ANESTHESIA FOR BILATERAL ADRENALECTOMY
A STATISTICAL AND CLINICAL ANALYSIS

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The temporary beneficial effects of bilateral adrenalectomy on the growth of human prostatic cancer were reported for the first time by Huggins and Scott in 1945 (1). In the succeeding years West and his co-workers (2), Cox (3), Galente, Fournier and Wood (4), and others have published series of cases in which both adrenals were removed in an effort to produce remission of the subjective and objective manifestations of advanced metastatic cancer of the breast and the prostate gland. The reports of these investigations have dealt mainly with the preparation of the patients for surgical extirpation of the adrenals and the clinical and physiological effects of their removal. With the exception of two recent articles, one by Musulin (5) and one by Franksson and Hallstrom (6), the problem of anesthetic management of patients for bilateral adrenalectomy for advanced cancer has received only cursory mention in the literature. The present report is a detailed statistical and clinical analysis of our experience in the administration of anesthesia to 150 patients scheduled for bilateral adrenalectomy at Memorial Center for Cancer and Allied Diseases between January 1951 and December 1955.

SOURCE OF MATERIAL

The material studied consisted of 150 patients, 20 men and 130 women. Although most of these patients were suffering from advanced cancer of the breast or prostate, a few had malignant disease of other organs (table 1). The age span in the group ranged from 17 to 72 years, with the majority of patients in the fifth and sixth decades (table 2). Since adrenalectomy was usually employed only after other

<table>
<thead>
<tr>
<th>Diagnosis of Patients Studied</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metastatic carcinoma</td>
<td>40</td>
</tr>
<tr>
<td>Sarcoma or melanoma</td>
<td>3</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>3</td>
</tr>
<tr>
<td>Adrenocortical hyperplasia</td>
<td>1</td>
</tr>
<tr>
<td>Pheochromocytoma</td>
<td>1</td>
</tr>
<tr>
<td>Other tumor</td>
<td>2</td>
</tr>
</tbody>
</table>

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attempts at definitive therapy had failed, the patients, in general were in either fair (83) or poor (34) physical condition. Frequently there were osseous and pulmonary metastases as well as disabilities related to cardiovascular and metabolic functions. Only 31 members of the entire group were considered good operative risks. In the early years of the series, adrenalectomy was employed after recurrence of symptoms following a temporary remission induced by castration or (in one case) by hypophysectomy. Later, in some patients, bilateral oophorectomy and adrenalectomy were carried out concurrently.

**TABLE 2**

**DATA ON PATIENTS GROUPED IN CATEGORIES BASED ON SEVERITY OF COMPLICATIONS**

<table>
<thead>
<tr>
<th>Category of Complication Severity</th>
<th>Men</th>
<th>Women</th>
<th>Ether</th>
<th>Cyclopropane</th>
<th>Mean Age (years)</th>
<th>Blood (units)</th>
<th>Awakening Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (none)</td>
<td>7</td>
<td>59</td>
<td>54</td>
<td>7</td>
<td>-49.7± 7.8</td>
<td>2.07±1.08</td>
<td>1.29± 8.97</td>
</tr>
<tr>
<td>II (minor)</td>
<td>4</td>
<td>14</td>
<td>15</td>
<td>2</td>
<td>-46.4± 3.0</td>
<td>1.78±1.09</td>
<td>1.04± 7.2</td>
</tr>
<tr>
<td>III (moderate)</td>
<td>1</td>
<td>10</td>
<td>16</td>
<td>3</td>
<td>-47.1± 9.6</td>
<td>2.00±1.94</td>
<td>1.30±1.23</td>
</tr>
<tr>
<td>IV (severe)</td>
<td>8</td>
<td>28</td>
<td>28</td>
<td>8</td>
<td>-46.9±13.0</td>
<td>2.32±1.51</td>
<td>1.12± 6.2</td>
</tr>
<tr>
<td>V (serious)</td>
<td>0</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>-51.6± 7.0</td>
<td>2.00±1.15</td>
<td>.92± 5.8</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>130</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition to the usual preoperative evaluation of the patient and the correction of abnormalities by digitalization, thoracentesis, control of diabetes, and similar measures, most of the patients received cortisol in some form immediately prior to surgery. The total preoperative dosage of cortisol varied, but usually ranged from 350 to 500 mg. In general, 200 to 300 mg of cortisol were administered in divided doses by the intramuscular route on the afternoon of the day preceding surgery. This was followed by 100 mg intramuscularly and 100 mg by mouth immediately prior to operation. Intravenous hydrocortisone was employed during the course of surgery, in those individuals who had received no preoperative preparation with the steroid or who developed complications considered amenable to additional doses of steroid.

