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The Evaluation of the cardiac patient for surgery

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THE EVALUATION OF THE CARDIAC PATIENT FOR SURGERY

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The recent introduction of new surgical procedures for certain cardiovascular diseases has given ample opportunity to confirm the old experience that these patients tolerate surgery "astonishingly well". The performance of a total thyroidectomy in patients with angina pectoris or cardiac decompensation, sympathectomy in hypertensive patients, and the surgical treatment of patients with pulmonary stenosis have shown that little risk is added by the cardiovascular lesion since the mortality in all these procedures is low. With these new indications, operations on cardiac patients are more frequently performed and it is timely to reconsider certain facts in the evaluation of cardiovascular patients as operative risks.

Although cardiac patients as a whole do tolerate surgery well, the fact remains that they do present a greater risk than do non-cardiacs and any surgery, either emergency or optional, carries with it a certain element of danger.

This problem is a large and difficult one when all the factors are considered. An attempt will be made in this paper to discuss the risks and problems involved in various cardiac disorders, the significance of certain cardiac signs and symptoms, and the preparations of the patient for surgery regarding medications and anesthesia. The principle cardiovascular diseases to be considered are coronary artery disease,

congestive heart failure, hypertension, syphilitic aortitis, rheumatic heart disease, auricular fibrillation, conduction disturbances and heart block.

In particular types of cardiac disorders such as coronary thrombosis, heart disease with nephritis, congestive heart failure, and angina pectoris the operative risks are substantially increased. The problem of whether any particular cardiac patient, irregardless of his lesion, can successfully undergo an operative procedure is today a question to be answered by the combined efforts of the internist, the surgeon, and the anesthesiologist. All must work as a team.

Goldburger (1) believes there are seven cardiac contraindications to elective surgical procedures in patients with lesions of the circulatory system. These are:

1) Cardiac Decompensation

2) Acute Myocardial Infarction

3) Acute Myocarditis

4) Bacterial Endocarditis

5) Mitral Stenosis and Auricular Fibrillation

6) Ventricular Paroxysmal Tachycardia and

7) Syphilitic Aortic Insufficiency. He further states that the presence of bundle branch block, hypertension, or compensated valvular heart disease (with the exception of

syphilitic aortic insufficiency), are not contraindications to elective surgery.

When considering surgical procedure in a cardiac patient the critical question is "Can he stand an operation?". Levine (2) believes the answer lies in reaching a decision on three vitally important questions. These are as follows: (1) The decision must be made as to whether the problem is actually surgical. This may seem strange at first but it is certainly true that many cardiac conditions present certain diagnostic features which simulate those features of acute surgical abdominal emergencies, (2) When an obvious disease exists which is amenable to surgical treatment one has to decide whether the prognosis of the cardiac situation is good enough to warrent subjecting the patient to a major operative procedure, and (3) When an operation is contemplated, the physician should have some idea as to the surgical or operative mortality in various cardiac disorders.

Ernstene (3) considers the answer to seven questions as being essential in the correct management of such a patient. These are as follows:

1) Does the cardiac abnormality increase the risk of the procedure?
2) Will the anesthesia and operation increase demands on the heart beyond the cardiac reserve and therefore

precipitate congestive heart failure?

3) Does the cardiac condition require preoperative treatment?

4) Is the prognosis of the heart condition so grave that surgery should be limited to an emergency or a palliative procedure?

5) Is the heart disease of such a nature that it carries the liability of sudden death during anesthesia and surgery?

6) What bearing does the state of the heart have on the choice of anesthesia? and

7) What cardiovascular complications are to be anticipated?

In further consideration of Levine's three questions it is quite possible the physician can save a patient an operation by the correct diagnosis in cases where an acute surgical abdomen supposedly exists. In other words he may correct a mistaken diagnosis. In children the manifestations of acute rheumatic fever with carditis and particularly pericarditis may be accompanied by abdominal pain and tenderness, fever, leukocytosis, and even nausea and vomiting. With the absence of joint symptoms it is easily seen where this condition may be mistaken for an acute appendicitis. (4)

It is well to bear in mind that with mitral stenosis two acute events may simulate acute abdominal conditions.

On rare occasions auricular fibrillation may be attended by acute pain and tenderness, abdominal rigidity, fever, leukocytosis, and slight icterus and thereby be mistaken for acute cholecystitis. Embolism of abdominal viscera is another circulatory condition with symptoms resembling the acute surgical abdomen. Emboli to the spleen or kidney can give sudden pain and tenderness with fever and leucytosis. With these phenomenon one would consider subacute bacterial endocarditis and auricular fibrillation. (2)

Probably the most common source of error of an acute abdominal condition in a cardiac case is the occurence of an acute coronary infarction. The resemblance may be that of acute biliary colic, perforated peptic ulcer, acute pancreatitis, appendicitis or even acute intestinal obstruction. (4)

In regards to women the diagnosis is not as difficult as in men for coronary infarction seldom occures in females unless they are over fifty years of age, have a family history of coronary disease, or are suffering from diabetes. (4)

Cardiac patients are not immune to acute surgical conditions however and in cases where a doubt exists and a delay is not permissible, it is probably safer to explore the abdomen. (5)

To aid in the correct diagnosis the following list of positive, almost positive, and highly suggestive evidences of

organic heart disease as suggested by Harrison (6) are of value.

1. Relable history of substantial distress appearing during exertion and disappearing with rest.
2. Enlargement of the heart.
3. Diastolic murmurs.
4. History of rheumatic fever.
5. Well marked elevation of blood pressure.
6. Chronic auricular fibrillation.
7. Heart rate less than 40.
8. Gallop rhythm.
9. A persistant and loud systolic murmur.
10. Positive electrocardiographic evidence, such as,
    (a) Marked prolongation of the A-V time.
    (b) Bundle branch block.
    (c) Certain T wave deformities.

In discussion of the second problem the question arises as to whether the patient will live long enough to make the risk and discomfort worth while. This in turn involves an estimation of the prognosis in the type of cardiac disease that is present. All too frequently female patients with hypertensive vascular disease or mitral stenosis are subjected to pelvic surgery only to succumb to circulatory failure a year or so later. It should be realized, however, that the prognosis of a serious cardiac condition is often difficult to assess.

The third problem is an attempt to estimate surgical mortality in patients suffering from different types of organic heart disease. Levine (7) reviewed 414 cases subjected to 494 operations. All surgical procedures were major and all cardiac abnormalities were organic. It was found that the total operative mortality of these 414 patients was 60 or 12.1 percent and the unexpected mortality only 6.3 percent. (Refere to Table I) This latter figure readily indicates that as a group, patients with heart disease undergo surgery fairly satisfactorily but that there is a definite increase in surgical mortality of cardiac patients since operative mortality of patients in general is only 1.5 to 2 percent. From Table I it is evident that the risk increases if congestive heart failure exists. Blumgart, Schlesinger, and Zoll (8) have brought out the fact that congestive failure adds greatly to the operative mortality. The presence of angina pectoris likewise carries a somewhat greater hazard primarily because these patients are subject to sudden coronary thrombosis or sudden death and these authors explained that peripheral vascular collapse such as frequently occurs following surgery may precipitate a coronary occlusion. The risk in coronary thrombosis is not so great if an accurate diagnosis of the cardiac condition is made and surgery postponed until a sufficient time has elapsed after the attack. In summary of these figures then it can be seen that those cardiac disorders causing the highest mortality during and following surgery are coronary thrombosis, heart disease with

nephritis, congestive heart failure and angina pectoris. (9)

TYPE CARDIAC CONDITION	NUMBER UNEXPECTED DEATHS	PERCENT
Valvular disease (147 operations).....	3	2.1
Nonvalvular heart disease (167 operations)..	8	4.9
Auricular Fibrillation (108 operations).....	3	3.0
Coronary Artery Disease		
Angina Pectoris (41 operations).....	3	7.7
Coronary Thrombosis (20)operations).....	8	40.0
Congestive Heart Failure (50 operations)....	7	14.0
With Nephritis.....	.....	14.8
Without Nephritis.....	.....	4.9
Hypertension (systolic over 160).....	.....	7.3
(systolic under 160).....	.....	5.9
Syphilitic Aortitis (13 operations).....	.....	7.7
Paroxysmal Tachycardia (60 operations).....	.....	0.0

TABLE I
Mortality of Surgical Cardiac Patients in Total Deaths and Percentage.

