The Management of Cardiac Patients in Relation to Surgery

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The internist frequently is called upon by his surgical colleagues for an opinion concerning the risk of anesthesia and of a surgical procedure in a patient who has organic heart disease. A request of this kind carries with it a number of implied questions, among the most important of which are:

1. Does the cardiac abnormality increase the risk of the contemplated procedure?
2. Will the anesthesia and surgical operation increase the demands on the heart beyond the limits of the cardiac reserve and therefore precipitate congestive heart failure?
3. Does the cardiac condition require treatment before operation?
4. Is the prognosis of the heart condition so grave that surgery should be limited to an emergency or palliative procedure?
5. Is the heart disease of such a nature that it carries with it the liability of sudden death during anesthesia and surgical operation?
6. What bearing does the state of the heart have on the choice of the anesthetic agent?
7. What, if any, cardiovascular complications are to be anticipated during the operation and postoperative period?

The information necessary to answer these questions usually can be obtained from the clinical history and physical examination without resorting to more elaborate forms of investigation.

It still is quite commonly believed that during anesthesia and surgical operations the heart is subjected to a considerably increased demand for work, but there is no evidence that this is actually the case. The two greatest dangers to which a patient is exposed during an operation under general anesthesia are anoxia and shock. If these are avoided by proper anesthesia, minimizing of blood loss, and careful manipulation of tissues, even prolonged and extensive surgical procedures do not increase the load on the heart as much as does moderate physical exertion. Competent anesthesia is seldom attended by cyanosis or more than slight alterations in respiration, pulse rate, and blood pressure; and changes of this kind are encountered no more frequently in patients who have organic heart disease with a satisfactory myocardial and coronary reserve than in normal individuals. It may be taken as a general rule, therefore, that if anoxia and shock are avoided, patients with organic heart disease who have been able to carry on normal daily activities without experiencing symptoms of myocardial or coronary insufficiency can tolerate general anesthesia and surgery with no more hazard than a normal person.1 There are a few exceptions to this rule, and these will be mentioned later. The presence of hypertension does not affect the validity of the general statement, provided that renal function has not been depressed to an important degree.

In estimating the risk of anesthesia and surgery in a patient who has organic heart disease, careful inquiry concerning dyspnea or substernal pain on exertion, paroxysmal nocturnal dyspnea, attacks of acute coronary failure, and

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former acute myocardial infarction is of much more importance than are the cardiac findings on physical examination. Certain findings, however, such as enlargement of the heart, murmurs indicative of valvular damage, gallop rhythm, and important disturbances of cardiac rhythm, may make it advisable to question the patient again in order to be certain that the questions have been understood and truthfully answered. The same consideration applies to the majority of electrocardiographic abnormalities. With few exceptions, an abnormal electrocardiogram in an individual who has had no symptoms of impaired myocardial or coronary reserve does not indicate added danger from anesthesia and surgery. As examples, bundle branch block does not of itself increase surgical mortality or postoperative morbidity, and patients who have auricular fibrillation without congestive failure tolerate anesthesia and operation satisfactorily if the ventricular rate has been properly controlled by digitalis.

Occasionally a need for anesthesia and surgery arises in patients who are suffering from congestive heart failure. In such circumstances it is advisable that there be a period of preoperative treatment, the intensity and duration of which will be determined by the degree of failure and the urgency of the surgical condition. A surgical emergency, such as acute appendicitis or a perforated peptic ulcer, will not permit delay, and the risk of immediate operation must be accepted. If, in a situation of this kind, the patient has not been receiving digitalis, a suitable preparation of the drug should be administered by intravenous injection before the anesthesia is started. The dose usually employed is one-half or somewhat more of the amount estimated to be necessary for complete digitalization. After the operation additional intravenous or intramuscular injections of smaller amounts can be given at intervals of four hours or so until the process of digitalization is complete. One of the mercurial diuretics should be given by intramuscular injection at the same time as the initial dose of digitalis and subsequently each day until the preparation no longer causes diuresis or loss of weight.

