PREOPERATIVE ESTIMATION OF THE ANESTHETIC AND SURGICAL RISK*

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POSTOPERATIVE morbidity and mortality may be reduced if the adverse factors which each patient presents are duly evaluated and heeded. Diligent search for these factors is rarely necessary—they are present as red flags in the usual history, physical examination and laboratory data, but the surgical train may rush the patient heedlessly past them toward the goal of operation with occasional unnecessary disaster. Due appreciation of the hazards presented by the patient's condition will affect choice of anesthesia (treated in this issue by L. F. Sise), choice of operation, preparedness for untoward events during and after operation, and most of all, the preoperative treatment employed, and by these means will favorably influence the outcome. "Careful preparation of the patient . . . often turn[s] a very poor risk into a fair or good one and save[s] days or weeks . . . in the subsequent convalescence, . . . if not life itself" (Wells[35]).

SCALES FOR GRADING RISKS

It is a distinct safeguard if each physician who goes over a case will note on the record his estimation of the degree of risk presented by the patient. A surgeon would hesitate to choose the more dangerous of two available operations in the face of written warnings from his internist, his anesthetist and his assistant. The International Anesthesia Research Society presents a very commonly used scale of A, B, C defined thus: "A: The good risks: patients free from organic disease, whose surgical condition is not likely to prove fatal. B: The fair risks: patients suffering from organic disease but whose surgical condition is not especially serious. C: The poor risks: patients whose surgical condition is so serious or so far advanced as likely to result in fatality." This scale provides no suitable classification for patients with extremely severe "organic disease" and mild "surgical condition." Some who have used it have found it inadequate, and have added a confusing array of other letters. We have found it more satisfactory to employ the scale ordinarily used for rating signs and symptoms (1, 2, 3, 4, meaning respectively slight, moderate, marked, and extreme). Thus "1" means Good Risk: nothing found in the patient's condition that adversely affects the risk; "2" means Fair Risk: one or more adverse factors are present, but are not serious; "3" means Poor Risk: prepare patient carefully for operation, choose the least operation that will give the needed surgical relief, and select the anesthetic drug and method with special regard to the patient's condition—this is, therefore, an unmistakable danger signal; "4" means: so seriously sick that death is likely unless the downward progress is quickly reversed. For this classification all unfavorable diseases and conditions the patient presents, whether "medical" or "surgical," are considered together, including the condition for which operation is to be performed. The severity of the proposed operation is not taken into account. Thus if a patient has severe hyperthyroidism, that alone marks him as a grade 3 risk, whether the operation proposed is thyroidectomy or merely reduction of fracture of a phalanx. In this way serious misunderstandings are

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avoided which might arise if the proposed operation were taken into account, for the operation might be changed at a moment's notice.

GENERAL FEATURES

In most cases more important information will be gotten from a few minutes of inspection of, and of talk with the patient, and from the hemoglobin estimation and the urinalysis, than will be found in all of the rest of the physical examination or laboratory data. The points of prime importance to be gleaned from such a brief interview are considered in this section and in the two that follow.

Age. An age of 55 years or over almost automatically takes the patient out of the grade 1 group. Butler, Feeney and Levine[2] found three times as many operative deaths in patients with heart disease over fifty years as in those under fifty years, and Miller[20] in an unselected series of general surgical cases found eight times as many deaths in those over fifty years.

Weakness. The usual laboratory reports throw no light on weakness and debility, and mention of them is too often omitted from records of physical examinations, yet they are of *the utmost importance.* The evidence comes from questioning and observing the patient, and from questioning the attending nurses. Moderate and severe degrees of weakness automatically brand patients as fair and poor "risks" respectively. *Prolonged invalidism* is of equal importance.[5]

Psychic State. A much depressed psychic state augurs ill for the period of convalescence. It is well to take heed of a definite *premonition of death.* In order to prevent the fulfilment of a powerful autosuggestion of this sort, it may be well to "steal" upon a patient so afflicted with a rectal anesthetic under the guise of giving a cleansing or nutritive enema, or with an intravenous drug under the guise of taking a blood sample.