About one hour preceding the scheduled time of operation, the patients were sedated with combinations of demerol, morphine, barbiturates, and belladonna derivatives. Endotracheal absorption circle technique was employed in all but one case. Ether was the main anesthetic agent in 121 patients, cyclopropane in 22, and pentothal-nitrous-oxide-oxygen in 5. A relaxant was used as an adjuvant to general anesthesia in 51 cases, and one patient received continuous spinal instead of general anesthesia. Although the average patient required two units of blood to maintain a satisfactory circulating fluid volume, three or more units were administered to 26 patients in the series (table 2).
METHOD OF STATISTICAL ANALYSIS

Statistical analysis was employed in the present series in order to help draw valid conclusions from a relatively small number of cases. Since anesthesia was administered by several different anesthetists with resultant variables in classifying and charting events, it was necessary to use a system of analysis of complications that would take into account the elements of chance, variability, and "slippage." The method used was devised by Bross (7) to study casualties in automobile accidents. In brief, Bross's technique of Ridit analysis involves the transformation of a classification into a number which has a meaning in terms of probabilities.

To apply the Ridit analysis to the present study, the charts of all patients in the series were carefully reviewed by two observers and the following items entered on a master study chart: name, number, date, age, sex, race, weight, diagnosis, risk, previous treatment or operation, anesthesia for previous operation, cortisone preparation, premedication, technique of anesthesia, position, complications during operation, fluid therapy, administration of hydrocortisone or vasopressors during operation, time of reaction from anesthesia, postoperative complications, and subsequent operations. After a suitable code had been devised, the data from the master study chart were transferred to IBM code cards for each individual patient and the information on these code cards then transferred to IBM punch cards.

Since the present investigators were interested in studying the relationships of age, sex, weight, risk, preoperative preparation with cortisone, anesthetic agent, position, previous castration, and operative and postoperative course of the patients, to complications occurring during anesthesia, the IBM punch cards were programmed into 5 categories based on the incidence and severity of complications encountered during the course of anesthesia and operation. The criteria for these categories in increasing order of severity were as follows:

Category I—patients with no anesthesia complications, who required neither vasopressor nor hydrocortisone during operation

Category II—patients with no charted anesthesia complication who received either hydrocortisone or a vasopressor during the procedure

Category III—patients who sustained a fall in blood pressure during induction, with positioning, or after removal of the first adrenal, but who did not require treatment with a vasopressor or hydrocortisone; also patients who developed an irregular pulse, tachycardia, or bronchospasm during the course of anesthesia

Category IV—the same as Group III, but who received a vasopressor or hydrocortisone

Category V—patients with severe anesthetic complications such as a marked fall in blood pressure after removal of the second adrenal, severe hypotension requiring the continuous administration of a vasopressor for maintenance of blood pressure, or pulmonary edema
It is recognized that these categories in increasing incidence of severity do not represent a linear scale, but this criticism is unimportant since the Ridit analysis was used to assign each group a number with a meaning in terms of probabilities.

All patients who could possibly fall into more than one category were placed in the category compatible with their severest anesthetic complication.