When congestive heart failure is present and the surgical condition is of such nature that operation can be delayed safely for a few days or longer, digitalization should be accomplished by the oral route or, if nausea and vomiting are present, by the intramuscular injection of one of the preparations designed for this purpose. If auricular fibrillation is present, the ventricular rate furnishes the most helpful guide as to whether or not the maximum therapeutic effect of the drug has been obtained; sufficient digitalis is given to reduce the rate, in the absence of fever, severe anemia and thyrotoxicosis, to approximately 70 beats per minute. When normal rhythm is present, the heart rate is of no aid in estimating the degree of digitalization, and one must then prescribe the amount of the drug required by the average patient and be guided by the general clinical response. The sodium content of the diet should be strictly limited, and one of the mercurial diuretics should be administered. Surgery should be postponed, if at all possible, until all evidence of congestive failure has disappeared. If this is done, the patient can reasonably be expected to stand anesthesia and operation without difficulty, but if sufficient delay is impossible and adequate treatment cannot be carried out, surgery may be followed by a considerable increase in the degree of failure.

Regardless of the adequacy of preoperative treatment, patients who have had congestive failure before operation must be watched closely during the period after surgery. Postoperative complications, such as pulmonary embolism, atelectasis, pneumonia, and abdominal distention, are not well borne and may be responsible for a return of or an increase in the manifestations of decompensation. The mortality related to these complications is considerably greater in patients who have had congestive failure before operation than in normal individuals or in those who have organic heart disease with little or no impairment of myocardial reserve.

Digitalis also should be administered before operation to persons who do not have congestive failure but who have experienced dyspnea of cardiac origin on moderate exertion or paroxysmal nocturnal dyspnea. Although these patients usually tolerate anesthesia and operation satisfactorily without preoperative dig-
italization, the added strain of unforeseen postoperative complications may be sufficient to precipitate cardiac decompensation. The preparatory use of digitalis will improve the ability of the heart to withstand such an added strain so that postoperative mortality should not be significantly greater than in individuals who have a normal myocardial reserve. The amount of the drug given should be sufficient to accomplish theoretic digitalization, and the dosage schedule will be determined by the time available.

All patients who have auricular fibrillation or auricular flutter should be completely digitalized before operation whenever possible, even though there have been no symptoms of diminished myocardial reserve and regardless of the ventricular rate. As in the case of persons who have symptomatic myocardial insufficiency without congestive failure, these patients are seldom adversely affected by anesthesia and surgery. However, anoxia, hemorrhage or shock during operation, and such postoperative complications as pneumonia, atelectasis, thromboembolic accidents and abdominal distention are liable to cause an abnormally great increase in the ventricular rate in the absence of digitalis control. This in turn may result in the development of cardiac decompensation. Blumgart demonstrated that a given amount of exercise causes a much greater rise in heart rate in individuals who have auricular fibrillation than it does in patients who have normal rhythm. After the administration of digitalis the response to exercise still remains greater than in persons with normal rhythm but the maximum ventricular rate attained is less than before the drug is used.

In the absence of symptoms of myocardial insufficiency, the presence of hypertension, enlargement of the heart, evidence of organic valvular disease, premature beats and electrocardiographic changes indicative of myocardial damage, preponderance of either ventricle or coronary artery disease are not to be considered indications for the preoperative use of digitalis. There is likewise no evidence that digitalis is of benefit in the preoperative care of elderly patients who have a normal myocardial reserve. Occasionally, however, an elderly individual is encountered who experiences dyspnea on exertion and yet presents no objective evidence of cardiac or pulmonary disease. The preoperative use of digitalis is warranted in such patients on the assumption that the dyspnea may be of cardiac origin even though no clear-cut proof is available.

In patients who have been able to carry on normal daily activities without experiencing symptoms of myocardial or coronary insufficiency, the fact that organic heart disease is present does not influence the decision as to the type of operation to be done. As in the case of persons with normal hearts, the procedure carried out should be the one required for the cure or correction of the surgical problem. The situation is different, however, when the heart condition is such that death from a cardiac cause must be anticipated within a period of two to four years at the most. All elective surgical procedures are then to be avoided. In patients who have had congestive heart failure, for example, the repair of abdominal or inguinal hernias should be postponed as long as the condition can be controlled reasonably well by mechanical means, and myomas of the uterus should be treated by radiation rather than by hysterectomy.

