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Surgical aspects of mitral stenosis

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THE SURGICAL ASPECTS OF MITRAL STENOSIS.

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PART ONE

INTRODUCTION

Since the beginning of the Twentieth Century, much interest has been manifested in cardiac surgery. Like all new developments in medicine, many ridicule and scoff at the idea, and others are indifferent, having a passive attitude toward the subject. Some take every new suggestion and advocate it, not fully realizing its possibilities. A few investigate, experiment, and compare results, and try to judge the feasibility of further procedure along these lines.

As the Ancients considered any injury to the heart as fatal, no true venture was made to repair injuries to the heart. Any such attempts were not considered worthy of trying and were soon forgotten, to lie dormant until the subject was again revived. Then, if a successful operation was performed, they were produced to show justification for the procedure.

Of the phases of cardiac surgery, valvular repair is very interesting, and touches the human heart strings. It is true that there is associated pathology between all valvular diseases and the body system, varying from the pronounced cases of arteriosclerosis to the mechanical obstruction of mitral stenosis. These latter cases are the types which we some day hope to benefit by reducing the amount of obstruction

surgically. It is very pathetic to see a young
person in the middle twenties with the stigma of mi-
tral stenosis, doomed to life imprisonment, and de-
prived of the many joys of the world. These are the
cases which may benefit from interest in surgery of
the mitral valve, particularly, mitral stenosis.

HISTORY

Surgery of the heart was inadvisable, accord-
ing to Bilroth in 1883, and Redinger in 1884, because
the heart was a vital organ being closely associated
with life (19). They felt it was inaccessible to
surgery because of the location within the thoracic
cage, the constant motion, and the terrific capacity
for hemorrhage. Similar ideas were expressed by the
Ancients, and many incidents were recounted where war-
riors struck in the hearts, suffered rather quick
deaths (37). These accounts caused the anti-surgical
views on the heart injuries until Larrey's report on
pericardiotomy, in 1810 (19). Then, gradually, papers
and monographs regarding heart surgery began to appear,
the first being Fischer's work of 1867, on heart
repair.

These accounts did not make much impression
until Bloch, in 1882, did some experimental work on
dogs, showing how the heart may be sutured. Two years

later, Rose demonstrated the deleterous effects of increased pressure in the pericardium. It was at this time that Bilroth said that cardiac surgery was a risky venture. Several attempts to suture the heart were made in 1896, by Cappelen and Farina. Just one year later, Rhen made the first successful cardiorrhapy, which marked a new era of surgery.

These incidents provoked experimental work on heart surgery, and many new facts were discovered which upset the older ideas about the heart. Elsberg conducted a series of experiments on rabbits and dogs, in which, he removed the apical third of the heart. He obtained good results which demonstrated that the heart is adaptable to surgery. The question of hemorrhage was another important item. Rhen and Sauerburch independantly tried to develop a bloodless field to control hemorrhage and permit direct vision of the operation. By clamping, the pedicle of the heart circulation could be stopped, and the heart opened under direct vision, for about a minute without any demonstrable damage. Next, they demonstrated that this time element could be lengthened by digital compression of the vena cavas. The results of these experiments proved that surgery of the heart was not impossible, that hemorrhage could be controlled, and, by diligent asepsis, that the mortality was not extra-

ordinarily high (19-48).

The most difficult problem was the collapse of the lung upon opening the chest. This collapse was feared even in draining a lung empyema, although advocated from the time of Hippocrates (19). Quenu, in 1896, was the first to attempt correction of the lung collapse. He devised a helmet to maintain positive intra-pulmonary pressure. Tuffier had a similar idea, in which he gave the positive pressure directly into the larynx. This idea approaches the present method. The first successful intrathoracic operation was performed by Parham, in 1898, by removing a small tumor from the chest. Many other methods had been tried but were discarded, when Meltzer and Auer, in 1909, introduced the present method of intratracheal insufflation by which positive pressure may be maintained, and a gaseous anesthesia administered.