Of importance also is the relative frequency of heart disease. Clawson (10) in a series of 30,265 autopsies listed 4,678 cardiac deaths. There were 2,597 (55.5 percent) hypertensive cases; 870 (18.6 percent) rheumatic; 514 (11 percent) bacterial endocarditis; 280 (9.5 percent) coronary arteriosclerotic with hypertension; 1215 (25.9 percent) with and without hypertension (coronary arteriosclerotic) and 327(7 percent) syphilitic heart disease. Thyroid heart disease, beriberi heart disease, and congenital heart disease were so infrequently encountered as to have no bearing on the statistical picture. Such a large series of cases establishes without question all elements of statistical significance regarding frequency of etiological factors in heart disease.

Selective service statistics offer another source of recent and reliable information concerning the incidence of heart disease. Rountree (11) reported that of 58 percent disqualified for physical defects, 6.5 percent were rejected because of cardiovascular disease. As a part of the project in studying this group of rejectees, 4,994 were re-examined by picked teams of cardiologists. In the 80 percent agreed to have organic heart disease, 60 percent were found to have rheumatic heart disease, 26 percent hypertension, 5 percent neurocirculatory asthenia, sinus tachycardia, and congenital heart disease. Electrocardiographic abnormalities alone were found in 32 cases, syphilitic heart disease in 17, and coronary disease in 6 cases. Here we have figures illustrating quite clearly how the age factor combined with etiology begans to limit the cardiologists problem in evaluation and prognosis.

The patient with heart disease, but who is not confronted with the necessity of surgical intervention, lives constantly under an added hazard, but knowledge as to the degree to which this hazard is heightened by operation is essential in weighing the risk of non-interference against the risk of surgical intervention. (12)

The opinion of Marvin (13) expressed in 1928 has received further support through the years. He stated that for the purposes ofanesthesia and surgery a heart that is damaged but is still carrying on an adequate job of circulation under normal conditions of life is the equivalent of a normal heart. It should

be noted however that the difference between heart disease and heart failure is essential. (14) The added risk due to heart disease is generally proportional to the degree of decrease in the cardiac reserve. The exceptions include syphilitic heart disease with aortic insufficiency, complete heart block, aortic stenosis, and angina pectoris. (15) Patients with these cardiac abnormalities are prone to sudden death and of course it is impossible to predict the course of events during surgery.

One should not minimize the importance of classifying absolutely every patient with organic disease of the heart before attempting to make a prognosis or estimation of his or her ability to undergo any unusual ordeal such as surgery. The risk involved depends to a great deal on the functional cardiac reserve but no accurate method is available to judge this reserve nor the probability of failure. The most valuable plan however is the classification of the American Heart Association which is as follows: (16)

Class I refers to those patients in which a diagnosis of organic heart disease has been established but in which the history and signs of any discomfort from ordinary activities are not present.

Class II includes those patients in whom ordinary activity produces mild discomfort.

Class III includes those patients in whom less than ordinary activity produces discomfort.

Class IV includes the patients who are uncomfortable even at rest or with no activity. This patient is usually bedridden.

In discussion of Levine's third point mention should be made of the risk involved in certain specific types of heart diseases. These disorders will be discussed in the order of their importance as to the hazard they present in adversely effecting the successful outcome of contemplated surgery.

CORONARY ARTERY DISEASES. The initial problem in coronary artery disease is that of coronary stenosis. (17) It is known that an all important balance in cardiac function and cardiac health must be maintained between myocardial demands and needs of blood and oxygen as compared to that supplied through the coronary arteries. With the group of patients having coronary disease a most difficult problem of evaluation is encountered. The patients are generally an old age group. They are subject to other complicating diseases. The diagnosis is one of inference. We can not feel the coronary artery and therefore detect a reduction in its calibre. In general we assume that a patient has coronary sclerosis when he develops anginal pain and we are able to rule out syphilis or when symptoms and signs of cardiac pathology appear in a middle aged or elderly patient without any other obvious cause. (16) The only direct evidence of coronary sclerosis is the discovery of lime salt deposits in the coronary arteries by x-ray studies. This, however, is rarely possible. We are dependent on signs of arteriosclerosis elsewhere. We rely upon

electrocardiographic findings to a greater degree here than in any other heart disease.

Of considerable importance is the fact that an advanced coronary sclerosis need not lead to a narrowing or occlusion of the lumen of a coronary artery and is not diagnosed because symptoms and signs are absent. It is safe to suspect coronary sclerosis in every adult with diabetes, hypertension, or myxedema. (18)

If coronary sclerosis leads to a stenosis of a coronary artery, the electrocardiogram obtained following exertion may aid in the diagnosis. In patients with coronary disease there are two outstanding dangers possible as complications of surgery. The development of a serious and often fatal arrhymia either during or following surgery is frequent and often not detected or credited with causing the fatality. The second great danger is that of precipitating a coronary thrombosis or a sudden death by ventricular fibrillation. This last danger seems to occur more frequently where there is a pre-existing extrasystolic irregularity. (19)

Struggling due to a bad anesthesia, inadequate oxygensupply, precipitous fall in blood pressure, increased intravascular clotting, and injudicious use of drugs will increase the dangers of these complications. (20) Any appreciable increase of heart rate must be avoided because this leads to added demand for blood by the heart muscle and this demand can not be met if coronary sclerosis is present. However, in view of the large number of patients with coronary sclerosis upon whom operations are done daily with-

out accidents, one can condlude that the risk in such patients is only slightly greater than in those with normal coronary arteries. (21) This statement is made with reference to patients wherein no symptoms of angina, of either rest or effort, is present. In these cases it is therefore extremely difficult to establish the fact that coronary sclerosis exists. Emergency surgery on a patient with angina pectoris coming on at rest or with minimal exertion can be performed, but elective surgery, never. (16)

The possibility of inducing relative anoxia of the myocardium by anesthesia and surgical procedures is a grave hazard. Two factors which unfavorably disturb the equilibrium between demand and supply of coronary circulation are (1) increased work of the heart and (2) decrease in the amount of blood as a result of decrease in blood pressure or shock. (20) Added demand on the heart during operation apparently has little significance. However, myocardial anoxia, as a result of diminished oxygen tension in the circulating blood during anesthesia or of lowered blood pressure, may lead to serious complications.

Coronary thrombosis is imminent in those patients in whom the attacks of anginal pain occur with greater frequency or even while at rest, and to whom nitroglyerine begins to bring less relief than before. Surgery in these patients should be postponed if possible. Specifically in angina of effort a reasonable period of freedom from attacks should elapse before surgical intervention provided an acute emergency does not exist. (22) Particular

care should be taken in the choice of anesthesia and surgical procedure to avoid exhaustion of the patients reserve.

A report by Brumm and Willus (21) of their experience in 257 cases of coronary arteriosclerosis is of some significance. Only those patients were included who had undergone major operative procedures. Thirty-two of these 257 patients had healed coronary infarctions at the time of surgery and in the remaining cases, angina pectoris had existed for an average of 3.1 years. The majority of these patients with sclerosis and serious surgical conditions were of advanced years, the mean age being 60. Half these cases showed significant electrocardiographic abnormalities such as incomplete or complete bundle branch block, complete heart block, auricular fibrillation, or significant T wave negativity. One hundred cases (39 percent) had well marked hypertension.