There are certain heart conditions which are liable to result in sudden death even under normal circumstances, and in patients who are in one of these states, the occurrence of even mild anoxia or shock during or after operation may directly precipitate the changes which abruptly terminate life. The conditions include angina pectoris, recent myocardial infarction, recent acute coronary failure, aortic stenosis, coronary ostial stenosis due to syphilitic aortitis, and high grade or complete auriculoventricular block complicated by the Adams-Stokes syndrome. Aortic stenosis and syphilitic aortitis may have caused no symptoms prior to the operation but the other conditions will have given rise to characteristic manifestations. In patients who have aortic stenosis or severe coronary disease, the most common cause of sudden death appears to be ventricular fibrillation which may or may not be preceded by a short paroxysm of ventricular tachycardia. Death from the Adams-Stokes syndrome is due,
with rare exceptions, to ventricular asystole. In patients who have had angina pectoris, myocardial infarction, or acute coronary failure, the fall in blood pressure which accompanies surgical or postoperative shock may so reduce coronary blood flow that acute coronary failure or myocardial infarction results. Either of these, if not suddenly fatal, may be responsible for the rapid development of congestive heart failure.

The risk of anesthesia and surgery in patients who have any of the forms of heart disease which are attended by the danger of sudden death must be recognized beforehand, and surgery should be carried out only when unavoidable. Everything possible must be done to prevent anoxia and a fall in blood pressure during the operation, and the surgical procedure employed must be the simplest one available. The risk must not be magnified beyond its true proportions, however, and patients must not be denied the benefit of surgery when an operation is necessary. Brumm and Williams reported only 11 deaths (4.3 per cent) from cardiac causes in 257 patients with severe coronary disease who were subjected to required surgical procedures. Attacks of angina pectoris had been experienced by these patients for an average of 3.1 years, and 32 had healed infarcts at the time of operation. Death occurred from coronary thrombosis in 7, congestive heart failure in 2, and abruptly without apparent coronary occlusion in 2. In patients who have had myocardial infarction, operation should be postponed, if at all possible, for at least three months from the onset of the attack.

Mention has been made of the advisability of avoiding operation whenever possible in patients who have, or have had, congestive heart failure. This, of course, does not apply when myocardial failure is due in whole or in part to a condition which can be corrected by surgery. Cardiac decompensation occurs in approximately 4 per cent of all patients who have hyperthyroidism, the two most important factors responsible for its development being accompanying organic heart disease and uncontrolled auricular fibrillation. Correction of the thyrotoxicosis by radioactive iodine, or by subtotal thyroidectomy after thorough preoperative preparation, usually restores myocardial reserve to a normal or nearly normal level. Reversion to sinus rhythm occurs spontaneously in approximately one-third of those patients in whom auricular fibrillation was present, and normal rhythm can be re-established in about one-half of the remainder by the administration of quinidine. Arteriovenous aneurysm, patent ductus arteriosus and chronic constrictive pericarditis also may be responsible for the development of congestive heart failure. Treatment by the measures ordinarily employed for cardiac decompensation is of limited value but surgical correction of the causative condition usually results in complete disappearance of the manifestations of failure.

Because skillfully administered inhalation anesthesia does not increase the work of the heart, the presence of organic heart disease is only occasionally of more than secondary importance in determining the choice of the anesthetic agent. The type of operation and the general condition of the patient usually are the deciding factors. Nitrous oxide–oxygen and ethylene–oxygen, supplemented by ether if necessary, are well tolerated by patients with organic heart disease when strict precautions are taken to avoid anoxia. Sodium Pentothal by intravenous injection may be used for minor procedures and for operations which do not require relaxation of the abdominal muscles if at the same time 100 per cent oxygen is administered by inhalation. Cyclopropane should not be used because of the possibility of inducing important ventricular arrhythmias. In this connection it should be emphasized that the administration of epinephrine during cyclopropane anesthesia is an extremely hazardous procedure. Cyclopropane sensitizes the heart to epinephrine so that the latter drug readily causes ventricular tachycardia and ventricular fibrillation.

In the presence of one of the forms of heart disease which is likely to cause sudden death, local anesthesia should be employed if possible. The same cardiac conditions contraindicate the use of spinal anesthesia whenever the required operation can be performed under some other agent. A pronounced drop in arterial blood pressure due to spinal anesthesia may reduce coronary blood flow to such a degree that fatal
cardiac arrhythmias, acute coronary failure or myocardial infarction result. The administration of Neosynephrine by subcutaneous or intramuscular injection greatly reduces the incidence of dangerous hypotension, and therefore diminishes the risk when spinal anesthesia must be used. Pituitrin should not be employed to combat the hypotensive effects of spinal anesthesia in patients with organic heart disease because of its constrictive action on the coronary arteries.