The proposal for surgery of the mitral valve to relieve stenosis, was first recorded by Sir Lauder (11-12), in 1902. He believed that mitral stenosis was one of the most distressing forms of cardiac disease, and resisted all forms of medical therapy. The small orifice of the mitral valve shows the hopelessness of the auricle for driving the blood past it to the ventricle, and one wishes that it may be divided as easily before death as afterwards.

This produced statements from Samway (43), who mentioned his proposal of notching the valve to relieve mitral stenosis, four years previously (42), and of Arbuthnot Lane (34), who states that several years ago, his colleague, Lauriston Shaw, made a similar proposal, waiting for a suitable case for operation. Burton was severely criticized by an Editorial in the _Lancet_ (27), which said that one just starting in the work of animal experimentation should not voice such an opinion, for the procedure on a beating human heart was much different than the work on the material in the autopsy room. Fischer (29), in 1902, adds that he doesn't believe the operation will succeed, as there is a marked cardiac fibrosis and usually a failure of the musculture, as was taught by Sir James McKenzie (19). Although Tollmer, in Paris, believed in the principle of the procedure, he doubted the ability of a technique being developed.

The proposal of mitral surgery occurred, no doubt, to thousands of physicians who had seen, at autopsy tables, young individuals, apparently normal except for the mechanical obstruction of the mitral valve (22). Added impetus was given to the work by some of the devices for intrapulmonic positive pressure, anesthesia, and Bauer's work on cardiolysis (19).

That benefit could be derived from surgery of the mitral valve, became universally agreed upon as experiments continued. MacCallum (39) in 1906, Cushing (17) in 1908, and Bernheim (8), all felt justification for further work. Carrel (13-14-15-47) did a great deal of experimental work, demonstrating the adaptibility of the heart and venous tissue. This was followed by the work of Allen (1), Cutler (19), Beck (4) and Souttar (45), who carried the great load of experimental surgery.

In 1929, Powers (40), and later Wilson (48), demonstrated experimental mitral stenosis in dogs. However, their surgical experience in relieving these stenosis was rather discouraging. Nevertheless, Cutler (22) was not dismayed in seeking relief of mitral stenosis. He concluded his paper of August 1932, by saying, "It is a problem to which I began to apply myself in 1917. There were, of course, great technical difficulties to be surmounted, but I am a firm believer in the theory that if a procedure is logical and offers a real reward, the technical difficulties are always surmountable."

Little or no recorded experimental work was evidenced in surgery of the mitral valve, as a new field was opened by Blumgart's and Berlin's advocation

of total thyriodectomies for congestive heart failure
and angina pectoris. Thus, the attention of the ex-
perimental and surgical profession was switched from the
surgery of the mitral valve to the lowering of the basal
metabolic rate.

DIAGNOSIS

Formerly, an accurate diagnosis of mitral
stenosis was not necessary, as the treatment was to
relieve the pulmonary congestion (19). With the at-
tempt to apply surgery to the mitral valve, the path-
ology of that valve then must be determined. The
most important point is the past history, for fifty
percent of the valvular cardiopathies have a history
of acute rheumatic fever, chorea or acute tonsilitis.
Others having no history, may be due to mild attacks
of rheumatic fever or chorea, the symptoms not being
perceptible until some valvular damage has been done.

The clinical picture is of cyanosis with high
coloring of the cheeks and lips, being termed the mi-
tral stenotic facies (23). Dyspnea is seen rather
early, which may progress into orthopnea and a chronic
cough. The vital capacity is reduced, having been
seen as low as 2000 c.c. Hemoptysis is rather common,
becuase of the congestion of the lungs, and mitral
stenosis should be considered in every case. Club

fingers accompany this cardiorespiratory pathology.

There usually is a prominance of the lower sternal area, with a systolic throbbing in the epigastrium. These signs point toward cardiac enlargement which is common to all heart diseases, but is also seen in mitral stenosis. A perceptible thrill at the apex is one of the earliest findings, and in some cases, the thrill may be absent due to severe constriction. A ventricular shock occurs at the end of the contracting phase, and is intensified during expiration and exercise. A sharp impaction is also noted in the pulmonary area as the pulmonic valves are forcibly closed by the increased pressure.