The degree to which the increased hazard imposed by major surgery in such obviously ill patients can be reduced by skillful medical and surgical care is shown by the fact that only 11 cardiac deaths occured (4.3 percent). Seven deaths were due to coronary thrombosis with acute cardiac infarction and two others occured abruptly with out thrombotic occlusion. This lowered mortality however was due to very careful preoperative preparation and study, particular selection of patients, expert administration of anesthesia and skillful surgery. Without such care and selection no such favorable results could, or should, be expected.

dePeyster, Gilchrist, and Paul (23) conducted a study of 33

patients who underwent urgent surgery, all of who presented evidence of myocardial infarctions which developed before operation, during operation, or in the convolescent period. A history of myocardial insufficency was obtained in two thirds of these patients on admission while one third gave no evidence of previous myocardial infarction. Those patients subjected to surgery with a previous history of infarction accounted for less than one half of the mortality (36 percent) as compared with those who have no evidence of previous myocardial infarction (63 percent). Patients with single episodes of infarction present less of a surgical risk (mortality 39 percent) than those patients with a history of multiple infarcts (mortality 60 percent). Operative risk based on the relationship of the age of the infarction to surgery appeared to be significant. The surgical risk in patients with myocardial infarction is related to the duration of infarction prior to operation. A critical period of three months is believed to be required to complete the essential repair of the damaged wall. (24) There were twenty patients who had had evidence of infarction of infarction more than three months before surgery. (23) Among these, four died of pulmonary embolism and one of cardiac causes. Three patients operated on had a history of infarction for less than three months before the operation. Of this group, two died of cardiac causes. Ten patients experienced an infarction during the operative or convalescent period. In each of these instances there was no history of any previously exist-

ing coronary disease before surgery. Seven of these died of cardiac causes during the convolescent periods. From this work it is apparent that the risk of cardiac death in patients with known pre-existing myocardial infarction is not excessife (about 5 percent), whereas the hazard is great in those patients with recent infarction or in those experiending infarction during the operative or convalescent periods.

This word and also that of Master, Dack, and Jaffe (25) support the belief that operations seem to precipitate attacks of postoperative thrombosis. That the minimization of shock and dehydration and the avoidence of infection is of utmost concern is supported by a fairly recent pathological and clinical study of 350 consecutive, unselected, necropsied patients. (12) Eleven cases of multiple fresh coronary occlusion and thirty-eight cases of sungle fresh coronary occlusion were found. Shock, with its attendent fall in blood pressure, dehydration, etc., appeared to be a precipitating factor in all cases of multiple fresh coronary occlusion and in one half the cases of single fresh occlusions. If surgery is necessary in patients with coronary artery disease then a short anesthesia and a speedy operative procedure with minimal trauma and bleeding must be assured.

It is also interesting to note that since the discovery of insulin in the treatment of diabetes, the arteriosclerotic complications of that disease have been the primary causes of death. The high incidence of acute coronary thrombosis in diabetics

has been pointed out again and again. (26) It is therefore wise for the physician to warn surgeons contemplating operations on older diabetics, both male and female, of the possibility of precipitating an attack of coronary thrombosis and the importance of avoiding pitfalls of shock or a fall in blood pressure form any cause. The dangers of hypoglycemia in precipitating acute myocardial infarction in such patients hould be kept in mind.

CONGESTIVE HEART FAILURE: Congestive failure greatly increases the risk in any prospective surgical patient and the chief concern of the physician centers around the presence or absence of cardiac failure. (4) A history of recent heart failure markedly increases the danger of any surgery, as does the actual presence offailure. Surgery in such patients should be resorted to only as a life saving measure for these patients show an unexpected mortality of 17 percent. (19) Any operation per se will very rarely precipitate the ordinary type of congestive failure unless sepsis or some cardiac accident occurs such as the spread of infection to the heart or the dislodgement of silent auricular thromb.

Apart from any unexpected and impredictable events, the actual strain on the heart from an operation is seldom greater than the strain already imposed on the heart previous to the operation. The prognosis of patients with congestive failure is greatly improved if adequate preoperative treatment can be administered. Even the patients with gross evidence of congestive heart failure

may be converted into less formidable risks as was shown by a group of 144 patients reported by Hamiliton (27) and confirmed by Bytler, Feeney, and Levine (7). In Hamiliton's report he states all 144 had definite signs of congestive failure and had major surgical operations with a resulting mortality of eight (5.5 percent). In each case, every effort was made to relieve failure, and when all evidence of congestion had disappeared, a further prolonged preparitary period of bed rest was employed. Bed rest for at least three weeks after complete subsidence of decompensation, however mild, is advocated. (27)

HYPERTENSION: Increased blood pressure per se is not responsible for added mortality as patients with uncomplicated arterial hypertension bear operation quite well. This fact is exemplified by the mortality of the Smithwick operation of lumbodorsal sympathectomy.(4) A longstanding hypertension with complicating coronary insufficiency presents a less favorable outlook. (16) Of greater importance than the blood pressure is the damage present in the heart and kidneys and adequate studies of these organs and their function will be more of a true criterion of the involved risk. (22) The association of nephritis or renal disfunction with hypertension adds materially to the hazard of surgery.

When hypertension is associated with a history of encephalopathy or with evidence of cerebrovascular involvement, great care must be exercised, because a major opertion may precipitate a destructive cerebral lesion. In established malignant hyperten-

sion, an operation should be avoided on account of the hopeless prognosis. (4)

SYPHILIC AORTITIS: Patients with syphilitic lesions of the aorta and the aortic valves are not favorable subjects for surgery. An unexpected mortality of eight percent is revealed by both Boas (19) and Levine (2). All but urgent operations should be avoided. The expectancy of life of these patients is short and the need for operation must be balanced against the prognosis of the heart condition.

Coronary thrombosis is, in this case, an unforseen development which may occur at any time. With early syphilitic aortitis the risk is reasonably safe if the patient has no aortic incompetency, coronary involvement, aneurysmal dilitation, or evidence of cardiac failure. (4) However, the recognition of syphilitic aortitis with coronary stenosis may be as difficult as coronary stenosis itself. Evidence of dilitation of the ascending aorta, a systolic aortic murmur, or a bell-like second sound, may be missing. (22)

Even an advanced stenosis of the orificies of the coronary arteries doesn't always cause anginal pain. If, due to excitement or anoxemia, or to the use of adrenaline, the muscular anoxia increases, sudden death from ventircular fibrillation may occur. A large percentage of patients who die suddenly without any obvious reason belong to this group. (22)

AURICULAR FIBRILLATION: Among cardiac irregularities, auricular fibrillation is first in importance. When found in children the

prognosis is so bad that surgeryshould be avoided if possible. (28) Auricular fibrillation of recent onset is also unfavorable. When present in mitral stenosis, it sometimes is a manifestation of congestive failure. Also a rather poor prognosis is offered in cases of auricular fibrillation occuring in conjunction with degenerative myocardial disease secondary to coronary insufficiency. On the other hand, auricular fibrillation in thyrotoxicosis is no contraindication to surgery. (29) In fact, it is wrong not to operate. In persistant forms of auricular fibrillation experience shows that the operative mortality is very low and therefore one should not regard this irregularity as a contraindication to surgery, unless there are other unfavorable features present. Everything depends on the etiology of the arrythmia and other findings. Auricular fibrillation, for example, is frequently found in otherwise healthy persons and may persist for decades without any untoward symptoms. (30)

RHEUMATIC HEART DISEASE: Rheumatic heart disease is associated with a lower mortality than is arteriosclerotic heart disease. (31) The well compensated rheumatic cardiac patient tolerates a surgical procedure about as well as the normal patient. The risk increases in those who have experienced an attack of heart failure in the past or those suffering from failure at the time of surgery. As the patitnt passes the age of thirty-five the surgical mortality increases for developing arteriosclerotic heart disease tends to impair the blood supply. (31)

Rheumatic heart disease patients are also susceptable to activation of rheumatic fever and complicating bacterial endocarditis. (32) The operative risk will be normal in a slight mitral stenosis, but will be greatly increased in tight stenosis of the valves and also in advanced stenosis of the aortic valves.

Patients with compensated aortic insufficiency of rheumatic origin seem to be excellent risks. (22)

The development of moderate hypertension during the course of mitral stenosis does not seem to be an unfavorable event. (4)

Operations in a patient with mitral stenosis showing evidence of decompensation should be deferred. It should be remembered that the heart in mitral stenosis may recover satisfactorily from even repeated breaks in compensation but the risks correspondingly increase with each decompensation. (31) With aortic valvular lesions of rheumatic origin the same reservations as with mitral stenosis may be followed. However, once decompensation has occured with aortic lesions recovery seldom takes place and as a rule the life expectancy is rather short.

