour; some preliminary ventilation measurements suggest that the actual rate might be slightly higher.

B. Evaluation Design

A preliminary observational survey of the operating rooms was conducted on September 29 by a team of four NIOSH industrial hygienists. During the following two days, breathing zone and general area samples were obtained for halothane and nitrous oxide. An average of four employees per operating room, including the anesthetist and surgeon in almost all cases wore Sipin pumps and charcoal tubes. Several area samples were also obtained. Where-ever feasible, the tubes were changed after each surgical procedure and were sent to the Analytical Research Laboratories, Inc., in Monrovia, California, where they were analyzed for halothane by gas chromatography. Sample results are presented in Table 1.

Anesthesiologists also wore a MSA pump modified for bag filling with a 30-liter Mylar bag attached. Air was drawn from the breathing zone via a 3-foot length of Tygon tubing, the bag was removed after each operation, capped off and a new bag was attached. Area samples were similarly obtained, pumps and bags being situated in trays near the walls of the operating rooms. Analysis for nitrous oxide followed almost immediately, using a Wilks Miran I Infrared Analyzer. Analyses were performed at a wave length of 4.48 micrometers and a pathlength of 5.25 meters, unless otherwise noted in the table of results. Nitrous oxide concentrations are also shown in Table 1.

C. Evaluation Criteria

1. Toxicologic Effects

Until recently, nitrous oxide was considered to be a simple asphyxiant without other significant physiologic effects. No standard has been set for occupational exposure to halothane either. Both of these chemicals have been selected for use in surgical procedures because of their abilities to produce narcosis or unconsciousness in sufficient concentrations. Much less is known about the effects of subanesthetic concentrations. Animal experiments, epidemiologic studies, and a recent NIOSH investigation are now providing evidence that chronic exposure to low concentrations of inhalation anesthetics may be a health hazard.

The teratogenic effects of nitrous oxide have been demonstrated in developing chicks and rats when pregnant animals were exposed to nitrous oxide in anesthetic concentrations.[1,2] Other animal experiments have shown the embryotoxicity in the rat of chronic exposure to low concentrations of nitrous oxide.[3] Nitrous oxide has also been associated with hematopoietic effect, including leucopenia and bone marrow depression.[4]

Halothane has similarly been shown to have teratogenic effects on developing chick embryos.[1] Subanesthetic halothane exposures have produced increased liver:body weight ratios and centrolobular hepatic fatty metamorphosis in other toxicologic experiments.[5,6]

There is also evidence from human exposures that anesthetic agents are potentially toxic. Since other halogenated hydrocarbons are known to be capable of producing liver damage, the hepatotoxicity of halothane has undergone comprehensive review. A committee on Anesthesia of the National Academy of Sciences-National Research Council reviewed several reports associating halothane anesthesia with post operative hepatic necrosis, but concluded that this was limited to certain hypersensitive individuals and that the actual incidence was very low.[7]

Epidemiological studies have also provided evidence on the toxicity of nitrous oxide and halothane. Increased incidences of headaches, fatigue, irritability, spontaneous abortion, and abnormal pregnancies were reported in a study of Russian anesthesiologists who used primarily nitrous oxide and ether.[8] Obstetric histories were obtained from 563 married women anesthetists and 828 women physician controls in the United Kingdom. It was determined that anesthetists working during pregnancy had an increased ratio of spontaneous abortions to live births and an increased frequency of congenital abnormality in live births. Women anesthetists also had a higher incidence of infertility than the control group.[9] The most comprehensive study was conducted by the American Society of Anesthesiologists Ad Hoc Committee on Effects of Trace Anesthetic Agents on Health of Operating Room Personnel.[10] Questionnaires were mailed to 49,585 exposed operating room personnel and 23,911 control persons. The exposed and unexposed groups were compared to determine whether there were important differences in occurrence rates of spontaneous abortions, congenital abnormality rate, cancer rate, hepatic disease rate, and renal disease rate. Spontaneous abortion rates were found to be higher among women working in the operating room that in comparable unexposed women. The congenital abnormality rate was found to be higher both for exposed women and for wives of exposed men than for their unexposed counterparts. Exposed women were also found to have an increased risk of developing cancer and renal disease than the control groups. Both male and female operating room personnel had significantly higher frequencies of hepatic disease than unexposed groups. Although it was recognized that other variables could account for these increased risks in disease rates, it was concluded that the exposure to waste anesthetic gases in the operating room was the proabable cause.[10]