Changes in Weight. Marked *obesity* presents a moderate though definite handicap.[5,34] It interferes with breathing whether the patient is under spinal or general anesthesia; it increases the difficulty and therefore also the trauma of abdominal operations; and it appears to make the patient more prone to develop complications during convalescence. On the other hand, more than a slight pathological *loss of weight* carries with it a parallel increase in the operative risk involved, probably due in large part to the depletion of glycogen reserve with resultant partial starvation of body tissues generally. In a series of 50 patients operated on for peptic ulcer, Studley[30] found a mortality rate of 33⅓ per cent in those who had lost 20 per cent or more of their body weight, as contrasted to a rate of 3.5 per cent among those who had lost less weight.

Vomiting. Persistent vomiting may plunge the patient very rapidly into an extremely grave condition because of the resulting acute starvation and acidosis. Ketonuria, a lowering of the carbon dioxide combining power of the blood, and sometimes a lowering of the *p*H value of the blood are corroborative data (Thalhimer[33]) The gravity of the risk may be lessened by the intravenous administration of glucose. Some prefer to give insulin with the glucose, since it helps not only in oxidizing glucose and thus in overcoming the acidosis, but also aids in storing glycogen.

High *intestinal obstruction,* on the other hand, produces degrees of alkalosis fully as serious as the acidosis of simple starvation. The chlorides of the blood are reduced and its content of nonprotein nitrogen is elevated. The risk should be lessened before operation is undertaken by the intravenous administration of physiological solution of sodium chloride.[33]

OXYGEN METABOLISM

It is likely that a basic function of most anesthetics is to interfere with cellular oxidation. Moreover several of the inhalation agents, as commonly given, tend to displace oxygen in the respiratory tract, while rectal, intravenous and spinal anes-

thesia frequently diminish the tidal respiratory volume to the point of producing varying degrees of anoxemia. Anoxia, or oxygen starvation of the tissues, is therefore an eternal problem to the anesthetist, and any additional pathological block to the free passage of oxygen to the tissues is of utmost importance in establishing the anesthetic risk, whether the block be mechanical, or chemical as from toxins.

Any mechanical *obstruction to free breathing*, such as ankylosis of the jaw, nasal blocking, an abscess bulging into the pharynx, paralysis of a vocal cord, or compression of the trachea from a mediastinal tumor, presents an important problem to the anesthetist which must be met by careful choice of anesthetic method and drug (such as cyclopropane with large proportion of oxygen, the intratracheal method, or the auxiliary use of helium), or rarely by preliminary tracheostomy.

Diminution of the *vital capacity* to less than half of the normal, definitely increases the anesthetic risk. Vital capacity varies directly with cardiac efficiency[16,23] and is lessened by emphysema, pulmonary tuberculosis, and other inflammations of the lung parenchyma and of the pleura. Pneumonias that accompany gas poisoning, measles and influenza are sometimes followed by fibrosis rather than by resolution, with resulting marked reduction of alveolar wall area and consequent increase of hazard in the use of drugs administered with low concentration of oxygen, such as nitrous oxide.[13] Percussion and auscultation in these cases give deceivingly negative findings. "The closer the vital capacity approximates tidal air, the graver the risk" (Moersch[21]).

The most frequent block to oxygen transportation is in the blood itself. The laboratory datum that most often serves as a danger signal to the anesthetist is the hemoglobin determination. It is not commonly realized that even as little as a half hour's administration of the usual inhalation anesthetics produces a significant reduction in the oxygen-carrying power of the blood, quite in addition to alterations in erythrocyte count and hemoglobin content.[32] "It seems to me nothing short of criminal to perform a major operation on a patient whose hemoglobin is lower than 70 without first alleviating the *anemia* with transfusions" (Thalhimer[33]). With the general tenor of this statement I would agree, but would qualify it by stating that many cases may well be handled by transfusion immediately following operation. We have found it safer to transfuse several hours or a day before operation rather than immediately beforehand. *The importance of anemia in determining anesthetic risk cannot be overestimated.*

CARDIOVASCULAR SYSTEM

Well over half of the recent literature on anesthetic risk deals with the heart and blood vessels. This great overemphasis is probably due to mistaking the cardiovascular signs of death for the primary cause of death. "Heart failure" is written on many death certificates that might better read "Surgical shock," "Postoperative obstruction of bowel," "Hemorrhage," "Asphyxia from respiratory obstruction," or "Poisoning from overdose of anesthetic agent." Butler, Feeney and Levine,[2] in an excellent analysis of convalescence from 494 operations on patients with definite heart disease, conclude that in the absence of nephritis or of a history of congestive failure or of coronary thrombosis, heart disease has little effect, if any, on operative mortality. Concerning another series of 336 operations on patients with heart disease, Hickman, Livingstone and Davies[8] conclude that as a group they are "fairly good risks."