CONDUCTION DISTURBANCES AND HEART BLOCK: The different forms of conductions disturbances were often considered as absolute contraindications for surgery and it has often been stated that only the most urgent operations should be performed when heart block is found. However there are many reports available of normal pregnancies delivered in patients with heart block and of surgery without accidents. (32) Here again the risk depends on

other factors and not on the presence of heart block per se. The conditions of the heart and the status of the deeper cardiac centers are important. (22)

An operation on a patient with heart block due to coronary sclerosis will naturally carry the risks of coronary sclerosis. If the heart block is due to a localized damage of the specific tissue by diphtheria or rheumatic fever without damage to the rest of the heart muscle, the heart block will not increase the risk. If attacks of Stokes-Adams have occured only the most urgent operations should be done. (22)

Extrasystoles should not cause any apprehension unless evidence of myocardial degeneration is present as well. Paroxysmal auricular tachycardia is usually harmless and is no contraindication to surgery. (16) Paroxysmal ventricular tachycardia is usually a sign of organic myocardial disease and surgery should be avoided unless dealing with an emergency.

There also are certain circulatory risks which are imposed by any surgical procedure. The commonest surgical developments which may adversely affect any diseased circulation are hemorrhage, shock, infections, and thromboembolism. (31)

Cardiac hypertrophy is the usual compensation for many forms of cardiac disease. The effectiveness of this compensation depends on the maintainance of an increased supply of oxygen and nutriments to the enlarged heart by way of the coronary vessels.

Hemorrhage is a serious threat to this compensatory mechanism

because it may hinder cardiac nutrition and oxygenation. Degrees of myocardial anemia which could be tolerated by a normal heart might result in irreversible and serious myocardial damage or in fatal cardiac disturbances when an enlarged heart exists or in one suffering from advanced coronary artery disease. Furthermore hemorrhage is a common cause of surgical shock with its accompaning hypotension which in turn reduces coronary blood flow, an occurence less well tolerated by the diseased or enlarged heart than by a normal one. (31)

That infection is of significace in considering the risks of surgery, even in the present age of antibiotic drugs, is born out by the fact that infection is one of the common precipitating factors of congestive heart failure in a cardiac patient. (31)

Despite the greater surgical risk of the various cardiac conditions the mortality is surprisingly low, even in emergencies, if proper preoperative and operative care is carried out. Scherf (22) states that the advances in the threapy of cardiac patients has reduced the operative risk.

With proper preparation many patients who previously would have been considered as contraindicated for surgery except in emergencies now come to the operative table. As a result the mortality has decreased considerably.

Brams (34) believes the reason for this improvement is due to (1) improved surgical technique, (2) improved anesthetic agents and methods of administration, (3) improved methods of preoper-

ative cardiac evaluation, (4) more complete information and statistics permitting more accurate generalizations regarding the outcome of a given case rather than reliance upon the single experience of one individual.

In evaluating any cardiac patient Blalock and Rovitch (35) feel that excitement, worry, discomfort, the effect of anesthetics on the heart and circulation, peripheral circulatory collapse with its marked alteration in the hemodynamics, postoperative pain, poor response to infection, and tendency to pulmonary embolism and infarction are all factors which increase the morbidity and mortality of cardiac patients. All of these factors should be analyzed and discussed before surgery.

A proper plan of procedure must be decided upon with the understanding that this type of patient presents a problem different from that of the noncardiac patient. The stresses and strains encountered during and after surgery are different than those of the patient during his daily routine. The strain put on the heart by an operation is very slight but the cardiac patient is more susceptible to changes such as increased peripheral resistance, hypotension, reflex stimuli, hypoxia, and hypercarbia. (9)

The method of correct cardiac evaluation and prognosis entails first the making of a diagnosis. In this type patient this includes a history and physical, x-ray studies, and electrocardiographic studies.

Always of value if it can be obtained with accuracy is the

history. The diagnosis of angina pectoris rests completely within the history. Some cardiac disorders do not exhibit this dependency. Almost twenty-five percent of patients with physical signs of rheumatic heart disease do not have a history of rheumatic fever. In a similiar manner the history for such serious disturbances of rhythm as bundle branch block is likely to be inadequate. (16)

Of importance is the careful evaluation of the patients' story regarding the ability of his heart muscles to care for his circulatory demands in such daily activities as walking up and down stairs and about his business or place of employment. The stress to be placed on the classification of each cardiac patient has been previously mentioned.

In many cases the preliminary and even final estimation of the cardiac status and the risk involved can be made upon the history but the final judgement as to the functional capacity of the heart should not be made until the date from the physical examination, the laboratory findings, the x-ray results, and the electrocardiographic tracings have been studeid and correlated.

Regarding the physical examination, several findings are more important than those made on direct auscultation of the heart itself. Any amount of dyspnea at rest should be considered just cause for placing the patient in Class IV and therefore postponing surgery if possible. (16) Cyanosis usually has a similiar significance if its cause is properly determended. Moist rales at the base of the lungs, hepatomegaly, and peripheral edema are all im-

portant physical signs pointing to a Class III orIV rating. These do not, however, have to be permanent findings, since thay may logically respond to treatment and then the patient might go through a surgical procedure without difficulty. In the examination of a patient the value of a routine procedure is important.

The cardiac examination may begin with palpation of the pulse, examination of the extremities for edema, palpation of the abdomen for fluid or hepatomegaly, and then a thorough chest examination. Finally the heart is examined by inspection, palpation, percussion, and auscultation. This routine was advocated by the late Logan Clendening. (36)

Mention of ophthalmoscopic examination, care in taking the blood pressure, and careful evaluation of the heart tones are important features which are frequently neglected.

In the use of x-ray the size and contour of the heart as determined by the six foot chest plate and fluoroscopic examination are among the most important laboratory observations of aid to the consultant. (16) Even the presence of murmurs indicating organic disease is of minimal importance if the heart is not enlarged and has a normal contour. (37) Such a heartwill most likely be well compensated and capable of undergoing severe demands.

Measurement of the heart based upon the observations of a roentgenologist are highly desirable. One must not be misled by a simple transverse postion of the heart, giving the impression of hypertrophy. Fluoroscopy showing auricular hypertrophy with

displacement of the esophagus, prominent pulmonary conus, dilitation of the aorta, hilar dance, and quality of the ventricular pulsation may be important contributions.

No examination of the patient with suspected or known heart disease is complete without an E.K.G. study. Its greater field of usefulness remains in the diagnosis of arrhythmias and in following the course of the patient with coronary thrombosis. (38)

The demand for some mechanical test giving tangible evidence of cardiac insufficiency has resulted in many procedures being devised. Currently popular is the oxygen deprivation test of Levy (39) and the "two step" tolerance test suggested by Master. (40)

Medical evaluation and survey boards in the two military branches were forced into the use of one of these tests because of the demand by higher authorities for positive statements regarding cardiac states. Neither of the two tests have been accepted as the answer to the problem, yet they do have some utility in coronary artery disease. Both tests are dependent upon changes in the E.K.G. resulting from a disproportion between oxygen requirements and the supply available to the heart muscle. This condition is attained by having the patient do a standard amount of exercise.

Significant E.K.G. changes are depression of the RST segments over one minute in any lead, a change in the upright T wave to a flat or inverted T wave, or a change from a negative T wave to a positive T wave. Widening of the QRS complex or the devel-

opment of large Q waves, prolongation of the PR interval, or heart block are also abnormal responses.

Wood (41) is of the opinion that the determination of the exercise tolerance does not require special instruments and is not determined by studying the response of the blood pressure and pulse to exercise, As a general guide however with the pulse rate failing to return to normal in two minutes following exercise a decrease in the cardiac reserve might be suspected. The test has no merit in evaluating a surgical risk, nor has it any standing when studying patients with coronary disease. More important than pulse rate variation is the evidence of undue dyspnea or cyanosis during the procedure. Wood (41) states the best evaluation of exercise tolerance is determined by questioning the patient carefully. The following questions should be asked: "Can you go about your daily tasks, walk as far as you want to, or keep up with people or your own age, and climb two or three flights of stairs?". There are two symptoms which stop patients which are important. These are dyspnea and anginal pain.

