

THE RECOVERY ROOM: A CLINICAL LABORATORY

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THE NUMEROUS publications on the subject of the recovery room bear witness to the fact that this intensive care unit is rapidly becoming an essential part of the postoperative care of surgical patients. The presence of trained medical personnel and the ready availability of diagnostic and resuscitative equipment have been recognized as obvious advantages in the treatment of complications arising in the first postoperative hours. Less attention has been paid to the fact that the same facilities and patients offer an unusual opportunity for study of major postoperative complications and development of effective therapy. The present report presents the results of three years of such study in the recovery room of Memorial Hospital.

SOURCE OF MATERIAL

To determine the incidence and type of major postoperative complications the operative and recovery room records of all patients (10,232) who were admitted to the recovery room were reviewed for the years 1956 and 1957. As a result of this study several investigations were instituted in an effort to decrease morbidity and mortality. These included an evaluation of antiemetic drugs, an analysis of bleeding and clotting disturbances, an electrocardiographic study of postoperative cardiovascular abnormalities, a method of radio-active blood volume determination, a technique for sterilization of endotracheal tubes and therapeutic measures designed to alleviate severe bronchospasm. Since most of these studies were in progress in 1958, the statistics for that year covering 4,629 patients serve as a measure of the effect of the investigations on the number and type of complications.

METHODS AND RESULTS

From the standpoint of therapy the most striking improvement occurred in the category

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of respiratory complications with special reference to the incidence of bronchospasm and laryngeal edema (table 1). The improvement in incidence of severe bronchospasm was largely due to two factors: (1) increased efforts to avoid the initiation of bronchospasm during anesthesia and (2) prompt prophylactic therapy in the recovery room.

Bronchospasm occurred most often in patients with preexisting pulmonary disease such as severe emphysema, pulmonary fibrosis or radiation pneumonitis. It was also noted that irritation of the larynx and trachea by endotracheal intubation or the instillation or trans-tracheal injection of topical anesthetic agents was the most frequent precipitating cause of this complication. As a result of these observations it was possible to reduce the incidence of bronchospasm by avoiding irritation of the tracheobronchial tree in patients with severe pre-existing pulmonary disease. This was accomplished in several ways: (1) by eliminating endotracheal intubation wherever feasible, (2) by employing a muscular relaxant rather than topical anesthetization of the larynx when intubation was mandatory, and (3) by substituting spinal for general anesthesia in many abdominal operations, such as oophorectomy.

Since our experience indicated that severe bronchospasm was extremely difficult to treat effectively, prophylactic measures were instituted on all patients with serious respiratory disease upon their arrival in the recovery room. These measures included the administration at regular intervals of bronchodilators

TABLE 1
RESPIRATORY COMPLICATIONS

Type of Complication	Number of Cases	
	1956-1957	1958
Obstructed respiration	14	12
Bronchospasm	66	8
Atelectasis	8	0
Status asthmaticus	1	0
Laryngeal edema	9	0
Pneumothorax	25	11
Total	123	31

such as aminophyllin and papaverine and the use of other drugs, including benadryl and the iodides. One of the most valuable adjuvants in the prophylaxis and therapy of the conditions has been the increasing employment of the intermittent positive pressure breathing apparatus for both assisted respiration and bronchodilator aerosol instillation.

The reduced incidence of postintubation laryngeal edema was largely due to improved technique in sterilization of endotracheal tubes resulting from the investigation published by Smith and Howland.¹

Although the total number of cases of postoperative bleeding was higher in the last twelve month period as compared to the preceding twenty-four months, 46 and 37 cases respectively, there was no significant increase in the number of patients who expired from excess blood loss, 6 for each period. The majority of cases reported as bleeding were relatively unimportant and easily controlled.

The important factor is the comparatively small death rate from hemorrhage in a hospital in which extensive traumatic extirpations requiring multiple transfusions constitute a high percentage of the total surgery. The successful therapy of the cardiovascular phenomena and hemorrhagic diatheses incident to massive blood replacement resulted from the operating and recovery room studies conducted in this hospital. These investigations have been reported in detail in previous publications.²⁻⁵ As a result of these studies the use of fresh whole blood, fresh lyophilized (anti-hemophilic) plasma and fibrinogen has produced successful results in the majority of cases. The fact that a few patients still expire from hemorrhage in spite of adequate therapy indicates that further work is necessary before this problem is completely solved.