Percussion reveals dullness to the right of the sternum, varying with the amount of right ventricular hypertrophy. Dullness can also be elicited in the second and third interspaces as the left auricle dilates. These signs coincide with the pathological process of mitral stenosis, resulting in dilatation of the left auricle, congestion of the pulmonary tree, and right heart hypertrophy.

In examining the heart by ascultation, the earliest sign is accentuation of the first sound, and remains until the myocardium is greatly weakened (19). The critical point is detection of a murmur in diastole.

In early slight stenosis, the murmur might be short presystolic crescendo in quality, ending with a snapping first sound. These murmurs may vary, some being rumbling and in mid-diastole. Later, as the stenosis becomes more marked, it may fill the entire diastolic period. The rhythm is usually regular, unless for a few extra systoles.

After a variable period, the auricles start fibrilating. It usually follows the initial infection by fifteen or twenty years, but may start much sooner. The typed of diastolic murmur that persists with the change of rhythm from the regular to the absolutely irregular, will depend somewhat upon the degree of stenosis. If the entire diastole has been filled with a murmur when the heart was regular, a long diastolic murmur will be heard when the heart fibrilates. However, there will be no presystolic accentuation in the latter. To hear this, the heart rate must be slowed, otherwise, the pause between beats will be too short. Conversely, a short diastolic murmur may even disappear. In general, the longer the diastolic murmur, the greater the stenosis.

Labratory work assists in confirming the diagnosis, cheif among which is roentgenology (33). Flat chest plates and fluoroscopy are both used, the former

to note changes in size, and the latter to watch heart action. In mitral stenosis, the heart casts a circular shadow by the dilatation of the left auricle and right heart hypertrophy. The right oblique view is especially valuable in demonstrating the left auricle. In this view, the large left auricle displaces the barium filled esophagus backward and to the right, causing a narrowing of the lumen.

The electrocardiogram is helpful, although not diagnostic, for myocardial damage is common in many conditions (19-46). There is a peculiar persistent, flat-topped, notched auricular wave. The waves vary, some being higher, wider or more notched, as the degree of the stenosis varies. There is a right axis deviation as shown by inversion of the QRS complex in Lead One, and the normal version in Lead Three. The right axis deviation indicates hypertrophy of the right heart, which occurs in mitral stenosis.

A singular valvular heart lesion is very infrequent, and some difficulty will be encountered in diagnosis (19). It would be much more simple if only a mitral stenosis were present, but one frequently finds other pathology as aortic insufficiency. Adherent pericarditis is common, but its importance is not so great, as the patient never complains of it.

PATHOLOGY

The pathology of mitral stenosis is rather striking (10). There is marked disproportion of the right and left ventricles, the auricles being about equal in size. The mitral valve, when viewed from above, appears as a funnel with a small orifice, either round or slit-like, hardly admitting the tip of a finger. The edges of the valves are glued together and greatly thickened, being so stiff and rigid that the necessary movements are almost impossible. Degenerative changes may occur, resulting in deposits of calcium giving a stoney hardness to the valve. The chordae are so shortened that the papilary muscle appears to be attached to the valve leaflets directly. The left auricle is dilated about ten times its normal size, and usually shows some hypertrophy. In many instances, thrombi are found in the auricle, particularly the auricular appendix. In rare cases ball thrombi may be found.

The pulmonary artery also shows some atheromatous changes, either local or general. The lungs may show brown induration from the hemosiderin of the blood, as well as heart failure cells, hemorrhagic areas, and infarcts.

The obstructive effects of the mitral lesion results in the chain of affairs, as, left auricle

dilatation, pulmonary congestion, and right heart en-
largement. With the occurrance of auricular fibrila-
tion, there is no active movement, only a twitching
of the auricles. This produces a good environment for
thrombi formation, and is rather commonly seen. The
thrombi may be attached to the endocardium by a thin
pedicle, or remain free, as a ball thrombus. With the
pulmonary stasis, the vital capacity is greatly reduced
by the reduction of alveolar spaces. This produces
the symptoms of dyspnea, orthopnea, cyanosis, and hemo-
ptysis. When the right heart is unable to carry the
load, and decompensation occurs, then heart failure
results.