2. Environmental Standards

Since there is insufficient data to correlate exposure concentrations to toxic effects, no standard limiting exposure to waste anesthetic gases has yet been put into effect. Exposure guidelines have therefore been formulated based on limiting exposure through technology designed to remove the waste gases and vapors from the operating room environment. A group of professors from Stanford University, working under a NIOSH contract, evaluated methods for eliminating waste anesthetic gases and vapors.[8] They concluded that effective control of the waste gases could reduce concentrations to less than 30 ppm of nitrous oxide and less than 0.5 ppm halothane during the routine use of inhalation anesthetics.

D. Evaluation Results and Discussion

The results of environmental sampling are presented in Tables 1 and 2.

Concentrations of nitrous oxide measured in the operating rooms at Winchester Hospital ranged from non-detectable levels to 3000 ppm with a median value of 540 ppm. The highest concentration was measured in the breathing zone of a nurse anesthetist during a laminectomy, in which the nitrous oxide:oxygen ratio was 4:2. Concentrations measured in the breathing zones of the anesthesiologist or nurse anesthetist were consistently higher than concentrations from general area samples. Sampling pumps for area samples were usually located on a tray by the edge of the room (the largest room was approximately 20 feet x 20 feet). Only three measurements did not exceed the recommended concentration of 30 ppm: one of these was from a sample obtained in the corridor and the other two were measured during a surgical procedure in which general anesthesia was not used. Approximately half of the measurements were between 400 and 700 ppm.

Halothane concentrations as high as 20.26 ppm were measured but the median value was only slightly higher than the recommended 0.5 ppm, with the majority of measurements falling between 0 and 1.0 ppm. The highest concentration occurred during a tonsillectomy and adenoidectomy. Over 17 ppm were measured while the halothane vaporizer was being filled and 13.42 ppm were found in the breathing zone of the nurse anesthetist during the laminectomy, where the highest nitrous oxide concentration was recorded. With a few exceptions, anesthesiologists and nurse anesthetists were generally exposed to higher concentrations than the surgeons and nurses: the average concentration found in the breathing zones of anesthesiologists was approximately 4 ppm while the averages for the other two groups were less than 1 ppm.

E. Conclusions and Recommendations

Since there are no defined "safe" levels of exposure to anesthetic gases, personnel exposure must be limited by the application of control measures including scavenging of gases at the anesthesia machine, "low leakage" practices by the anesthesiologist/nurse anesthetist, and equipment maintenance. Environmental data indicate that the use of activated charcoal canisters is somewhat effective in reducing the concentrations of halothane in the operating rooms at Winchester Hospital. Almost half of the concentration measurements were within the prescribed 0.5 ppm level, reportedly attainable during routine use of anesthesia. However charcoal canisters are not effective in reducing the amount of nitrous oxide released into the operating room air. Concentrations of nitrous oxide in almost all cases exceeded that concentration which has been reported to be achievable - 30 ppm. Leakage from the anesthetic circuit, poor anesthesia work practices, leakage from the connections to the charcoal canisters, or inadequate room ventilation are probably responsible for the presence of excessive halothane and nitrous oxide.

The leakage of gases through cracks in rubber and plastic material could be investigated by pressurization, immersion in water, and observation of any bubbling. There may also be poor fittings, missing or damaged gaskets. In order to determine leakage from the anesthesia machine and CO_2 absorber a non-leaking breathing bag and tubing must be used, then the increase in anesthesia gas concentration with time should be monitored in an operating room.