In the group of cases studied for the years 1956 and 1957 there were 1,248 patients with cardiovascular complications including 635 with a tachycardia over 120/minute, 454 with hypotension, 146 with an irregular pulse and 5 cases of congestive failure. Although the etiology of the tachycardia or hypotension was readily established in many of these patients and appropriate therapy applied, a sufficient number either failed to respond to therapy or presented other problems to war-

rant further diagnostic procedures. In addition, the diagnosis of myocardial infarction in three deaths was based on the rapid onset of congestive failure with a fatal termination. There was no electrocardiographic confirmation of this presumptive diagnosis. With a view to establishing more accurate diagnostic and therapeutic measures in patients with cardiovascular abnormalities, routine postoperative electrocardiograms have been taken in the recovery room for the past 12 months on selected patients, namely, those with tachycardia over 120/minute, bradycardia under 60/minute, unexplained hypotension, cardiac arrhythmias and all others in whom the electrocardiogram might assist in diagnosis. Tables 2 through 5 summarize the data obtained by means of these electrocardiograms in the first 615 cases of this series. Although the types of arrhythmias were of interest, they added little from the standpoint of diagnosis. The real value of the study became apparent in determining the etiology of unexplained hypotension and tachycardia. With the aid of the electrocardiogram it was possible to detect or rule out the presence of myocardial infarction or ischemia, thus permitting more accurate diagnosis and therapy. The electrocardiogram was also useful in following the course of therapy of patients suffering from anoxia due to

TABLE 2

Type of Abnormality	Number of Cases
Bradycardia	241
Tachycardia	35
Hypotension	25
Cardiac arrhythmias	223
ECG for diagnostic purposes	91
Total	615

TABLE 3

Type of Arrhythmia	Number of Cases
Sinus arrhythmia	92
Wandering pacemaker	29
Sino-atrial block	2
Auricular premature contractions	21
Auricular flutter or fibrillation	7
Nodal premature contractions	18
Ventricular premature contractions	48
Ventricular tachycardia	2
None	4
Total	223

TABLE 4

Cause of Tachycardia	Number of Cases
Cardiac decompensation	3
Over digitalization	1
Anoxia (due to respiratory difficulties)	10
Decreased blood volume	10
Decreased plasma volume	3
Diabetic acidosis	1
Intravenous Isuprel	1
Toxic patient pre-operatively	6
Total	35

TABLE 5

Cause of Hypotension	Number of Cases
Hyperactive carotid sinus	3
Phenothiazine	2
Decreased blood volume	7
Decreased plasma volume	4
No obvious cause	9
Total	25

emphysema, bronchospasm or other pulmonary pathology. Improvement in pulmonary function was reflected in the electrocardiogram by decreasing evidence of cor pulmonale or right heart strain.

In contrast to three patients who expired with a presumptive diagnosis of myocardial infarction in the 1956-1957 period, 8 cases of "silent" myocardial infarction were discovered in the first 615 postoperative electrocardiograms of the study now in progress. Although these patients exhibited symptoms of hypotension, tachycardia, bradycardia, cyanosis or cardiac arrhythmia, none complained of characteristic substernal or arm pain. The diagnosis was made solely by electrocardiogram and confirmed by transaminase determinations and serial electrocardiographic tracings.

From the standpoint of accurate diagnosis of hypotension and tachycardia, another study has proved of great value. This entails the use of radioactive isotopes in the determination of blood volumes. Since apparatus is located in the anesthesiology laboratory, adjoining the recovery room, rapid and accurate measurement of hematocrit, red cell mass, plasma volume and total blood volume is readily available at all times.

One of the most detailed studies in the recovery room concerned the incidence, causative factors and therapy of postoperative nausea and vomiting. Since this work has been reported in detail in previous publications,⁶⁻⁹ it is sufficient at the present time to present only a brief resume of the pertinent facts. The method employed was a double-blind technique with randomization of drug administration to balance any unrecognized variables that might affect the results. The data was transferred to IBM cards and then submitted to statistical analysis. The total number of patients in the study was 3,794 and the six antiemetic drugs employed included four phenothiazine compounds (trifluorpromazine, promethazine, fluphenazine and perphenazine) and two nonphenothiazine drugs (cyclizine and trimethobenzamide).

Although significant individual differences existed between the various phenothiazine drugs with respect to prolongation of sleeping time and production of hypotension, their action on the prevention of postoperative nausea and vomiting was so similar that they could be considered as a single group in contrast to a second group of nonphenothiazine compounds. Both the phenothiazine and nonphenothiazine drugs were successful in reducing the incidence of nausea and emesis, but the phenothiazine derivatives were more effective in this respect.

In addition to the evaluation of antiemetic drugs the study revealed a large number of interesting facts related to the occurrence of postoperative nausea and emesis. The most important was the marked preponderance of these symptoms in women as compared to men. It was also found that the phenothiazine drugs were more effective in protecting men than women. No statistically significant difference existed in the incidence of postoperative nausea and emesis in patients premedicated with scopolamine as compared to atropine. Of the narcotic premedicants, however, morphine had a distinct advantage over meperidine in that there was a lower incidence of nausea and vomiting following morphine premedication. There was no significant relationship between the incidence of nausea and vomiting and barbiturate premedication. The type of anesthetic agent and the method

of administration (mask or endotracheal tube) were also studied. The highest percentage of patients exhibiting nausea and vomiting after operation was found in the group who had received cyclopropane and the lowest among those anesthetized with pentothal nitrous-oxide-oxygen. Ether occupied an intermediate position. Intra-abdominal surgery resulted in a greater incidence of postoperative nausea and vomiting than operations on other areas of the body but the site of operation within the abdominal cavity (upper or lower) was unimportant. In the final analysis it is believed that a dose effect relationship exists between the anesthetic agent and the incidence of nausea and vomiting and that the difference in incidence between men and women is related to hormonal differences.