**TABLE 3**

**Calculation of Ridit**

<table>
<thead>
<tr>
<th>Category of Complication Severity</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 Ridit</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (none)</td>
<td>51</td>
<td>25.5</td>
<td>0</td>
<td>25.5</td>
<td>.234</td>
</tr>
<tr>
<td>II (minor)</td>
<td>11</td>
<td>5.5</td>
<td>51</td>
<td>56.6</td>
<td>.518</td>
</tr>
<tr>
<td>III (moderate)</td>
<td>15</td>
<td>7.5</td>
<td>62</td>
<td>69.5</td>
<td>.638</td>
</tr>
<tr>
<td>IV (severe)</td>
<td>24</td>
<td>12</td>
<td>77</td>
<td>89</td>
<td>.817</td>
</tr>
<tr>
<td>V (serious)</td>
<td>8</td>
<td>4</td>
<td>101</td>
<td>105</td>
<td>.953</td>
</tr>
<tr>
<td>Total</td>
<td>109</td>
<td></td>
<td>109</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Explanation:**

Column 1: The frequency distribution in the identified distribution (reference class).

Column 2: One-half of the corresponding entry in column 1.

Column 3: The cumulative of column 1 (displaced one category downward).

Column 4: Column 2 + column 3.

Column 5: The entries in column 4 divided by grand total (109).

The numbers are the Ridits. The higher Ridit score corresponds to the more serious complication.

The Ridit scores for the five categories were computed by the method illustrated in table 3. The reference class or “unidentified distribution” to which all patients were referred consisted of 109 women who received ether as the primary anesthetic agent. This group was used in computing the Ridit score since it represented as “pure” a class as possible and also constituted the largest number in one class in this series. The Ridit score obtained for each of the five categories was then employed to compute the Ridit score for each subgroup in the over-all series. If the Ridit scores had been computed on the entire group, the results would not have been markedly different. The higher Ridit score corresponds to the more serious complications.

Confidence Intervals (95 per cent) have been used in the graphical presentation in order that the reader can see for himself whether a given factor is statistically significant (figs. 1, 2 and 3). When the confidence intervals for two subgroups do not overlap there is a significant difference between the series. When the intervals for two subgroups largely overlap there is little evidence of a difference between the series even though the central values (solid band) may differ. When there is a natural order for the subgroups (examples,
Fig. 1. Ridit score (solid band) and 95 per cent confidence limits (hatched bars). The categories correspond to complication severity so that the more severe the complication, the higher the Ridit score.

Fig. 2. Ridit score (solid band) and 95 per cent confidence limits (hatched bars). The categories correspond to complication severity so that the more severe the complication, the higher the Ridit score.
Fig. 3. Ridit score (solid bars) and 95 per cent confidence limits (hatched bars). The categories correspond to complication severity so that the more severe the complication, the higher the Ridit score.

Age, operative risk, etc.) the pattern of the confidence intervals must also be taken into consideration. Thus, if the means show, say, a consistent increase (or decrease) then even if there is a slight overlapping of the intervals the results will be significant. On the other hand if there are no consistent changes then isolated instances of non-overlapping confidence intervals generally mean very little.

The IBM cards were then programmed so that for each category sum of squares was obtained for age, weight, total dosage of cortisone preparation, units of blood, and awakening time, and the standard deviation of the mean was calculated (table 2).

Results

Although the majority of patients in the present series were only fair or poor operative risks, there were comparatively few serious operative or postoperative complications. Of the 150 individuals in the group 84 had an entirely uneventful operative course. The most frequent complication in the remaining patients was hypotension of varying degree exhibited at some time during the surgical procedure. In addition, there were 2 instances of bronchospasm, 1 of pneu-
Pneumothorax, 1 of hypoxia in a patient with pheochromocytoma, 3 cases of pulmonary edema, and 1 cardiac arrest.