Because of the excessive concentrations of nitrous oxide which cannot be controlled through the use of charcoal canisters, it is recommended that a scavenging program be adopted which would collect the exhaust gases at the points of leakage, especially the pop-off valve, and dispose of them into the exhaust grille of the non-recirculating air conditioning system or into the central vacuum system. Waste gases could still pass through activated charcoal within the disposal pathway, however the canister should be within a closed system so that gases conveyed through the canister (including nitrous oxide) would not be released into the operating room.

The ventilator must also have a waste gas collector since the pop-off valve is closed while the ventilator is in use. Existing ventilators can be converted for scavenging or new units may be purchased. All scavenging components must be gastight. The air conditioning system is also of prime importance in providing a disposal pathway for the anesthesia gases. Between 10 and 15 air changes per hour would probably be sufficient to remove waste gases from the room. The actual effectiveness of the general room ventilation could be checked by setting up several monitoring sites in a room. With high air exchange rates, there should not be significant differences in concentrations at various locations.

The NIOSH publication, Development and Evaluation of Methods for the Elimination of Waste Anesthetic Gases and Vapors in Hospitals, provides comprehensive information on methods for determining sources of leakage and means for reducing leakage at the source, as well as recommendations for work practices that can reduce gas leakage.

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VI. AUTHORSHIP AND ACKNOWLEDGMENTS

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Table 1

Concentration of Waste Anesthetic Gases in Operating Rooms at Winchester Hospital

September 30, 1975

Room/Operation	Sample Period	Anesthetic	Job Title	Halothane (ppm)	Nitrous Oxide (ppm)
1/Vein Ligation & Stripping	7:50- 8:35	Halothane, N_2O (face mask)	Surgeon	0.63	
	7:58- 8:30		Asst. Surgeon	0.93	300
	8:30- 8:58		Asst. Surgeon		420
	7:42- 8:50		Scrub Nurse	1.09	
	7:43- 8:55		Circulating Nurse	1.16	
	7:45- 9:00		Area	0.83	270
5/Cystoscopy	7:59- 8:41	Halothane, N_2O	Anesthesiologist	0.05	960
	8:05- 8:50		Surgeon	2.15	
	7:40- 8:45		Circulating Nurse	5.99	
	7:50- 8:40		Area	3.09	660
5/Cystoscopy	9:00- 9:15	Halothane, N_2O	Anesthesiologist	0.22	340
	9:05- 9:15		Surgeon	0.03	
	8:45- 9:15		Circulating Nurse	0.21	
	8:45- 9:15		Area	0.15	280
3/D & C	7:50- 9:10	Halothane, N_2O	Nurse Anesthetist[1]	5.75	960
	7:55- 9:20		Surgeon	<0.01	
	7:55- 9:06		Circulating Nurse	0.03	
	7:45- 9:10		Circulating Nurse	0.05	180
4/Sigmoid Resection	7:57- 9:53	Halothane, N_2O	Anesthesiologist	2.31	840
	8:00- 9:45		Surgeon	0.52	
	8:05- 9:45		Asst. Surgeon	0.88	
	7:45- 9:54		Scrub Nurse	0.77	
	8:00-10:00		Circulating Nurse	0.52	
	8:05- 9:57		Area	0.75	520
3/D & C Abd. Hysterectomy	9:17-10:27	Spinal	Nurse Anesthetist	N.D.	N.D.
	9:20-10:17		Surgeon	<0.01	
	9:10-10:28		Circulating Nurse	<0.01	
	9:06-10:28		Circulating Nurse	<0.01	
	9:08-10:25		Area	<0.01	N.D.
4/Rem. Lipoma, Rt. shoulder	10:07-10:55	Halothane, N_2O	Anesthesiologist	2.05	1140
	10:14-10:57		Asst. Surgeon	0.98	
	10:08-11:00		Scrub Nurse	0.43	
	10:00-10:55		Circulating Nurse	<0.01	
	10:14-11:00		Area	0.44	410