Dyspnea: If the patient has myocardial infarction he will have dyspnea on effort. Yet since we all have dyspnea on effort, this symptom must be evaluated on the basis of the amount of effort necessary to produce it, and upon the noncardiac factors which can contribute to it, such as age, weight, anemia, asthma, psychologic factors, and the like. The actual point to be determined remains; is the patient more out of breath than he ought to

be when these factors are taken into consideration. If so, the probability exists that he is dyspneic because of heart disease. Some patients are stopped by a relatively mild degree of dyspnea, expecially if they are nervous about their hearts. When a patient is really stopped by morcardial infarction he is not only dyspneic, but all in and he "can't go any further".

Anginal Pain: If the patient has coronary insufficiency he will have pain or distress on effort. Many errors are made in recognizing and evaluating this symptom, because the patient is not questioned carefully enough or the examiner does not know what angina feels like. If a patient has definite angina of effort two other facts must be discovered. (41) The first being, did the patient have a cardiac infarction in the past, and if so, how long ago. To completely answer this question one must inquire not only concerning a former "heart attack" but also concerning the diagnosis under which a coronary occlusion often hides its idenity, i.e., indigestion, pneumonia, gall bladder attacks, pleursey, etc. If such as a cardiac infarction has occured healing must be complete before elective surgery is allowed.

The second fact to be brought out is whether the angina of effort stayed about the same in the last six months with respect to severity, duration, and amount of effort necessary to produce it. Recent changes may be taking place in the coronary circulation and that a new infarction may be in the making.

Ernstene (3) is of the opinion that questioning about dyspnea, substernal pain on exertion, paroxysmal nocturnal dyspnea, attacks of acute coronary failure and acute myocardial infarction are of much more value than physical findings. He feels that finding cardiomegaly, murmurs indicative of valvular damage, gallop rhythm and important disturbances of cardiac rhythm make it advisable to requestion the patient.

Once the patient has been adequately and completely evaluated and a surgical procedure decided upon, the preoperative preparation and management of the patient is of significnce. The treatment of heart disease before operation should be along scientific lines. The haphazard method of giving digitalis or other drugs, on the off chance of doing good or in the hppe of warding off subsequent trouble often turns out to be most harmful.

The prophylactic treatment of patients with organic heart lesions aims at restoration of optimal compensation of the cardiac musculature to tide the heart safely over the critical operative and postoperative period. Unfortunately reserve cardiac power can not be accululated in advance. The shortest and least exhausting operation is always the procedure of choice for patients with heart disease. This principle also applies to the choice of anesthesia.

The frequency with which immediate surgery is considered necessary has declined greatly in recent years. (12) In the vast majority of cases an opportunity for preoperative preparation of

the patient is available. Various phases of the preoperative care will be taken up in the following paragraphs.

Sedation is the first phase that will be discussed. The preoperative use of barbiturates such as phenobarbital in $\frac{1}{4}$ or $\frac{1}{2}$ grain doses, three or four times daily to lessen apprehension and its effects on the cardiovascular system has won widespread adoption. (12) Larger doses such as $1\frac{1}{2}$ to 3 grains of phenobarbital sodium, amytal, or pentobarbital, the evening before surgery and again immediately prior to the operation are commonly administered. Frequently however, when larger doses are given and particularily when morphine sulfate is administered the synergistic effect of a general anesthesia may result in dangerous consequences during the course of the operation. Delayed absorption of medications by mouth may cause the action of the drug to appear during surgery, with resulting anoxemia and subsequent arrhythmias or vasomotor collapse.

In the administration of sedatives sufficient disage should be employed to produce drowsiness but narcosis should be avoided. Usually the use of the smaller dose mentioned above is preferable to that of the larger dose of barbiturates. If the patients are alert or nervous immediately preoperatively, one sixth to one fourth grains of morphine may be given hypodermically.

In the use of opiates or sediatives for the first time in a patient one occasionally finds idiosyncrasies such as the patient becoming excited rather than drowsy. Since some cardiac patients

will not withstand complications that more normal subjects might easily overcome, such unwanted and even dangerous occurences must be avoided by the administration several days preoperatively, if possible, of test doses of all the medications that are to be used during the immediate preoperative and postoperative course. This procedure makes it possible to observe the nature of the reaction and gauge the opitmal dosage with minimum hazard to the patient. (42)

In recent years the advantage of intravernou fluids has become quite apparent. Those responsible for its administration must of necessity be well acquainted with the cardiac status of the patient. Whole blood, plasma, or other fluids may be necessary but must be administered with caution because an excessive amount may result in serious sequellae such as pulmonary edema and acute cardiac decompensation. One must replace blood as it is lost and maintain the fluid volume both in the splanchnic bed and peripherally. Failure in adequate fluid replacement may result in shock. On the otherhand, overloading of the myocardium may be the very thing that kills the patient. (43)

To procede with safety requires skilled knowledge of the physiologic mechanisms involved and sufficient clinical data such as color, tone, and temperature of the skin, capillary reflex time, blood pressure and pulse pressure, pulse, and respirations. These factors should be correlated together with the surgical procedure at that particular time. For example, should a tach-

ycardia occur at the moment of extreme surgicalstimulation, it is considered to be of little importance, but with no reflex stimulation, increasedtachycardia and tachypnea may be indicative of early cardiac failure. A change in respirations, such as gasping, associated with rapidly increased pulse rate and marked pallor of the skin, may be indicative of impending cardiovascular collapse. None of these factors mean very much by themselves unless their interrelationships with each other, the surgical procedure, and the influence of the anesthesia are evaluated. (16)

The cardiac patient is better able to with stand a state of moderate hypotension than an over loading. Tachycardia with its shortened diastolic phase and diminished coronary circulation prevents the heart form responding to a greater load. Shock and hypotension with their diminished cardiac return and output, may call for an added exertion by the heart which it might be unable to produce. The compensatory ability of the individual is greatly decreased in the old and arteriosclerotic patient and therefore shock must be prevented at all costs. Overloading must be avoided and the heart maintained at a slow and efficient rate. (44)

Recent work has shown the importance of estimating blood volume since many chronically ill patients arrive at the operating room with normal hematocrit values, yet with a decreased red blood cell volume. (45) This state interferes with adequate oxygenation and one might say that such patients are in a form of chronic shock. The full significance of the dehydration from insensible water

loss, from vomiting and diarrhea and from other causes has been appreciated only in recent years through the work of Gamble and his associates.(46) The nature and amounts of fluid to be administered should result in an urinary output of at least one liter per day. (44)

Cardiac patients are all too frequently subjected to vigorous dieuretic medication with restriction of salt and fluids before surgery, only to receive, according to routine orders a few hours later, large quantities of saline solution by vein or hypodermoclysis. Nospecific routine can be followed in respect to cardiac patients. If slight congestion of the lungs and other evidences of edema remain the physician may properly consider that the patient has somewhat more than the normal available reserves of electrolytes and fluid that may be utilized in replacing the loss brought about by surgery. (43)

Of very marked importance in the proper preoperative care of a cardiac patient who is scheduled for surgery is the question of digitalization. The almost routine digitalization of patients over the age of fifty has received diminished acceptance. No reliable evidence indicates that any useful purpose is served by this method in patients who do not have congestive heart failure or auricular fibrillation. (42)

When considering congestive heart failure it is generally accepted that digitalis should be imployed whenever there is evidence of failure. A history of exertional dyspnea, cyanosis, hepatomegaly, pulmonary statis or edema is a strict indication

for digitalization. Treatment should be adequate. Unless time is an essential factor the slower method of digitalization is preferable and provides a better estimate of the dose necessary to maintain prolonged optimal effect without toxic reactions as nausea or ectopic rhythms.

If time is limited, however, rapid digitalization by the parenteral route is preferable according to Neurath (20). Certain surgical emergencies such as operations on the gastrointestinal tract make oral medications impossible.