A closer analysis of the operative course of the 56 patients who developed hypotension reveals that the fall in blood pressure was associated with a change in position in 36 individuals and was readily corrected by the administration of a vasopressor. Hypotension in 9 of the remaining 20 patients was apparently the result of inadequate replacement of blood lost during the course of surgery, and in another 4, was due to pericardial effusion, tension pneumothorax, massive pleural effusion, and severe cardiac disease, respectively. Since 2 of the remaining 7 patients in this group developed hypotension for the first time after removal of the second adrenal gland, it is conceivable that their fall in blood pressure was associated in some way with depletion of steroid or catecholamine. No etiologic factor could be detected for the appearance of hypotension in the remaining 5 patients. The depression in blood pressure occurred at varying times during the course of operation and was effectively treated by the administration of a vasopressor.

In the present series the preoperative dosage of corticoid preparation varied from none to 600 mg. The Ridit score (fig. 1) was somewhat higher for patients who had received less than 400 mg. of cortisone than for those prepared with larger doses. The large range in the confidence limits rules out any significant difference. No consistent trend is seen with increasing preoperative dosage of cortisone. The highest Ridit score was obtained in those patients who received 600 mg. of cortisone in the preoperative period. This paradox was explained by the fact that these patients were poor operative risks who were prepared for surgery and then postponed a day or so owing to the development of a complication.

The Ridit score indicates that the factors of sex, position on the operating table, and history of previous castration had no significant relation to the development of anesthetic complications (figs. 1, 2 and 3). Age also played a comparatively minor role. Although the mean values for patients in the seventh and eighth decades were higher than for those in the younger age groups (fig. 2), the 95 per cent limits were so wide that the difference was of no statistical importance. The high Ridit score of the 4 patients in the third decade is readily explained on the basis of the patient's diseases (melanoma, leukemia, and pheochromocytoma) and of their poor preoperative condition.

There was no consistent trend to relate weight and the Ridit score (fig. 2). Anesthesia complications did not appear to be related to weight per se. A significant trend might have been discovered if patients were classified into three groups based on ideal weight: group 1—20 per cent or more below ideal weight; group 2—ideal weight ± 20 per cent; group 3—those 20 per cent or more above ideal weight. The
possible significance of such classification was not realized when the study was set up.

The type of anesthetic agent had no significant relation to the development of anesthetic complications. Although cyclopropane showed a slightly higher Ridit score than ether (fig. 3), there is no statistical importance in this difference. The low Ridit score for anesthetic procedures other than inhalation reflects bias in selection of patients, the 6 individuals anesthetized by these methods having been selected because they were considered good risks.

In contrast to the factors which have been enumerated, the preoperative state of the patient bore a definite and consistent relationship to the occurrence of anesthetic complications. The poorer the risk, the higher the Ridit score (fig. 3). From this score it is possible to predict that the odds are about 3 to 1 that a poor-risk patient will develop more serious complications than the good-risk. In addition to the significant difference between the poor-risk and the good-risk patients, the trend is made consistent by the intermediate position of the fair-risk patient.

Additional evidence to support this contention is afforded by the following two case histories which are representative of the group of the patients who developed the most serious complications, namely, pulmonary edema, persistent marked hypotension, hypoxia, and cardiac asystole. Both of these individuals were anesthetized with intratracheal ether after induction with a small amount of pentothal.

Case 1.—The patient was a 41-year-old woman with advanced metastatic cancer of the breast, severe myoccardial disease probably owing to pericardial extension of cancer with pericardial effusion, and moderately severe pulmonary insufficiency as the result of lymphangial pulmonary spread of disease. Digitals and mercurial diuretics were employed in the preoperative preparation. During the course of the oophorectomy preceding adrenalectomy, the patient developed moderately severe respiratory distress with wheezing respirations which failed to respond to aminophyllin. A progressive fall in blood pressure from 140/100 to 90/80 mm. of mercury and a rise in pulse rate occurred during removal of the first adrenal gland. When intravenous lanatoside-C produced no improvement, a continuous drip of norepinephrine was started and the operation discontinued. The patient's condition remained satisfactory until the fourth postoperative day when she experienced a sudden episode of cardiac decompensation from which she failed to respond adequately. After repeated relapses, death occurred on the thirty-eighth postoperative day.