To determine the degree of risk involved, various *mathematical indexes* based on the blood pressure and the pulse rate have been widely used. Some[27] place considerable faith in them, but most find them very unreliable.[4,14,31] Sykes very suitably ridicules them by reporting 8 cases in which the indexes gradually changed from "Bad risk—inoperable" to "Good risk—oper-

able" as each patient approached death from apoplexy, carcinoma, heart disease, phthisis, duodenal ulcer, or influenza. "Moot's rule"* is so figured that it would classify a large proportion of patients with severe hyperthyroidism as inoperable; and the "Energy Index"† would designate many patients in severe shock as "good risks." When normal, they appear to be of little or no value; when abnormal, they may be helpful by corroborating other more important data. The *breath-holding test* of Sebrasez is probably more significant,[6,27,29,34] but due allowance must be made for the individual's will power, training (chiefly of swimmers), and degree of intelligent cooperation. While resting in bed, the patient closes his mouth at the end of a deep inspiration, pinches his nose, and holds his breath as long as he can. A result of twenty-five seconds or more is normal, and one of fifteen seconds or less is held to indicate marked reduction of cardiac or respiratory reserve. A normal result in patients with heart disease is significant.[27]

The most important information concerning the heart and circulation is to be obtained by briefly questioning the patient concerning dyspnea and chest pain. "A *history* of the patient's activities and symptoms is far more valuable than the physical examination. . . . If the individual is able to indulge in moderate activity without symptoms, no concern need be felt about the ability of the heart to sustain the very slight extra work entailed by a surgical operation provided the anesthetic is properly administered" (Marvin). Rodman and Leaman[25] speak of "the folly of basing any opinion upon what is heard over the heart by the use of the stethoscope; for the purpose of operation and anesthesia, a heart which carries its daily burden well, without excessive dyspnea or chest pain, is equivalent to the normal organ." Sir James Mackenzie contrasted symptoms with mechanical tests thus:

> The standard by which the heart's strength is to be measured is not . . . fixed. . . . The field of normal response to effort varies widely in different healthy individuals. . . . The amount of effort he can normally put forth without distress . . . is the only practical standard by comparison with which it can be determined whether the field of the heart's response to effort is restricted. The subjective symptoms of heart failure are *never* absent when the heart's efficiency is in any way impaired.

In the early stages of heart failure "the patient becomes conscious of certain sensations of distress or discomfort on making an effort which formerly he was able to make without experiencing these sensations."

A simple and most valuable outline for *cardiovascular examination and grading*, parallel to those of the American Heart Association, is presented by Rodman and Leaman,[25] and could be adopted advantageously by everyone in rating cardiac patients for operation:

> "Class 1. Good risk. [This corresponds to our anesthetic risks 1 and 2.] Patients in whom ordinary physical activity does not cause undue fatigue, palpitation, dyspnea, or chest pain. All cases of well compensated valvular heart disease except the syphilitic; hypertensive heart disease with no renal involvement.
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> "Class 2. Risk fair with careful medical supervision and preoperative treatment. [This corresponds to our anesthetic risk 3.] Emergency surgery only until risk improves. Cases of beginning congestive failure and angina. These all show undue fatigue, palpitation, dyspnea, or chest pain on *ordinary* physical activity. All patients classed here can have risk improved to class 1, if operation is not emergency.
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> "Class 3. Surgery contraindicated. [This corresponds to our anesthetic risks 3+ and 4.] These patients show signs of cardiac insufficiency at rest, or signs of active heart infection. They cannot carry on *any* physical activity

* Pulse pressure in mm. Hg divided by diastolic pressure; 40 per cent to 60 per cent is called "operable"; below 25 per cent and above 75 per cent is called "probably inoperable."