1/Total Abd. Hysterectomy	9:30-10:26	Halothane, N_2O	Nurse Anesthetist	3.17	
	9:30-10:49		Surgeon	1.10	
	9:15-10:45		Scrub Nurse	1.21	
	9:15-10:45		Circulating Nurse	0.75	
	9:20-10:20		Area	0.79	
	9:30- 9:57		Nurse Anesthetist		1100
	9:57-10:23		Nurse Anesthetist		1260
	10:23-10:26		Nurse Anesthetist		700
1/D & C	10:55-11:09	Halothane, N_2O (face mask)	Nurse Anesthetist	N.D.	950[2]
	10:49-11:09		Surgeon	N.D.	
	10:51-11:14		Scrub Nurse	N.D.	
	10:51-11:12		Circulating Nurse	0.01	
	10:53-11:16		Area	N.D.	420
-	11:07-12:28	-	Head Nurse	0.01	
-	8:20- 9:45	-	Anesthesiologist	0.03	
Hall - Rm 3	11:08-12:47	-	-	N.D.	10
3/Left med. Menistectomy	10:50-11:52	?	Surgeon	1.24	
	10:37-12:33		Nurse	<0.01	
	10:50-11:40		Nurse	0.01	
1/T & A	13:12-13:59	Halothane, N_2O	Anesthesiologist	20.26	580
	13:04-13:57		Surgeon	3.66	
	13:05-13:58		Scrub Nurse	1.89	
	13:10-14:00		Circulating Nurse	1.90	
	13:12-13:50		Area	0.25	280
	13:50-14:02		Area	0.46	300
3/Exc. Papilloma, Nasal Pharynx	13:34-14:40	Pentothal; some Halothane, N_2O	Surgeon	0.30	
	13:32-14:40		Nurse	0.65	
	13:20-14:39		Circulating Nurse	0.35	
4/Laminectomy	13:05-15:05	Halothane, N_2O (4:2 = $N_2O:O_2$)	Nurse Anesthetist	13.42	3000[3]
	13:10-15:03		Surgeon	1.40	
	13:05-15:03		Scrub Nurse	1.48	
	12:53-15:03		Circulating Nurse	1.25	
	13:05-15:05		Area	1.13	660
2/Expl. Lap., Bowel Resection Hernia Repair	11:30-11:47	Halothane, N_2O	Anesthesiologist	0.32	
	11:43-15:08		Nurse Anesthetist	4.65	640 (11:43-12:55 620 (12:55-15:08
	11:28-12:31		Scrub Nurse	0.68 [4]	
	11:27-15:24		Area	3.83	

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4/Rt. Ing. Herniorrhaphy	7:48- 8:46	Spinal	Scrub Nurse	N.D.	