Important cardiovascular complications are uncommon during operations skillfully performed under competent anesthesia. Disturbances of cardiac rhythm occur with considerable frequency but only occasionally are they of such a nature as to be of clinical significance. Kurtz, Bennett and Shapiro observed abnormalities in the electrocardiograms of nearly 80 per cent of 100 patients subjected to surgery, the incidence of changes being higher in persons with abnormal hearts than in those without heart disease. The most common alterations consisted of sinus arrhythmia, premature beats and downward displacement of the pacemaker. More important arrhythmias occurred in only seven instances.

In a recent study of electrocardiographic changes during cyclopropane-ether anesthesia, Johnstone reported the frequent occurrence of sinus bradycardia and A-V nodal rhythm. The changes apparently were due to reflex vagal inhibition of the heart secondary to stimulation of nerve endings in the air passages by the anesthetic agent. In one patient, sinus bradycardia progressed to transient complete cardiac arrest. Atropine prevented extreme sinus bradycardia but, in doses of less than 1.2 mg., did not affect the incidence of A-V nodal rhythm. It was observed, however, that if carbon dioxide was allowed to accumulate in the anesthesia circuit, atropine might induce ventricular tachycardia or frequent ventricular premature beats. Attention also was directed to the fact that the simultaneous administration of atropine and prostigmine may result in the development of ventricular fibrillation. Prostigmine has been employed as an antidote for overdosage with curare, and in order to avoid its use Johnstone recommends that only a single dose of curare be given to any patient. Muscular relaxation should be maintained subsequently by anesthetic agents and not by the administration of more curare.

Anoxia, shock and a considerable drop in blood pressure during anesthesia and surgery may be responsible for the development of premature beats even in patients who have perfectly normal hearts. When anoxia is the cause, the arrhythmia frequently can be abolished promptly by increasing the oxygen content of the anesthetic mixture. If the premature beats are of ventricular origin and occur with increasing frequency in spite of added amounts of oxygen, they may be eliminated by the intravenous administration of procaine amide hydrochloride (Pronestyl) in doses of 100 to 500 mg. The same preparation is of value in terminating ventricular tachycardia during anesthesia. The drug may be useful also in the treatment of supraventricular tachycardia. Tachycardia of the latter type, as well as that of ventricular origin, often can be brought to an end by the intravenous injection of procaine hydrochloride in doses of 30 to 70 mg.

The two most serious cardiac complications of inhalation anesthesia are standstill of the heart and ventricular fibrillation. Both conditions cause sudden disappearance of arterial pulsations and audible heart beats, and the electrocardiogram or direct inspection of the heart therefore is necessary to distinguish one from the other. Cardiac arrest and ventricular fibrillation are rare occurrences but either may develop without warning during any type of surgical procedure and in the entire absence of organic heart disease. Both can be treated successfully if the diagnosis is made promptly and treatment started within three to five minutes. Because accurate recognition is of such fundamental importance, the time may well come when an inexpensive oscilloscope will be a part of every anesthetist’s armamentarium. There must also be a plan of action to be followed whenever such an emergency arises. The procedure to be followed is the one recommended by Beck. Once the diagnosis is made, the heart should be exposed without delay. The practice of intracardiac injection of epinephrine
through the chest wall should be discouraged because it involves loss of time and may be responsible for the development of ventricular fibrillation in a heart in standstill. Having exposed the heart, the surgeon immediately begins cardiac massage, usually at a rate of approximately 40 contractions per minute, and only after this has been carried on for a few minutes does he stop momentarily to ascertain whether the condition is one of standstill or ventricular fibrillation. In the event of standstill, massage is resumed and is continued until spontaneous cardiac contractions appear. The first beats may be very feeble, and if they do not increase in strength, 1 cc. of 1:1000 epi-
nephrine is injected into the chamber of the right auricle or ventricle. This is the only situation in which epinephrine should be employed in cardiac resuscitation. When ventricular fibrillation is present, 5 per cent procaine is applied to the surface of the heart, and cardiac massage is continued without interruption. If the arrhythmia persists, 5 cc. of a 2 per cent procaine solution are next injected into the right auricle or right ventricle. Massage is continued, and if the disturbance is not terminated, electric shock is next employed. Alternating current of 1 to 1.5 amperes is applied to the heart for a fraction of a second through special electrodes.

Postoperative cardiac complications are not common and are seldom responsible for death of the patient. The greatest incidence is encountered in individuals who have severe coronary artery disease.\textsuperscript{10, 11} In these patients, death may be due to acute myocardial infarction, congestive heart failure or the sudden development of ventricular fibrillation. Master and his associates\textsuperscript{26} found that of 625 instances of coronary occlusion, 35 (5.6 per cent) occurred following some surgical procedure.