Familiarity with one preparation, if possible one marketed for both oral and parenteral use, is desirable in order to estimate correctly the dose and the duration of administration of the drug for optimal effect. The digitalizing dose has great individual varations.

In addition to digitalis, restriction of sodium in the diet and employment of mercurial dieuretics should be observed in congestive heart failure. Care should be taken not to reach the point of hemoconcentration. Even small degrees of pulmonary congestion should be completely eliminated since the prolonged postoperative recumbent position favors pulmonary stasis and the possibility of developing right heart strain or hypostatic pneumonia. (31)

The preoperative emergency treatment of patients with evidence of decompensation or a too rapid ventricular rate in auricular fibrillation is best done at the present time with Strophanthin K or pure digitalis glucosides such as digitoxin. The employment

of these drugs by intravenous injections is permissible only if the patient has been free of digitalis treatment for a few days. (12) These substances are crystalline materials which are given according to weight.

Strophanthin rapidly loses its strength due to the alkali in the glass of the ampules and only reliable preparations should be used. Cedilanid and digoxin are pure digitalis glucosides derived from digitalis lonata. The dose of two cubic centimeters (0.4 mg.) of Cedilanid or one cubic centimeter (0.5 mg.) of digitoxin is used intravenously. Digitaline (Nativille) is digitoxin in the amount of 0.2 to 0.4 milligrams. While the benefical effects of strophanthin are fully developed within thirty minutes the effect of the digitalis glucosides are only slightly delayed and is fully established while the patient is being prepared for the planned surgery. (22) In the absence of clinically recognizable congestive failure determination of vital capacity, of venous pressure, and of the circulation time have only limited significance as to the patients ability to undergo an operation safely. The same reservations hold true of the E.K.G. As a rule abnormal patterns, if stationary, are no reason to defere surgery. (44) Another indication for digitalis is cardiac hypertrophy particularly in patients with hypertension. An enlarged heart is prone to decompensation. Since digitalis decreases the size of the heart and increases the minute volume, prophylactic digitalization is indicated. (20)

The treatment of cardiac arrhythmias deserves mention because

disorders of the cardiac rhythm constitute one of the most frequent conditions that confronts the physician. Knowledge of the precise mechanisms of the various arrhythmias is essential. It is true certain irregularities are of little significance and may require no treatment while others necesitate specific therapy. Also the action of the drugs used in the treatment of the various arrhythmias must be understood for medication which terminates one arrhythmia may be ineffective or even dangerous in another.(12)

The most important types of cardiac arrhythmias are as follows:

Extrasystoles, auricular or ventricular

Paroxysmal auricular tachycardia

Paroxysmal ventricular tachycardia

Auricular flutter

Auricular fibrillation and

Heart block with Adams-Stokes attacks.

Drugs that exert a beneficial effect are as follows:

Quinidine

Digitalis

Acetyl-beta-methylcholine (Mecholyl)

Emetics, such as syrup of ipecac.

The clinical recognition, electrocardiographic characteristics, and the mechanism of the various arrhythmias are clearly outlined in the various cardiological texts. Gold (47) states that although a differential diagnosis of the various arrhythmias can be made solely by clinical means, an electrocardiogram is usually necessary

to establish the diagnosis and to ensure safe and effective treatment. The routine tracing may fail to be of value but a tracing should be made before and during carotid-sinus pressure. A patient with a rapid regular tachycardia of 150-175 a minute may have either sinus tachycardia, paroxysmal auricular tachycardia, auricular flutter, or ventricular tachycardia. While the E.K.G. tracings may be equivical the application of carotid-sinus pressure may clarify the diagnosis. If auricular and ventricular contractions are slowed, the diagnosis of sinus tachycardia is evident. If both auricle and ventricle are brought to a complete momentary standstill, the diagnosis of paroxysmal auricular tachycardia may be confirmed. If auricular flutter is present, the ventricular rate may beslowed, and the auricular deflections of 300 or more a minute may be readily seen. Carotid-sinus pressure may produce no effect on either the aruicle or ventricle, in which case, and in the presence of other characteristics of the ventricular deflection, a diagnosis of ventricular tachycardia is indicated.

If carotid-sinus pressure is not effective, occular pressure, holding the breath at the end of deep inspiration, straining at the end of deep inspiration with the glottis closed, or lying across the bed with the head hanging over the side of the bed, may be of assistance.

Annarrhythmia caused by extrasystole, which in itself is the commonest of all cardiac irregularities, is so common that even these who enjoy complete health rarely escape it. Extrasystoles

frequently occur unassociated with organic heart disease in nervous and apprenhensive patients. While it is true that in occasional cases, when numerous extrasystoles mask the underlying sinus rhythm, differentiation from auricular fibrillation may be difficult without the aid of the electrocardiogram, in the majority of cases extrasystoles represent a harm less and unimportant disturbance without clinical significance.

In some cases extrasystoles are an indication of myocardial damage or even of approaching ventricular fibrillation with instantaneous death. This is especially true for extrasystoles occuring in coronary disease, particularily in myocardial infarction, or for extrasystoles appearing during digitalis treatment or during anesthesia with certain agents such as chloroform, trichlorethylene, cyclopropane,or prophlene. (22)

Extrasystoles of ventricular origin may predispose patients with coronary arteriosclerosis to attacks of paroxysmal ventricular tachycardia and quinidine should be employed in the treatment. In this type patient it is recognized that digitalis may increase myocardial irritability and therefore increase the number of extrasystoles, yet in others with ventricular extrastoles the favorable effect of digitalis on the heart results in abolition of the irregularities and the extrasystoles.

The fact that the same measures which cause extrasystoles may under certain conditions abolish them is true of quinidine, potassium and choline, and stimulation of the vagus and of sympathetic

nerves of the heart, as well as being true of digitalis.

Under such circumstances it is advisable to effect partial digitalization by relatively small doses such as 1.5 grains two or three times a day. Also the use of repeated small doses of the barbiturates such as phenobarbital in doses of ¼ grains three or four times a day is a valuable adjunct. (12)

Paroxysmal auricular tachycardia frequently occurs in the absence of organic heart disease just as do extrasystoles. Such an irregularity is sudden in onset, lasts a few seconds to hours or even days and is characterized by its extraordinarily constant rate of 150-200 beats a minute. If the attacks are short and infrequent, no treatment is necessary. Since the attacks frequently cease spontaneously and are greatly influenced by emotional states, the physician attending a patient early in the attack should defer vigorous therapy and prescribe sedation, such as 5.0 grains of barbital, 3.0 grains of sodium amytal, or 15 grains of triple bromide tablets to be followed by smaller doses in two or three hours until drowsiness occurs.

Carotid sinus pressure, prevously mentioned, may terminate the attack if spontaneous subsidence does not occur.

If the attack persists after application of pressure and trial with the sedatives, Mecholyl, which is the most effective drug for this condition, may be administered. (48) It should first be determined if bronchial asthma, angina pectoris, hyperthyroidism, or recent myocardial infarction is present. Mecholyl is a power-

ful parasympathetic stimulant and not uncommonly produces flushing, salivation, profuse perspiration, nausea, vomiting, and occasionally dyspnea, precordial pain, or collapse. Cautious administration should therefore be practiced. A syringe containing 1/50 or 1/100 grains of atropine should always be at hand for immediate use since atropine is an instantaneously effective antidote. With the proper dosage of Mecholyl abrupt cessation of the attack should occur within fifteen minutes. If the dose is too large the heart may manifest complete standstill for thirty or forty-five seconds.

Quinidine in large doses (10 grains) by mouth every two hours until a total of 30, 40, or even 50 grains has been given is often employed in the treatment of this type of tachycardia. (12) The toxicity of such large doses and the uncertainity of success have led to a less frequent use of quinidine. Large doses of digitalis are usually unsatisfactory.