2/Sigmoidoscopy, Polypectomy, Transverse colon Resection	7:45- 9:23	Halothane, N_2O	Anesthesiologist	2.96	560
	7:52- 9:18		Surgeon	1.40	
	7:40- 9:18		Scrub Nurse	0.39	
	7:40- 9:23		Circulating Nurse	1.10	
	7:52- 9:23		Area	1.67	
	7:52- 8:40		Area		300
	8:40- 9:23		Area		400
1/Exc. Bunionette, Rt. foot	8:32- 9:09	Spinal; N_2O	Anesthesiologist	0.01	
	8:30- 9:07		Surgeon	0.10	
	8:30- 9:11		Scrub Nurse	0.02	
	8:43- 9:11		Circulating Nurse	0.03	
	8:32- 9:11		Area	0.03	400
4/Laparotomy, Appendectomy	9:18- 9:55	Halothane, N_2O	Anesthesiologist	1.12	1300
	9:23- 9:48		Surgeon	1.04	
	9:13- 9:55		Scrub Nurse	0.56	
	9:13- 9:55		Circulating Nurse	0.76	
	9:23- 9:55		Area	0.53	480
2/Biopsy, Left Breast	10:04-10:40	N_2O	Anesthesiologist	1.86	1000[5]
	10:16-10:40		Surgeon	2.24	
	9:58-10:40		Scrub Nurse	1.27	
	9:58-10:45		Circulating Nurse	0.95	
	10:05-10:40		Area	1.20	400
3/Mastoid Tympanoplasty	7:50-11:00	Halothane, N_2O	Nurse Anesthetist	2.14	680
	8:03-10:55		Surgeon	0.83	
	7:42-10:59		Scrub Nurse	1.57	
	7:46-11:02		Circulating Nurse	N.D.	
	8:00-11:00		Area	0.96	350
3	8:03- 8:06	Filling Vaporizer	Anesthesiologist	17.55	
4/Rt. Colectomy	10:10-12:15	$N_2O:O_2$ = 70:30	Anesthesiologist	0.04	See Rm 4 @ 9:18am
	10:15-11:58		Surgeon	<0.01	
	10:05-12:15		Scrub Nurse	0.02	
	10:15-12:15		Circulating Nurse	0.06	
	10:15-12:01		Area	<0.01	680
4	9:20- 9:23	Filling Vaporizer	Anesthesiologist	0.50	
2/Cholecystectomy	11:07-13:55	N_2O	Anesthesiologist	0.68	
	11:14-13:54		Surgeon	0.48	
	11:00-13:48		Scrub Nurse	0.46	
	11:04-12:57		Circulating Nurse	0.96	
	11:03-13:40		Area	0.50	
	11:14-13:36		Asst. Surgeon	0.43	
	11:03-12:50		Area		540
	12:50-13:40		Area		560
	11:14-12:14		Anesthesiologist		900
	12:14-13:13		Anesthesiologist		960

1 - Nurse anesthetist worked in rooms 1 and 3 both
2 - Estimated from slope of curve - bag exhausted
3 - Path length changed to 0.75 meters
4 - Minimum value - pump malfunctioning
5 - Estimated from slope of curve - bag exhausted
N.D. - None detected

Table 2

Comparison of Exposures to Halothane by Job Title

Job Title	Sample Period	Operation (Room)	Halothane (ppm)
	Sept. 30:		
Anesthesiologist or Nurse Anesthetist	7:59- 8:41	Cystoscopy (5)	0.05
	9:00- 9:15	Cystoscopy (5)	0.22
	7:50- 9:10	Veinligation & Stripping (1), D & C (3)	5.75
	9:17-10:27	D & C, Abd. Hysterectomy (3)	N.D.[1]
	10:07-10:55	Rem. Lipoma, Rt. Shoulder (4)	2.05
	9:30-10:26	Total Abd. Hysterectomy (1)	3.17
	10:55-11:09	D & C (1)	N.D.
	13:12-13:59	T & A (1); Exc. Papilloma, Nasal Pharynx (3)	20.26
	13:05-15:05	Laminectomy (4)	13.42
	11:30-11:47	Expl. Lap., Bowel Resection, Hernia Repair (2)	0.32
	Oct. 1:		
	7:45- 9:23	Sigmoidoscopy, Polypectomy, Transverse Colon Resection (2)	2.96
	8:32- 9:09	Exc. Bunionette, Rt. Foot (1)	<0.01[1]
	9:18- 9:55	Laparotomy, Appendectomy (4)	1.12
	10:04-10:40	Biopsy, Left Breast (2)	1.86[1]
	7:50-11:00	Mastoid Tympanoplasty (3)	2.14
	10:10-12:15	Rt. Colectomy (4)	0.04[1]
	11:07-13:55	Cholecystectomy (2)	0.68
	8:03- 8:06	Filling Vaporizer	17.55
	9:20- 9:23	Filling Vaporizer	0.50
	Sept. 30:		
Surgeon or Asst. Surgeon	7:50- 8:35	Vein Ligation & Stripping (1)	0.63
	7:58- 8:30	Vein Ligation & Stripping (1)	0.93
	8:05- 8:50	Cystoscopy (5)	2.15
	9:05- 9:15	Cystoscopy (5)	0.03
	7:55- 9:20	D & C (3)	<0.01
	8:00- 9:45	Sigmoid Resection (4)	0.52
	8:05- 9:45	Sigmoid Resection (4)	0.88
	9:20-10:17	D & C, Abd. Hysterectomy (3)	0.00[1]
	10:14-10:57	Rem. Lipoma, Rt. Shoulder (4)	0.98
	9:30-10:49	Total Abd. Hysterectomy (1)	1.10
	10:49-11:09	D & C (1)	N.D.
	10:50-11:52	Left Med. Menistectomy (3)	1.24
	13:04-13:57	T & A (1)	3.66
	13:34-14:40	Exc. Papilloma, Nasal Pharynx (3)	0.30
	13:10-15:03	Laminectomy (4)	1.40