INCIDENCE

The incidence of mitral stenosis is not fully
realized until an accurate check on the diagnosis has
been conducted. Grant (30), in 1933, tabulated his
findings in one thousand cases of heart diseases. By
following them for ten years, he could confirm his diag-
nosis by their future findings. As can be expected,
some cases were incomplete, they having disappeared
leaving no information. This, however, was in the mi-
nority, the percentage of cases not followed up being
less than two percent. Twenty-three percent of the
patients had symptoms of mitral stenosis, only one or

two cases being reclassified later. Ninety-seven men
had mitral stenosis with a definite history of rheuma-
tic fever. In contrast to this, one hundred and forty-
one men had no history of rheumatic fever, chorea, or
tonsilitis, and were termed the idiopathic mitral
stenotic group.

In the rheumatic group, the largest number of
patients were between the ages of twenty and thirty
years, the average being thirty. Seventy-seven patients
of this group had no complications, while the remaining
twenty were complicated by pericarditis, tuberculosis,
and other diseases. In the uncomplicated cases, about
twenty-five percent showed no changes in symptoms or
findings in the ten year period. Of the remainder,
thirty-five percent had died in this same period, while
the rest showed progressive increase in cardiac en-
largement, decrease in exercise tolerance, and the be-
ginning of auricular fibrilation. The complicated
cases had a higher mortality, as could be expected,
sixty percent dying in this period, while only two
percent were living uneventfully.

The majority of idiopathic cases ranged in age
from twenty to forty years, the average being thirty-
two and four-tenths years. Of the one hundred and
forty-one men in this group, one hundred and twenty-one

had no complications, while the remainder had some
other disease with the mitral stenosis. At the end
of the ten year period, thirty-eight percent of this
group were dead, twenty-eight percent were living an
uneventful life, and the rest showed progressive heart
injury. In the complicated group during this same
period, sixty-six percent had died, the other third
showing progressive cardiac changes.

This seems to make a rather impressive picture,
the greatest percent being in the early thirties of
life. As could be expected with patients having other
diseases with the valvular damage, the mortality rate
was higher. It was also demonstrated that a rather
high percent of those having no other complications
were alive at the end of the ten year period.

SELECTION OF CASES

All cases of mitral stenosis are not suitable
for valvular surgery, and should not be attempted, be-
cause of the high mortality (20). Cutler (19) believes
there are several factors to be considered in the se-
lection of suitable cases for surgery. They should
be beyond the age of repeated attacks of rheumatic
fever, to prevent further stenosis and hardening of the
valves. There should be enough mechanical constriction

as to form a real stenosis, for the surgical risk is too great for mild cases. If the operation is a success, a good myocardium is necessary to carry the load, and should be able to compensate.

In Allen's discussion of Cutler's (20) cardioscopic valvulotome, he mentions his criteria for successful cases. Allen stated, "The ideal case of mitral stenosis is one which is still progressing. Which has a good myocardium with a moderately high vital capacity, and adequate oxygen saturation ability." The selection of the case is mainly theoretical, as no surgeon could convince these patients of surgery, and none would risk the patient's life, if some did consent. Consequently, the first mitral surgery was performed on patients already resigned to their fate.

RATIONAL OF PROCEDURE

Many questions had to be answered before the thought of producing a mitral insufficiency was considered. In 1775, Vieussens noted the limited output in mitral stenosis (19). With Burton's (11) suggestion of 1902, concerning surgery of a stenotic mitral valve, the Lancet (27) criticized the idea, as this procedure might cause some insufficiency with very doubtful benefit to the patient. According to MacCallum (39), that would be more beneficial than a stenosis, for in a

stenosis, the left auricle and the right ventricle must enlarge to force the blood into the left ventricle, which assumes no part of the responsibility. In mitral insufficiency, the stagnation of the lesser circulation is relieved by the increased activity of the left ventricle. The insufficiency is thus responsible for two things, relief of pulmonary congestion, and increase of systemic arterial pressure.