Auricular fibrillation occurs as a relatively unimportant postoperative complication in approximately 10 per cent of all patients subjected to thyroidectomy for hyperthyroidism. The arrhythmia generally begins within the first two or three days after operation and usually lasts for less than 48 hours. It seldom requires special treatment, although it seems advisable to begin gradual digitalization at its onset. One of the serious complications to which patients with mitral stenosis and auricular fibrillation are subject is an embolic accident due to dislodgment of a portion of a mural thrombus in the auricular appendages. A development of this kind, however, is no more likely to occur during surgical operations or the postoperative period than at other times.

There is one feature of the postoperative management of patients who have organic heart disease which deserves emphasis. This has to do with the administration of fluids by intravenous injection. All preparations which contain sodium, including whole blood and plasma, should be avoided unless their use is specifically indicated. When fluids must be given, the solution employed should consist only of 5 per cent glucose in distilled water whenever possible. In the presence of organic heart disease the administration of large amounts of sodium-containing fluids may be directly responsible for the appearance of pulmonary edema and other features of congestive heart failure even though there may have been no symptoms of myocardial insufficiency before operation. The danger is, of course, particularly great in patients who have congestive failure before operation even though all manifestations of decompensation have been controlled satisfactorily by treatment before surgery is undertaken. Occurrences of this kind probably have not been too uncommon in the past and undoubtedly have been a factor in furthering the erroneous belief that patients who have organic heart disease do not tolerate anesthesia and surgical operations satisfactorily.

The occurrences of pneumonia, atelectasis, thromboembolic accidents, and abdominal distention during the postoperative period constitute especially great dangers for patients who have organic heart disease and may be responsible for the initial development or return of congestive heart failure. The antibiotic drugs, early ambulation, prompt use of anticoagulants on the first appearance of evidence of phlebothrombosis, and continuous gastric suction have greatly reduced the incidence of these complications and have therefore improved the
The outlook of cardiac patients who require surgery.

**SUMMARY**

Skillful anesthesia and surgical operations do not significantly increase the demands upon the heart for work. Patients who have organic heart disease but who have been able to carry on normal daily activities without symptoms referable to the heart tolerate anesthesia and operation without difficulty provided that anoxia, hemorrhage and shock are avoided. Hypertension, cardiac enlargement, valvular disease other than advanced aortic stenosis, and electrocardiographic abnormalities, per se, do not increase surgical mortality or postoperative morbidity. When symptomatic myocardial insufficiency or evidence of congestive heart failure is present, a period of preoperative treatment with rest, digitalis, sodium restriction and mercurial diuretics is advisable. Treatment should be as thorough as possible during the interval in which the operation can be safely delayed. With adequate management, patients who have had myocardial failure can be expected to tolerate anesthesia and surgery satisfactorily. Postoperative complications, such as pneumonia, atelectasis, thromboembolic accidents and abdominal distention, are not well borne, however, and may be responsible for a return of cardiac decompensation.

Patients who have auricular fibrillation or auricular flutter should be digitalized before operation even though there have been no symptoms of impaired myocardial reserve and regardless of the ventricular rate.

Surgery should be avoided if possible in persons who have severe coronary disease, aortic stenosis, coronary ostial stenosis due to syphilitic aortitis, and high grade or complete auroclotventricular block complicated by the Stokes-Adams syndrome. Spinal anesthesia should not be employed in the presence of these conditions.

The decision as to the exact type of operation to be performed is seldom influenced by the existence of organic heart disease.

The presence of organic heart disease is only occasionally of more than secondary importance in determining the choice of the anesthetic agent to be given by inhalation. Cyclopropane, however, should not be used.

Although unimportant disturbances of cardiac rhythm occur frequently during anesthesia and operation, serious complications such as ventricular tachycardia, standstill of the heart and ventricular fibrillation are uncommon. The treatment of these conditions has been discussed.

Postoperative cardiac complications are not common and are seldom responsible for death of the patient. The greatest incidence occurs in patients who have severe coronary artery disease.

The intravenous administration of fluids which contain sodium should be avoided during operation and the postoperative period unless their use is specifically indicated.

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Circulation. 1951;4:430-436
doi: 10.1161/01.CIR.4.3.430

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/4/3/430

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