Oct. 1:

7:52- 9:18	Sigmoidoscopy, Polypectomy, Colon Resection (2)	1.40
8:30- 9:07	Exc. Bunionette, Rt. Foot (1)	0.10
9:23- 9:48	Laparotomy, Appendectomy (4)	1.04
10:16-10:40	Biopsy, Left Breast (2)	2.24
8:03-10:55	Mastoid Tympanoplasty (3)	0.83
10:15-11:58	Rt. Colectomy (4)	<0.01[1]
11:14-13:54	Cholecystectomy (2)	0.48
11:14-13:36	Cholecystectomy (2)	0.43

Nurses

Sept. 30:

7:42- 8:50	Vein Ligation & Stripping (1)	1.09
7:43- 8:55		1.16
7:40- 8:45	Cystoscopy (5)	5.99
8:45- 9:15		0.21
7:55- 9:06	D & C (3)	0.03
7:45- 9:10		0.05
7:45- 9:54	Sigmoid Resection (4)	0.77
8:00-10:00		0.52
9:10-10:28	D & C, Abd. Hysterectomy (3)	<0.01[1]
9:06-10:28		<0.01[1]
10:08-11:00	Rem. Lipoma, Rt. Shoulder (4)	0.43
10:00-10:55		<0.01
9:15-10:45	Total Abd. Hysterectomy (1)	1.21
9:15-10:45		0.75
10:51-11:14	D & C (1)	N.D.
10:51-11:12		0.01
10:37-12:33	Left Med. Menistectomy (3)	0.00
10:50-11:40		<0.01
13:05-13:58	T & A (1)	1.89
13:10-14:00		1.90
13:32-14:40	Exc. Papilloma, Nasal Pharynx (3)	0.65
13:20-14:39		0.35
13:05-15:03	Laminectomy (4)	1.48
12:53-15:03		1.25
11:28-12:31	Expl. Lap., Bowel Resection, Hernia Repair	0.68[2]

Oct. 1:

7:48- 8:46	Rt. Inguinal Herniorrhaphy (4)	N.D.[1]
7:40- 9:18	Sigmoidoscopy, Polypectomy, Colon Resection (2)	0.39
7:40- 9:23	Sigmoidoscopy, Polypectomy, Colon Resection (2)	1.10
8:30- 9:11	Exc. Bunionette, Rt. Foot (1)	0.02
8:43- 9:11		0.03
9:13- 9:55	Laparotomy, Appendectomy (4)	0.56
9:13- 9:55		0.76

9:58-10:40	Biopsy, Left Breast (2)	1.27
9:58-10:45		0.95
7:42-10:59	Mastoid Tympanoplasty (3)	1.57
7:46-11:02		N.D.
10:05-12:15	Rt. Colectomy (4)	0.02
10:15-12:15		0.05
11:00-13:48	Cholecystectomy	0.46
11:04-12:57		0.96

1 - No halothane used
2 - Minimum value, pump malfunctioning
N.D. - None detected