Case 2.—The patient was a plethoric, 50-year-old woman with a blood pressure of 170/110 mm. of mercury and signs of incipient, acute left heart failure in the immediate preoperative period. Bed rest produced some improvement in her cardiac status. After the patient had been anesthetized and placed in the lateral position and the kidney rest had been elevated preparatory to removal of the first adrenal gland, she became cyanotic, the blood pressure fell rapidly, and fine rales appeared in both lungs. Intravenous lanatoside-C was administered, the left adrenal was removed rapidly, and the patient was sent to the recovery room.
Since her status improved after operation, it was decided to excise the right adrenal gland nine days later. Except for transient electrocardiogram changes, the second operation proceeded uneventfully. Two hours after the termination of surgery, however, her condition started to deteriorate and she died on the third postoperative day. Postmortem examination revealed congestive heart failure with marked coronary sclerosis.

A review of the postoperative courses of the patients in the present series reveals that 91 made a completely uneventful recovery with no major complications. Disorders of the respiratory and cardiovascular systems were responsible for most of the morbidity and mortality in the remaining members of the group (table 4). Inadvertent opening of the pleura, undetected during the course of surgery except in one patient, was responsible for the relatively large incidence of tension pneumothorax. Prompt institution of underwater drainage resulted in improvement of symptoms in every case.

<table>
<thead>
<tr>
<th>TABLE 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Postoperative Complications</strong></td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Adrenal insufficiency</td>
</tr>
<tr>
<td>Atelectasis</td>
</tr>
<tr>
<td>Pneumothorax</td>
</tr>
<tr>
<td>Aspiration</td>
</tr>
<tr>
<td>Tracheostomy</td>
</tr>
<tr>
<td>Pleural effusion</td>
</tr>
<tr>
<td>Pulmonary infarct</td>
</tr>
</tbody>
</table>

Two episodes of myocardial infarction developed in the first few days after surgery. One of these occurred in a 66-year-old, poor-risk man who had run a persistent hypotension during operation in spite of adequate fluid replacement; the other, in a 63-year-old, fair-risk man who had an uncomplicated operative and postoperative course until the fifth day, when he displayed symptoms and signs of coronary occlusion. Both patients responded to therapy without further complications. Cardiac failure in the immediate postoperative period complicated the course of an antely and chronically ill, hypertensive female with parenchymal and pleural metastatic disease and electrocardiographic evidence of myocardial insufficiency. Upon transfer to the recovery room after an uneventful operative course, the patient developed persistent hypotension with bradycardia and depressed respiration. The administration of norepinephrine as supportive therapy was necessary. A few hours later she was treated for pulmonary edema with intravenous lanatoside-C and aminophyllin and the response was fair. Death occurred on the operative night as the result of aspiration of gastric contents, in spite of emergency tracheostomy and other resuscitative measures.

The diagnosis of adrenal insufficiency in the postoperative period in 6 patients was based on the fact that their symptoms, such as
hypotension, tachycardia, weakness and elevation of temperature, responded to the administration of increased doses of intravenous and intramuscular steroid.

There were 9 fatalities in the series; 2 on the operative day, 3 within the first week after operation, and the rest at periods varying from 10 to 38 days after surgery. One of the two deaths in the first twenty-four hours occurred in a patient who had been successfully resuscitated following an episode of cardiac asystole in the operating room. Although the exact etiology of the cardiac arrest was not ascertained, displacement of the heart due to a large hiatus hernia may have been a factor. A second poor-risk patient expired on the operative night following a prolonged episode of hypotension and depressed respirations in the immediate postoperative period which failed to respond to therapy. Two other patients with a history of severe myocardial disease preceding operation died as the result of cardiac decompensation within the first few days after surgery. A fifth died on the seventh postoperative day after a stormy course complicated by repeated episodes of bleeding from an undetected source, increasing jaundice, diminishing urinary output, and finally, in the last 36 hours, several grand mal seizures. Death occurred in the remaining 4 patients from various causes; 2 from massive pulmonary embolus, one from a cerebrovascular accident, and one from cardiac extension of metastatic disease.