The congestion of the lung has a deleterous effect upon the ventilating capacity. Drinker, Peabody, and Blumgart (26), concluded from their experimental work that mitral insufficiency alone does not produce dyspnea, as does stenosis, unless myocardial damage has occurred. Souttar (35) thought the problem to be mainly mechanical, which in turn can give rise to myocardial damage. He believed the relieving of the mechanical obstruction would undoubtedly be of immense service to the patient, and be followed by marked improvement of the general condition. He concludes his work by saying, "I could not help being impressed by the mechanical nature of these lesions, and by the practicability of their surgical relief."

Allen (2-20) has shown by manometer readings that with a stenosis of the mitral valve, the mean blood pressure within the left auricle is high and the

pulse pressure is small. With a mitral regurgitation, the mean blood pressure within the left auricle is lower and the pulse pressure is larger. With a normal mitral valve, the mean blood pressure is still lower, but the pulse pressure is smaller than in an insufficiency. If one can lower the mean blood pressure by incising a stenotic valve to relieve the obstruction until it approximates the normal, then congestion back of the valve should be relieved. In mitral stenosis, the back pressure is high and continuous, but with insufficiency, the pressure is lowered and intermittent. Clinically, we find a pulmonary congestion in stenosis, but seldom in regurgitation.

Wilson (48) does not believe it possible to restore the valve to its normal condition. Rather, he supports the clinical view that mitral incompetence is of less serious consequence than mitral stenosis.

EXPERIMENTAL MITRAL INSUFFICIENCY

As Elsberg had shown the heart was adaptable to cardiac surgery by the removal of the apical third of the ventricle, and Rehn and Sauerburch tried to develop a bloodless field for surgery by compression of the vena cava, a typical mitral stenosis was necessary for further experimentations (19). The first to create a lesion of the valves, was an ophthalmologist,

Becker, in 1872, who caused an insufficiency of the tricuspid, noting its effect upon the eye. Many other experimenters did extensive work in producing valvular insufficiency, rather to evaluate insufficiency than stenosis. Sir Lauder Burton (11) tells of his effort to produce insufficiency in cats. By a transpleural approach, he was able to introduce long-handled tenotomy knives into the left ventricle and make transverse sections of the mitral valve. He stated that there was very little bleeding from the ventricles. In his work upon the cadavers, he found the hardest parts of the valve to cut, are the edges, which are firm and resisting to the blade.

The Editorial in the Lancet (27) questioned this procedure, believing the valve edges would again adhere unless instruments were used to keep them apart, the blood being unable to do it in the first place. MacCallum (39), in 1906, told of his work in producing artificial mitral obstruction by screw-clamp. He also passed a suture about the atrioventricular ring, but was troubled by the pressure on the cornary vessels. Lastly, he introduced a distensible rubber balloon into the left auricle, producing an obstruction. These experiments demonstrated typical pressure changes of mitral stenosis.

Hoecker of Germany, and Cushing and Branch of the United States, did considerable work on this subject (19). Cushing (17) tells of their valvular lesions in the dogs, and states, "It remains to demonstrate the possibilities that an experimentally produced mitral stenosis with a compensatory failure, can be symptomatically improved by division of the narrowed mitral orifice on the living animal, before attempting a similar procedure to relieve the corresponding pathological lesion in man." Bernheim (8), in 1909, succeeded in producing a clinical picture of mitral stenosis, by passing a ligature about the base of the mitral valve leaflets, and by tensing the ligature, narrowed the orifice. Then, by cutting the ligature, the valve returned to normal.

In 1910, Carrel (13) suggested that by the dilatation of the mitral valve by digital exploration of the auricle, or by clamping the pedicle, it might be feasible to open the ventricle and section the mitral valve. Jegar's (19) monograph of 1913, believed in the idea of shunting the blood around the stenotic valve. The method was to transplant a section of the preserved vena cava between the congested chamber and a large vessel. One experiment was tried, the animal dying four days later of embolism. No other experiments were continued in that field. Carrel (14-15), in 1914,

writes of his work on cardiac surgery, improving the
method of operative approach and technical percision.
With Tuffier (47), they succeeded in sectioning the
pulmonary ring, allowing some insufficiency, and patch-
ing with a piece of preserved vena cava.