† The value of the systolic pressure in mm. Hg is added to that of the diastolic pressure, and the sum is multiplied by the number of heart beats per minute. From 12,000 to 18,000 is considered normal.

without discomfort. Here we include severe angina patients, cases of cardiac decompensation with edema and severe dyspnea, and patients with recent coronary occlusion with marked reduction of the myocardial reserve."

Concerning the importance of various *lesions* and conditions, it is generally agreed[2,7,8,9,15,24,25] that coronary occlusion, angina pectoris, congestive failure and syphilitic aortitis carry high operative mortality; and that valvular heart disease and auricular fibrillation if uncomplicated by failure, and paroxysmal auricular flutter, fibrillation, or tachycardia do not add appreciably to the anesthetic or surgical risk. The risk attending congestive failure may be greatly lessened by preparation with digitalis and rest. Pulsus alternans, heart block, and bundle branch block (producing reduplication of the first sound at the apex) are regarded as very serious by some, but it is probable that their importance varies directly with the severity of symptoms of the diminished cardiac efficiency which may accompany them.

High blood pressure, even in the extreme range, if unaccompanied by myocardial or renal insufficiency, diabetes, hyperthyroidism or the like, adds only slightly to the operative risk (McQuiston and Allen[19]). This is probably contrary to the popular view, but is corroborated by others (Butler, Feeney and Levine,[2] Hermann[7] and Hickman, Livingstone and Davies[8]). Marked degrees of arteriosclerosis increase the risk slightly and require careful choice of anesthetic drug and method.

McQuiston also analyzed 250 cases of *low blood pressure*[18] uncomplicated by jaundice, diabetes, syphilis or Addison's disease, and found the mortality rate lower than in a parallel group with normal pressure. His series consisted of 100 cholecystectomies, 100 operations on stomach and duodenum and 50 gynecologic operations on patients whose systolic pressure was not higher than 100 mm. Hg. Life insurance statistics have shown the mortality rates among persons with low pressures to be but 35 per cent of the expected rates.

If a patient's usual pressure has been lowered by disease or other pathological state such as *shock*, the risk is increased proportionately to the amount of lowering of the pressure.

HEPATIC INSUFFICIENCY

Knowledge of the normal and abnormal functioning of the liver is woefully crude and fragmentary. Its relationship to anesthesia is probably supremely important because of its detoxifying power, its metabolizing of carbohydrates and storing of glycogen, and the injury which anoxemia and some anesthetics inflict upon it. No test or tests of its function have received even general approbation and common application.

Risk of hepatic failure may be minimized by the administration of liberal amounts of carbohydrate before operation.[10] In cases of suspected liver damage, such as may occur from prolonged sepsis, toxicity or starvation, the supply of carbohydrate should be even more bountiful in order to build up the glycogen reserve. This is important for detoxification, repair of liver damage and reduction of clotting time.

Obstructive jaundice is likely to be followed by postoperative hemorrhage.[10] The risk is therefore serious. No reliable prediction of the likelihood or severity of bleeding may be made from consideration of the degree or duration of jaundice or from the bleeding and clotting times as ordinarily performed. However, in about 30 of our cases in which the bleeding time has been obtained according to the method of Ivy,[11] it has predicted correctly the probability of hemorrhage. Transfusions, carbohydrates, and calcium gluconate are used to reduce the bleeding time (Ivy) and the likelihood of hemorrhage.

In the presence of hepatic insufficiency, anesthetic agents should be chosen which have the least toxic effect on the liver and which do not depend on the liver for detoxification.

DIABETES

Since the advent of insulin, Joslin[12] and others[1,17] have been preaching that diabetes, if properly treated, does not influence the surgical risk materially. According to our scale of grading, the untreated diabetic would fall into grade 2, 3 or 4, depending on the severity of the disease, and with suitable treatment he would be raised to grade 2 if there were no additional unfavorable factors. It is to be remembered, however, that if diabetes is of more than five years' duration, arteriosclerosis is probably present, and that if gallstones or gangrene are present, there is almost surely coronary disease also (Joslin[12]).