Paroxysmal ventricular tachycardia, although distinctly uncommon, is a serious condition and must be promptly recognized and treated. This disorder is more commonly associated with serious myocardial disease than is paroxysmal auricular tachycardia. The development of ventricular fibrillation is favored by digitalis and the use of this drug is therefore definitely contraindicated.(49)

Quinidine is effective and should be employed until toxic or therapeutic effects are evident. Bedause of the seriousness of the condition, it is usually advisable to begin with a dose of 10

grains. Its effect will be evident in two hours, at which time the dose can be repeated or increased. Larger and more frequent doses although entailing a risk, may be indicated in desperate circumstances. (50)

The prophylactic use of quinidine is indicated in patients with acute myocardial infarction who develop multiple ventricular premature beats. Similarly, in certain persons who are prone to develop recurrent attacks of paroxysmal ventricular tachycardia, quinidine in doses of 5.0 grains administered four times daily is frequently effective. (50)

Auricular flutter is another infrequent cardiac irregularity. In this condition the auricle beats at a rate of 250-350 per minute. The rate of beating of the auricles is extraordinarily constant. The ventricular rate is frequently half that of the auricles, but may vary from time to time. Quinidine and digitalis are the two effective drugs in the treatment of this disorder. Most authorities advise the initial use of quinidine alone. Large doses are sometimes necessary. In the presence of rapid ventricular rates digitalis should be used.

By producing auriculoventricular block, the ventricular rate may be controlled at normal levels even though the flutter of the auricles persists. The administration of digitalis frequently converts auricular flutter to auricular fibrillation. Normal sinus rhythm may then occur spontaneously on withdrawal of digitalis or following the administration of quinidine. (48)

In auricular fibrillation much depends on the other cardiac findings and on the etiology of the arrhythmia. Usually if the ventricular rate is less than 90 no treatment is necessary. (20) The indications and contraindications for the use of quinidine in restoring normal rhythm in patients with auricular fibrillation continues to be a subject of controversy. The abolition of this arrhythmia by using quinidine has very limited application. Auricular fibrillation of long standing, of cardiac enlargement, of advanced mitral stenosis, of active rheumatic infection, and of prior congestive failure contraindicate its use. (50)

Patients with persistant auricular fibrillation are better stabilized and more safely controlled by appropriate dosage of digitalis. The urgency of the situation will influence the speed with which the patient is digitalized.

When an emergency operation is necessary and it is not possible to wait until the digitalis action is established, the injection of $\frac{1}{4}$ milligram of strophanthin or one of the pure digitalis glucosides will slow the heart in one half hour. The procedure of giving one or more cubic centimeters of one of the old soluble digitalis prepartions is not to be recommended for these injections must be repeated often in order to get an effective slowing if the rate and this may take hours. The slowing of the ventricles with digitalis is difficult in patients with pulmonary embolism, hyperthyroid disease, or during high fever.

As of late the problem of diabetes mellitus is handled much

more effectively when surgery is considered than in the past. Concerning the insulin dosage, Rolland (51) used the following schedule. If the patient is getting over 20 units of protamine zinc insulin then the day before surgery he gets 2-3 doses of soluble insulin and if the patient is getting less than 20 units of PZI then this is continued up until the day of surgery and then soluble insulin is substituted. The management on the operative day is variable with different men. Some starve the patient and give no insulin that day. Others give PZI in diminished doses to those accustomed to it and others give small carbohydrate feedings with soluble insulin to cover it. The latter plan seems to be the most effective as it sends the patient to surgery with a reasonably normal carbohydrate metabolism and an adequate store of glycogen in his liver. The carbohydrate feeding varies but Benger's food with lactose in milk was found to be the best tolerated in Rolland's series. (51)

The dosage of soluble insulin is usually one half to two thirds of the usual morning dose. It must be enough to prevent ketosis in the immediate postoperative period and on the other hand must not be enough to cause hypoglycemia which is difficult to recognize in the anesthetized and sedated patient.

In the use of these drugs in various cardiac disorders one should remember that other medicinal agents have effects on the cardiovascular system also and that these drugs in conjunction with the "cardiac drugs" may lead to dangerous or even disastrous

consequences. The most frequently used drugs of this type are as follows: (16)

Posterior pituitary extracts: When these drugs are used in treating abdominal distention they may, through vasoconstrictor action, precipitate severe angina pectoris and collapse.

Carbon dioxide mixtures: The inhalation of such mixtures for relief of intractable hiccough, particularly after genitourinary operations, imposes a strain on the heart, since the ventricular rate is increased and the blood pressure and minute volume output of the heart becomes somewhat elevated particularly if concentrations of more than five percent are utilized.

Ergot: The administration of ergot to produce uterine contractions after dilation and curettage not infrequently leads to severe cardiac pain.

Atropine: While atropine sulfate is apparently an effective dilator of the coronary arteries and also is used to lessen the bronchial and upper respiratory secretions, it has the disadvantage of markedly increasing the cardiac rate through the inhibitory effect on the vagus nerve. This leads to greater requirements of the heart muscle for oxygen. These requirements can not be met if a coronary stenosis exists and anoxia of the involved parts of the heart muscle appears with all its consequences. Elevation of the ventricular rate is particularly prone to occur in patients with auricular fibrillation.

Insulin: Degrees of hypoglycemia that would be tolerated read-

ily by most patients may precipitate the characteristic manifestations of acute myocardial infarction in the presence of coronary arteriosclerosis.

Adrenalin: Particularly in patients with angina pectoris due to coronary arteriosclerosis and even the presence of asymtomatic coronary narrowing or occlusion, adrenalin may incite severe cardiac pain and occasionally may produce collapse and death. This is bought about by the action of this drug which increases coronary blood flow. The added motility and the higher heart rate cause such greater demands on the cardiac muscle for oxygen that very severe disturbances may occur.

Cocaine and novocain: The ready absorption of cocaine and novocain when applied to the upper respiratory passages may cause the beginning of collapse or of cardiac arrhythmias, and at times of ventricular fibrillation and death. This danger is present in normal persons, but particularly in patients with an irritable myocardium resulting from the reduction in coronary blood flow by coronary arteriosclerotic lesions.

Once the patient has been adequately prepared for surgery the question naturally arises of what type anesthesia should be used. The duty of the anesthesiologist is to acquaint himself thoroughly with the cardiac status, the overall physiologic state, and particularly the cardiac reserve of the individual patient. The amount of strain that a patient is able to stand may be measured by several physiologic tests, such as the breath-holding time, determ-

ination of the vital capacity, and an overall estimation of the cardiovascular system. In general, the greater the vital capacity the better the respiratory exhange and anesthetic potential. The more efficient the circulation the better the transport of oxygen, of carbondioxide, and of the anesthetic mixture and the better the control of the blood pressure. (52)

In order to overcome the hazards of operating in the face of cardiac disease several factors should be considered: The anesthetic must be safe; the induction must be relatively quick so that excitement and struggling may be kept to a minimum; adequate oxygenation must be maintained to combat hypoxia; elimination of carbon dioxide must be efficient; the working conditions for the surgeon should be satisfactory; and the anesthetist must be skilled and familiar with the management of the anesthesia.

That the preoperative care in the cardiac patient must be meticulous has been mentioned. Particular attention must be given to the prevention of preoperative anxiety. Very commonly the nervous tention incident to the anticipation of the operation quickens the heart rate to a level higher than that provoked by the operation itself. This occurs especially when the patient is broughy into the operating room fully conscious and the anesthesia is started with the patient on theoperating table. Again the excitement state of the anesthesia, whether it be nitrous oxide, ether, or ethylene is always accompanied by a great rise in the heart rate which usually exceeds the maximum rate during operation

as well as that induced by preoperative excitement.

Fluctuations in rate are closely linked to the depth of anesthesia; when the anesthesia becomes light, the heart rate quickens. In a placid individual local anesthesia is often associated with a remarkable stability of heart rate. In trebromethanol anesthesia the excitement stage with its rapid pulse is usually avoided.(53) During the operation itself the heart rate is usually remarkably constant, and is little influenced by manipulation of tissue or viscera unless hemorrhage or shock set in.

Probably one of the most important single requirements is an adequate and continuous supply of oxygen. This implies that a patients airway be maintained at all times.

Should depression of respiration occur with resulting hypoxia and hypercarbia, the added strain on the heart may result in failure. Even though respirations do remain adequate a tissue hypoxia can still develop if there is an inadequacy of circulating hemoglobin to supply the tissues with the required amount of oxygen or if there is marked impairment of circulatory efficiency. Thus the presence of hypoxia, whether stagnant or anemic, must first be recognized.