The danger of the open method of cardiac sur-
gery, in which the great vessels were clamped, was
anoxemia (15-19). The stopped circulation was found
to cause irrepairable damage to the cortical cells of
the brain, the animals exhibiting symptoms of decere-
bration. In animals, the time which the circulation
could be stopped without serious ill effects, was de-
termined as two and a half to three and a half minutes.
In larger animals or man, this time limit may be ex-
tended slightly longer. The vital centers could exist
for a longer time with the circulation stopped, but
one could see the folly of doing a successful valvular
operation to have the animal behave as though decere-
brated.

Because of the time limitation, which the
Lancet (27) said destroyed the skill of the best
surgeon, this method of operation was made obsolete.
Allen and Graham (1) realized that a new method of
visualization was necessary, if valvular cardiac sur-
gery were to succeed. With the factors of anoxemia and

vision before them, they began to cast about for some
solution. It was noticed that when the heart was im-
mersed in a bloody fluid, as in a specimen jar, that
the part pressed against the sides of the jar could be
readily seen. They devised an endoscope which could
be passed through the heart wall, the lense at the
tip of the instrument being pressed against the inter-
nal structures, and a visual field created. A long
handled knife was attached to the barrel of the instru-
ment to divide the valve leaflets. Allen termed this
instrument, the cardioscope, and with it he was able
to produce typical insufficiency in the mitral valves
of dogs.

In this same time, Cutler (22) was doing ex-
perimentation in creating insufficiency, starting the
work in 1917. He likewise did not believe in the
stopped method of cardiac surgery. His method of at-
tack was similar to Burton's (11) original work of
1902, using long handled knives which could be plunged
through the ventricular wall to section the mitral
valve. Later, he developed a heavy shearing instru-
ment which could be inserted into the ventricle, ap-
proximating the mitral ring, and excising a portion
of the valve leaflet (4). Cutler named this instru-
ment, the valvulotome, and could produce mitral insuffi-

ciency in a large proportion of dog hearts.

Souttar (45), in 1925, writes of his experience with digital dilatation of the mitral valve. He had originally planned to section the valve by passing a hernial bistoury through the opening in the auricle, which he made to insert his finger. However, he did not proceed with this method, but dilated it with his finger. The next year, Dmitreiff (25) recounted his experiments in which he invaginated the left auricle to dilate the mitral valve. Cutler (20) combined Allen's cardioscope with his valvulotome, so that the heavy shearing instrument would have a visual apparatus. Wilson modified the cardioscopic valvulotome with a sealed sheath, so there would be greater modility in handling the instrument.

Many facts were uncovered by the experiments in cardiac valvular surgery, which were hoped would improve the management and technique of human valvular surgery. The foremost was that the heart is amendable to surgical repair, and does not stop with slight trauma, although there are areas which cause cessation of the rhythm.

The Lancet (27) questioned Burton's proposal of surgery of mitral stenosis, by asking if the cut edges of the valve leaflets would not adhere and grow

together. In the experimental work of Allen (2) and
Cutler (19), the cut edges had thickened and were cov-
ered with endocardium. They also stated that the heart
healed by first intention, in aseptic cases the edges
approximating, leaving a smooth scar. There is a
strong union of muscle, as shown histologically by
the presence of fibroblasts, mononuclearcytes, wander-
ing cells, and connective tissue elements. The endo-
cardium heals readily, leaving a smooth surface covered
with endothelial cells. In none of Cutler's cases,
had he ever found any thrombi, either on the valve or
musculature. The only case of recorded thrombus oc-
curred in Jegar's work, in which he tried to shunt
the blood around the stenotic valve. Claude Beck (5),
when questioned if manipulation did not produce emboli,
stated that though he had never looked for any, the
animals always appeared healthy and active.