"Glycogen in the liver is everything to the diabetic. With it, his life is secure; without it, he dies," (Joslin[12]). He should therefore receive an adequate diet including adequate carbohydrate for glycogen storage, and sufficient insulin to keep the urine free of sugar and if possible to hold the blood sugar below 0.150 per cent (Allan[1]). "Give him carbohydrate within three hours of his operation: orange juice, strained cereal, ginger ale. Give too little insulin rather than too much" (Joslin), in order to avoid a hypoglycemic insulin reaction. In case the surgical disease involves acute infection, operation should be performed immediately without waiting for the usual preoperative treatment of the diabetes. That will be less severe when the burden of the surgical disease has been removed. The lifting of the load of hyperthyroidism or of gallstones by operation likewise ameliorates diabetes (Joslin[12]).

Severe acidosis with threatening coma involves the most serious risk. Tests for urinary acetone and diacetic acid are positive; the breath smells of acetone; estimation of the carbon dioxide combining power of the blood gives corroborative evidence. The risk should be lessened by vigorous treatment with carbohydrates, insulin and fluids. After acidosis has been overcome, the patient should be kept on an adequate carbohydrate diet (at least 50 to 100 gm. daily), with insulin if needed, free of ketonuria and of glycosuria, for several days before operation in order to allow the heart to recover from the injury inflicted on it by the state of acidosis. This recovery is indicated by the gradual drop of the pulse rate toward normal.[28]

RENAL INSUFFICIENCY

Certain anesthetics impair kidney function, others depend largely on the kidneys for their passage from the body, and operation throws a heavy additional load on the kidneys by reducing the available fluid through perspiration, hemorrhage, vomiting, diminution of fluid intake and shock, as well as by increasing the nitrogenous waste products in the blood through protein destruction associated with fever and operative trauma.[3] Any impairment of renal function increases the risk of anesthesia and of operation in corresponding degree.

In the presence of hypertension, general arteriosclerosis or albumin and casts in the urine, one or more tests of renal function should be done. The kidneys should be able to concentrate the urine to a specific gravity of at least 1.024,[3] the fractional phenolsulphonphthalein test should normally show excretion of 55 per cent in the first half hour,[26] and the nonprotein nitrogen of the blood should not exceed 40 mg. per hundred c.c. Blood urea nitrogen of over 35 mg. per 100 c.c., or phenolsulphonphthalein excretion of less than 20 per cent indicates very serious renal damage.[22] The impairment of renal function as shown by these various tests indicates the degree of increase of surgical risk. The eyegrounds also may give very important evidence concerning the severity and prognosis of the nephritis.

Following 26 operations on patients with acute nephritis, O'Hare and Hoyt[22] had 2 deaths, one from mercuric chloride poisoning, the other from empyema, and the outlook for both patients was considered probably hopeless before operation. The other 24 had normal convalescence except

for the urinary sediment. The risk for this group of patients therefore is only moderately increased. They should receive alkalis before operation, and while the urinary volume is low operation should be avoided if possible. Among 21 chronic nephritic patients, with high blood pressure and seriously impaired renal function, the same authors report a mortality, namely of 33 per cent. These patients should receive alkali for three days before operation and the daily urinary output should be kept above 1500 c.c. by forcing fluids. Even under most favorable circumstances, operation on this group of patients is hazardous.

THYROTOXICOSIS

Death from postoperative thyroid storm may be prevented in all but the most seriously sick patients if it is realized that each of the following factors is of unfavorable prognostic significance: age of forty years or over; duration of disease greater than one year; loss of one-fifth or more of the body weight; failure to gain weight during the preoperative period of rest and iodine treatment; failure of the pulse rate to drop to 100 or below during the preoperative period; high basal metabolic rate before treatment, and failure of the rate to show a good drop under treatment to a level less than plus 50; vomiting or diarrhea; marked physical restlessness; and failure of preoperative narcotics to produce the usual sedation. The grading of surgical risk is in accordance with the number and severity of these adverse factors. In the case of each seriously sick patient it should be decided before operation whether the entire surgical procedure may safely be done at one time or should be divided into two or more operations. If the latter course is chosen, it should be adhered to rigidly, even though the pulse rate, the pulse pressure and the oxygen consumption during operation indicate a favorable course.