**Discussion**

Since the secretions of the adrenal glands play a vital role in the physiologic adjustments of the human body, it is theoretically conceivable that anesthetic complications resulting from diminution in steroid and catechol amine output may occur after extirpation of these structures. Brewster, Isaacs, and Wainx-Anderson (8) produced evidence, based on laboratory studies in dogs, which showed that ether exerts a direct depressant effect on the myocardium which is proportional to the concentration of ether in the blood. These authors believe that the apparent cardiac stimulation manifested in light stages of ether anesthesia results from reflex release of epinephrine and norepinephrine from adrenal medullary and sympathetic nerve endings, and that catechols released from the adrenals are essential in counteracting the depressant effects of ether. If their investigations were applicable to human beings, they would seem to contraindicate ether in patients scheduled for bilateral adrenalectomy, since the operative procedure removes one of the sources of epinephrine and norepinephrine. The results in the present series, however, appear to confirm the opinion of Millar (9) that reflex circulatory release of the vasoconstricting agents is "only one facet of the complex compensatory
mechanisms operating to maintain circulatory function during ether anesthesia."

Since Artusio demonstrated the beneficial effects of the analgesic stage of ether anesthesia (10), it has been deemed advisable to anesthetize many of the poorer risk patients by this technique. Although this resulted in a preponderance of poor-risk patients in the group who received ether in comparison to those anesthetized with cyclopropane, there was no significant difference in the Ridit scores. It is evident, therefore, that the development of complications during the course of bilateral adrenalectomy bears little relationship to the choice of ether or cyclopropane as the anesthetic agent.

Although moderate hypotension of a transient or more permanent nature was the most frequent complication during the operative and postoperative course of the patients in the present series, it was readily explained in the majority of cases by obvious reasons such as a depleted blood volume, changes in position, tension pneumothorax, or disease due to pericardial metastases or intrinsic cardiac disease. In comparison with Mushin’s report (6) of a 19.1 per cent incidence of hypotension following removal of the second adrenal gland, only 2 patients (1.5 per cent) in the present series developed an unexplained fall in blood pressure at this time. One of these responded to intravenous hydrocortisone. There was no significant relation between the type of anesthetic agent and the incidence of complications relating to the cardiovascular system.

The preoperative preparation and operative and postoperative care of the patient with benign or malignant pheochromocytoma and Cushing’s disease have been discussed at length by many investigators including Davis, Peet, and Van’t Hoff (11), Millar (9), Apgar and Pepper (12), Cope and Raker (13), Kvale, Roth, Manger and Priestley (14), and others. The two cases in the present series, one of Cushing’s disease and one of bilateral malignant pheochromocytoma, presented no unusual aspects and were anesthetized successfully with observance of all the necessary precautions. Although no cortisone was administered preoperatively to these patients, intravenous hydrocortisone was used during the course of surgery and the steroid continued via the intramuscular route in the postoperative period.

Considerable variation of opinion exists with respect to the total dose of preoperative cortisone that constitutes adequate preparation for patients scheduled for bilateral extirpation of the adrenal glands. In the present series, it ranged from none to 600 mg. The time of administration of cortisone, whether on the day preceding operation or during the course of surgery, appeared to bear little relation to the development of anesthetic complications. The majority of patients received from 300 to 400 mg. of steroid at some time before the second adrenal was removed. Acute adrenal insufficiency is not a major problem during anesthesia for bilateral adrenalectomy since it has
been shown that adrenal insufficiency usually does not develop for a variable number of days following withdrawal of the steroid (16). Although one might expect this time to be shorter due to the stress of anesthesia and operation, the administration of additional amounts of hydrocortisone to patients who developed hypotension during the course of operation failed to combat the hypotension in all but one case, indicating that adrenal insufficiency was probably not the basis for the difficulty.