DISCUSSION

The number and variety of patients and types of operative procedures and the presence of highly trained medical personnel make the recovery room a place superior to any other for the study of the problems affecting the patient in the first hours after operation. Although most of the investigations discussed in the preceding section might have been carried out on the surgical wards, the time consumed and the number of skilled personnel required would have been almost prohibitive.

The personnel and physical setup of the recovery room at Memorial Center lends itself particularly well to a program of investigative procedures. An Attending Anesthesiologist with ability to diagnose and treat complications and employ techniques such as the interpretation of electrocardiograms and electroencephalograms is available at all times. The nurses in attendance are capable and alert observers, trained to report any deviations from the normal to the Anesthesiologist. In the electrocardiographic study, for example, of the 615 cases analyzed to date, only four instances were found in which an abnormality of pulse, reported by the nurse, was not confirmed by a subsequent electrocardiogram. Since the electrocardiogram was taken a short period after the nurse's report, it is conceivable that an irregular pulse had been present at the time it was taken and subsequently became regular.

The research laboratory, staffed by a full-time chemist and under the supervision of the Anesthesiology Department, is located adjacent to the recovery room. This laboratory contains a variety of equipment, including the means for determining blood volumes by radioactive isotopes. The proximity of the laboratory to the patient area permits rapid emergency determinations as well as those required for more deliberate investigation purposes.

With the facilities mentioned above it has been possible to conduct several simultaneous investigative procedures and secure results directly applicable to patient care in a relatively short period of time. The efficiency of the improved therapy in several fields is readily demonstrated by a comparison of the statistics for the years 1956-1957 with those for 1958. Although a great deal has been accomplished, the work reported represents only the initial efforts in a field in which much remains to be accomplished. With its patient load, personnel and laboratory facilities the recovery room is the ideal place for investigation of the physiology and pathology of the immediate postoperative period.

SUMMARY

The availability of patient material, personnel and laboratory facilities make the recovery room an ideal place for the study of postoperative complications and therapy. Investigations have been instituted into the cause and treatment of postoperative respiratory complications, factors responsible for protracted bleeding, the detection of cardiovascular complications and the incidence and treatment of postoperative nausea and vomiting. Data obtained in these studies are presented. Eight cases of "silent" myocardial infarction were detected by appropriate electrocardiographic studies in 615 postoperative patients.

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EEG IN SCHIZOPHRENIA Electroencephalograms were made during rapid injections of 100 mg. of thiopental. Before sleep occurs, specific changes are noted in the electroencephalograms of schizophrenic patients. There are accentuated beta activity, bursts of fast activity, and theta activity of high amplitude. The differences between EEG's of schizophrenic and non-schizophrenic individuals are statistically significant. After response to therapy, the patient no longer shows the specific changes. (*Goldman, D.: Specific Electroencephalographic Changes with Pentothal Activation in Psychotic States, Electroencephalog. & Clin. Neurophysiol.* 11: 657 (Nov.) 1959.)

MUSCLE PAIN Succinylcholine causes liberation of potassium from skeletal muscle; curare not only does not cause this liberation of potassium, but even prevents liberation of potassium by succinylcholine. It was assumed that generalized muscular pain, following administration of succinylcholine, is largely due to liberation of potassium and the initial muscular fibrillation causing mechanical lesions and liberation of lactic acid. In a group of 100 patients, it was found that injection of 0.05 mg. of d-tubocurarine/kg. of body weight at least 2 minutes prior to administration of succinylcholine prevented, or markedly decreased, this muscular pain in 96 patients. In a control group of 100 patients, 64 patients had rather severe complaints. Twenty-five to fifty per cent more succinylcholine was required to produce the same degree of muscular

relaxation in the patients given a preliminary dose of curare than in the control group. (*Mayrhofer, O.: The Effectiveness of d-Tubocurarine in the Prevention of Muscular Pain Following Succinylcholine, Der Anaesthesist* 8: 313 (Nov.) 1959.)

CONVULSIONS One or more of the following clinical findings were associated with 21 children under five years of age (most were less than one year) who died of severe and persistent convulsions: 1) fever; 2) respiratory difficulty; 3) severe malnutrition; 4) hypoglycemia. Widespread injury to cortical ganglion cells was found at necropsy in each instance, with special predilection for Sommer's band of the Ammon's horn formation, the occipital, and sometimes the parietal cortex, and the Purkinje and granular cells of the cerebellar folia. Similar anatomic findings were observed in ten additional cases of birth injury, in which asphyxia but not convulsions was a prominent feature. Experimentally, regardless of how convulsions were initiated, cerebral anoxic changes were produced which could destroy cortical ganglion cells in the cerebrum and cerebellum. Also, insulin-evoked hypoglycemia, even when it did not induce convulsions, likewise destroyed cortical cells. Thus, the cerebral lesions described in both infants and experimental preparations result from convulsive seizures and do not cause them. (*Zimmerman, H. M.: The Basis of Convulsive Attacks in Children—An Experimental Study, Bull. New York Acad. Med.* 35: 801 (Dec.) 1959.)