The risk presented by the so-called apathetic thyroid patient is perhaps not so generally recognized. These patients are elderly, have had the disease a long time and have lost much weight. Many of the signs of thyroid toxicity have long since disappeared, as if the fire had burned itself out: the demeanor is calm, the pulse rate may be slow and the basal metabolic rate only slightly elevated. In spite of apparent non-toxicity and in spite of a most favorably appearing course on the operating table, thyroidectomy in these patients must be divided into two stages, and every supportive measure must be given in order to prevent gradual waning of strength and life after operation. Death occurs in these patients without any sign of a relighting of thyroid activity such as is seen in patients in the common stimulated phase of thyroid toxicity.

The danger of pressure from thyroid tumors has been considered in the section entitled "Oxygen Metabolism."

MISCELLANEOUS FACTORS

Addison's disease marks the patient as presenting at least grade 3 risk.[5,18]

The *chronic alcoholic* is more susceptible to postoperative complications than others. With operations of an emergency nature, the usual intake of alcohol had better be maintained, lest sudden withdrawal cause cerebral edema. When plenty of time is available the patient should undergo a "cure" and be prepared for operation by plentiful intake of carbohydrate.

The presence of any *infection* in the body would seem to increase the likelihood of postoperative infections, the degree of risk depending on the location and severity of the infection, from peridental sepsis at one extreme to overwhelming septicemia at the other. Statistics from the Wisconsin General Hospital[36] show that with cyclopropane anesthesia both major and minor postoperative respiratory complications were three times as frequent in patients with preoperative respiratory complications as in those without preoperative respiratory complications. With ether anesthesia there was not this difference, but all figures were high.

Asthmatic patients as a whole withstand anesthesia and operation very well. Etherization is sometimes followed by a prolonged period of freedom from asthmatic attacks, and accessory drugs such as morphine, ephedrin and epinephrin give temporary relief.

One major operation should not follow another *recent major operation* too closely. It should be borne in mind that widespread, persistent, marked deviations from normal of the functions of many systems are produced by apparently simple operative procedures and by even the less harmful of the anesthetic agents. Unless sufficient time elapses between two major operations to allow the patient to resume his normal activities and to regain his normal vigor and appetite, the risk of a second operation is definitely increased.

COMMENT

Technically difficult or laborious procedures are not usually required for an approximate estimation of the anesthetic risk. Four of every five dangerous situations will be detected, and clues to the fifth will be obtained from minimal data concerning the patient's age, strength, glycogen reserve, cardiovascular symptoms, urinalysis, and hemoglobin content of the blood. These require but a brief visit of inspection and questioning, and some degree of medical experience and judgment, in addition to the simple laboratory tests made. The further details of history, physical examination, special examinations, and laboratory data will often throw additional light, should usually be available, and should always be obtained where the minimal data indicate that they may be helpful.

With the exception of chloroform, any of the commonly used anesthetic agents and methods is reasonably safe for almost every patient. However, the pathological state of the patient is only one of the hazards that lurk in the vicinity of the operating room. Fully as important in the ultimate outcome are the surgeon and the anesthetist. The former obviously has abundant opportunity to run into trouble, and a careless or poorly trained anesthetist may lead a patient to his death when every other circumstance favors complete recovery. He may administer ether too rapidly and thus induce respiratory complications. He may fail to observe or evaluate the signs of shock or to institute measures to combat it. He may permit spinal anesthesia to run too high and may fail to administer artificial respiration. He may permit respiratory obstruction to develop with resultant complications or death, immediate or late. Every general hospital should provide a place for, and every surgeon should see that his patients have the services of, a competent anesthetist. It may even be said that *the skill of the anesthetist is the most important factor in the determination of the anesthetic risk.*

SUMMARY

Careful preoperative estimation of the anesthetic and surgical risk will aid in the avoidance of many pitfalls. A scale for grading the degree of risk is presented. The estimation of the risk and the methods to be used to lessen or compensate for it are considered under the topics of weakness, prolonged invalidism, the psychic state, nutrition, acidosis and alkalosis, oxygen metabolism, the cardiovascular system, hepatic insufficiency, diabetes, renal insufficiency, thyrotoxicosis and minor miscellaneous topics.

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