With the ready availability of a rapidly acting intravenous hydrocortisone preparation, the necessity no longer exists for the administration of large intramuscular doses of steroid on the day preceding operation. However, since parenterally injected hydrocortisone is rapidly destroyed and the body’s store of cortisone is depleted within a few hours after removal of the glands (15), it is advisable to supplement the intravenous preparation with the first of a series of intramuscular injections of steroid as soon as the decision is made to remove both adrenals. Intramuscular cortisone is then continued at regular intervals during the postoperative period.

All 6 patients who showed signs of adrenal insufficiency in the postoperative period had received 350 to 500 mg. of cortisone prior to extirpation of the glands and were being maintained on periodic doses of intramuscular steroid at regular intervals. Four of these patients were subjected to unusual stresses in the first 24 hours after surgery, namely, tension pneumothorax with cyanosis, respiratory obstruction, bronchopneumonia and hypercalcemia, and an intense heat wave; a fifth suffered from leukemia and the sixth was the first patient in the series—at a time when little information was available with respect to adequate steroid replacement. The increased steroid requirements during stress could account for the development of adrenal insufficiency. All 6 patients responded well to adequate therapy.

Although there was a high incidence of preoperative pulmonary disease due to metastasis, relatively few operative and postoperative complications were attributable to the respiratory system. The 2 cases of bronchospasm which developed during the course of anesthesia responded readily to appropriate bronchodilator therapy. Copious, inspissated pulmonary secretions, which constituted a definite hazard in many of the patients with intrinsic pulmonary disease, resulted in atelectasis in 6 patients, 2 of whom required tracheostomy to insure an adequate tracheobronchial toilet. A third tracheostomy was performed because of the development of severe laryngeal edema in the period immediately following surgery. It must be assumed that the edema was secondary to endotracheal intubation.

Hollander and his co-workers (17) have emphasized the danger of excessive fluid therapy in patients with adrenal insufficiency secondary to bilateral adrenalectomy since these individuals have an increased antidiuretic tendency. Three patients in the present series developed
pulmonary edema during the course of surgery. Since in each instance this complication occurred prior to removal of the first adrenal gland, it is difficult to conceive that steroid deficiency played an etiologic role in these cases. Other factors that could predispose to the development of pulmonary edema were present. Two of the patients suffered from severe myocardial disease with episodes of failure in the preoperative period, while the third had a relatively asymptomatic mitral stenosis. A combination of adrenal insufficiency and the administration of 3 pints of blood could have been an etiological factor in a fourth patient who developed pulmonary edema a few hours after an uneventful removal of both adrenal glands. Although we believe that fluid should be carefully administered during anesthesia for bilateral adrenalectomy, our experience indicates that the cardiovascular status of the patient rather than an increased antidiuretic tendency is the prime factor in determining the development of cardiac failure following excessive use of fluids during operation. In the postoperative period, however, the increased antidiuretic tendency may be more important.

Careful analysis of the data revealed that the one factor most strikingly related to anesthesia complications was the preoperative state of the patient. A low Ridit score was consistently found in patients in good general condition while those who were classified as fair or poor risks had a higher Ridit score. Although patients who weighed below 40 kg. had higher Ridit scores, these were actually cachectic patients classified as poor risks. In the final analysis it appears, therefore, that the risk or general condition of the patient is the only factor closely related to the development of anesthetic complications.

**Summary and Conclusions**

The charts of 150 patients scheduled for bilateral adrenalectomy were reviewed and the information entered on IBM punch cards. This data was then analyzed statistically by employing the Ridit score and calculating the 95 per cent confidence limits.

No statistically significant relationship was found between the development of anesthetic complications and age, sex, previous castration, weight, preparation with cortisone, and position on the operating table.

There was no significant difference in the severity of anesthetic complications between those patients who received diethyl ether and those patients who received cyclopropane as the maintenance agent.

There was a definite consistent relationship between preoperative risk and severity of anesthetic complications. The odds are about 3 to 1 that a poor-risk patient will have more severe anesthetic complications than a good-risk patient.

We wish to thank Dr. Irwin J. Bross for his advice and aid in the statistical analysis, and Dr. Henry T. Randall for reviewing the manuscript.
REFERENCES