It has veen repeatedly demonstrated that stimulation of a ventricle which is in bad metabolic condition, for instance after damage by anoxia or anemia, may cause ventricular fibrillation. (54) The result is thesame whether the stimulus is mechanic, electric, or whether an intrinsic stimulus appears in the form

of an extrasystole. One stroke with a blunt instrument, one induction shock, one extrasystole is sufficient. To produce this effect the stimulus must appear in the early phase of diastole and most of the extrasystoles do appear during this early vulnerable phase. (54)

During an anesthesia there are multiple causes for damage to the ventricular muscle and therefore ventricular fibrillation and sudden death do occur during anesthesia and it is not always possible to prevent it. Scherf (22) believes, in contradistinction to some statemtants in literature, that ether does not cause extrasystoles and does not damage the heart muscle and is therefore the preferred anesthesia in cardiac patients.

The condition of the vascular bed and the status of the cardiac reserve are of importance. A reduction in the peripheral vascular pressure, a decrease or increase in the venous return to the heart, and the occurence of shock and various reflexes during the procedure must be prevented.

A brief discussion of the various anesthetic agents and their usefulness in patients with cardiac desease is needed to complete the question of anesthesia. One may avoid unnecessary depth of anesthesia by supplementary technics such as utilization of curare, local anesthesia or intravenous barbiturates. The following anesthetic agents are in common use today:(12)

Nitrous oxide: This gas has the advantage of having no toxic effects on the parenchymatous tissues. When used with curare it

will produceadequate relaxation for many surgical procedures, but its use probably should be limited to those cases in which little reflex activity is expected. It has the disadvantage and hazard in that the induction stage may be accompanied by breath-holding and excitement. A relatively low oxygen content is also associated with its use, which by itself is contraindicated in surgery of cardiac patients. With a fifty percent concentration of oxygen it may be used for induction.

Ethylene: Very similar to nitrous oxide, with the exception that a slightly higher concentration of oxhgen may be adm nistered. An explosive element, however, is added.

Cyclopropane: The use of cyclopropane depends to a great degree on the skill and the experience of the anesthetist as well as the type of pathology present in the patient. A conscientious effort must be made during its administration to follow the cardiac status from second to second, not from minute to minute. It may be the anesthetic agent of ch oice in the patient in whom a prolonged diastolic phase and slow heart beat are desirable and where there is little evidence of bundle branch block and prolonged conduction time. In those cases where reflex stimuli to the myocardium would be expected cyclopropane may again be a wise selection. In combination with ether and oxygen it gives smoother inductions with a more pleasently acquired state of waking. Cyclopropane alone is contraindicated because of the risk of inducing serious cardiac arrythmias especially in patients with

coronary artery insufficiency.

Ethyl chloride, Vinethene, and Chloroform: These will be omitted purposely from the discussion, since their toxic effects on the myocardium involve such a great hazard to the patient.

Ether: Generally speaking, ether adds very little to the surgical risk. Slight disturbance is produced to the body as a whole but it may have a definite beneficial effect on the physiology of the heart. Its use is limited in that it must be preceded by an induction agent, and the patients slow emergence delays the return of normal reflexes. The safety factor is high and it is the anesthetic agent of choice especially when skilled personnel are not available.

Spinal: Here again the cardiac status of the patient and his ability to withstand changes in the circulation are of extreme importance. Hypotension frequently is produced by spinal anesthesia. A high spinal anesthetic should be avoided if at all possible, but when used for lower abdominal surgery or for perineal surgery it has an important position. The presence of pulmonary congestion might be an indication for its use.

Locals: This is an ideal type of anesthesia for the cardiac patient when it can be utilized without undue psychic strain. It is frequently used incombination with nitrous oxide and oxygen, thus providing the desirable psychic relaxation. When used alone with oxygen it does not protect the body against the always present reflexes, unless used in deep anesthesia.

There are also some newer agents which are being tried but which have not been entirely proved as yet. The use of quinidine hydrochloride is becoming increasingly popular. An injectable preparation has been made available. It is possible now to administer this drug intravenously in patients having sympotoms which make prompt action desirable.(55)

Tovell and Steven (56) claimed to protect patients from dangerous cardiac irregularities by the administration of quinidine twenty-four hours preoperatively followed by a therapeutic dose one hour prior to the beginning of the anesthetic. Sadove, Galston, and Wyant (12) prefer the use of intravenous procaine whereever possible, in spite of the fact that it is a myocardial depressant.

The use of ouabain to combat myocardial depression, particularly during shock, has recently redeived attention in work done by Sankey and Crawford (57). Procaine amide is a new agent which is being studied for its prophylactic and therapeutic value in cardiac arrhythmias. While there appears to be little doubt as to its value in the correction of ventricular arrhythmias, sufficient time has not yet elapsed to assign to this drug its final place among the agents at our disposal in the management of the cardiac patient.

SUMMARY

The recent trends in cardiac evaluation and surgical techniques bear out the old experience that patients with cardiac disorders tolerate surgery remarkedly well. This type patient does however present some increased risk over the non-cardiac patient.

"Can the patient stand an operative risk" is a question which is answered by three questions. (1) Is the problem surgical?; (2) Is the prognosis good enough to warrent subjecting the patient to surgery?; and (3) What is the surgical mortality in various cardiac disorders?

The classification of the cardiac patient, the evidences of heart disease, and the contraindications to elective surgery are listed.

In studying the surgical mortality in cardiac patients undergoing major surgery it has been found that the cardiac disorders causing the highest mortality are coronary thrombosis, heart disease with nephritis, congestive heart failure, and angina pectoris.

The risks involved in the important cardiac disorders are as follows:

Coronary Artery Disease: Two outstanding dangers exist: (1) The development of a fatal arrhymthia and (2) Precipitating a coronary thrombosis or sudden death by ventricular fibrillation. The importance of careful preparation is discussed.

Congestive Heart Failure: The mortality of 17 percent testi-

fies to the risk involved in operating on cardiac patients with recent failure or the actual presence of congestive failure. Surgery is rarely the precipitating cause of failure however. The risk in these patients is minimized with adequate preparation.

Hypertension: Hypertension of long standing or malignant hypertension present present unfavorable risks but hypertension per se is no contraindication to surgery provided the heart and kidney function is adequate.

Syphilitic Aortitis: An 8 percent mortality occurs in these patients and therefore they are not favorable subjects for surgery.

Auricular Fibrillation: The risk involved depends on certain other factors and auricular fibrillation can, or need not be, a contraindication for surgery.

Rheumatic Heart Disease: The well compensated rheumatic heart patient stands surgery about as well as the normal patient. Heart failure and increased age amplify the risk.

Conduction Disturbances and Heart Block: The risk again depends on other factors.

In examination of the patient the history is of the most importance and the best guide as to the ability of the patient to undergo surgery is the exercise tolerance of the patient. The important roles played by dyspnea and anginal pain are discussed.

The preoperative preparation of the patient includes sedation,

proper intravenous fluid therapy, and the development of adequate digitilization.

Cardiac arrhythmias play an important part in evaluating the cardiac patient and their prompt recognition and proper treatment is imperative to the life of such a patient.

When considering anesthesia and anesthetic agents, ether seems to be the agent of choice although various other agents do have a definite but more specific use.

CONCLUSION

In considering the cardiac patient, if the correct diagnosis of the existing organic lesion along with its etiology is made, if the patient is placed in his correct classification, if the risks in the various cardiac disorders are recognized, and if the patient is examined adequately by means of history, physical, and laboratory studies, the evaluation of the patient as a surgical risk should be quite complete.

It seems there is a decreasing amount of risk in surgery for the cardiac patient in the following order of diagnosis: coronary thrombosis, heart disease with nephritis, congestive heart failure, hypertension, syphilitic aortitis, nonvalvular heart disease, and auricular fibrillation.

Once proper evaluation is established, preoperative care along with proper selection and administration of anesthesia can do a great deal toward reducing the mortality.

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