The question of sepsis in cardiac surgery was
thoroughly tried, as all the experimentation included
this phase. Carrel's work (14), in 1914, was confirmed
by Allen (2) and Cutler (4). They likewise have shown
that pericardial adhesions and heart tamponade could
be kept at a minimum in their animal experiments (2-19).
Allen (1) has demonstrated the usefulness of continuous
circulation of cardiac valvular surgery, although his
cardioscope has not proven as successful, in regard to

visualization. Cutler (4-19) demonstrated that the valvulotome could excise a sufficient piece of the mitral valve to produce incompetence, and when in combination with the cardioscope, was rather effective in visualization. With Wilson (48), modifications of these instruments developed into a rather efficient and useful instrument.

EXPERIMENTAL INTERAURICULAR FISTULA

Another idea was expressed by Jarotsky, in 1926, in which he believed the symptoms of mitral stenosis could be relieved by making an interauricular fistula. He believed this would relieve the pressure on the left auricle, and cited the cases of Lutembacher. These cases of Lutembacher, all had interauricular fistulas. The two cases cited by Jarotsky, lived to an old age, and only showed slight symptoms of mitral stenosis, while the other cases died in middle age with marked symptoms. It is the belief of Wilson, that the two cases were congenital affairs, and were compensated from birth.

Holman (31) states that the enlargement of the heart due to interauricular communication, was due to dilatation and hypertrophy, caused by the increased load and assumption of the right heart, to overcome local resistance. The overload is caused by the congestion in the left auricle, forcing blood into the

right auricle and adding the load to the right ventricle. This cycle may be continuous, and if sudden, may result in considerable embarrassment or even death. The physiological results are, a fall in blood pressure with increased pulse rate, and gradual accumulation of total blood mass (32). In one of Wilson's (48) experimental stenotic animals, an interauricular communication was created, but proved neither helpful nor beneficial. An autopsy was performed, and the fistula only measured one millimeter in diameter. This was believed to be inadequate for any functional test. It was thought that part of the septum must be excised to prove effective. Dmitrieff (25) developed a similar idea, and his technique was to make a small incision in the left auricle, through which a finger could be inserted to guide an instrument to pierce the septum. No further results were recorded of this type of experimentation.

EXPERIMENTAL MITRAL STENOSIS

The attempt to produce experimental mitral stenosis was first considered by MacCallum (39), and later by Bernheim (8), who produced an artificial mitral stenosis. Carrel (14), in 1914, in his experimental work on the heart, tried to produce a stenosis by excising a wedge of the myocardium in the region of

the mitral valve, staying clear of the large cornary
arteries, and reapproximating the edges. The incision
healed, but no stenosis was apparent. They tried to
sew the valve leaflets together to form a button-hole
stenosis, using the stopped circulation method of sur-
gery. Even with the chambers open, the lesion created,
did not give the desired results. All in all, Carrel's
(19) work on experimental mitral stenosis did not prove
effective, and he concluded that it was not possible to
produce this type of lesion.

After Coryllos (16) had demonstrated that it
was impracticable to produce mitral stenosis by strong
caustics, as sodium or potassium hydrates, or by mech-
anical injury, special radium applicators to produce a
fibrosis of the mitral leaflets were devised. The
results of these experiments appeared in 1923. They
had inserted their radium applicators through the
auricular appendix, placing them on the leaflets.
Using strong doses of radium emanation (200-400 m.c.),
they had some promising results. In some hearts thus
treated, the microscopic results showed marked conges-
tion of the valve base, and patchy thickening at the
borders of the other leaflets.

Although the results were promising, many
felt that experimental mitral stenosis was vague and

far away. Cutler (21), in 1929, expressed himself by saying, "Should it be possible to produce experimental mitral stenosis, the question concerning insufficiency could be settled in the labratory. Unfortunately, our own attempts for seven years, along this line, have been as unsuccessful as the attempts of other and more experienced investigators."

Powers (40), in 1929, believed two processes are necessary to acquire a chronic irritation of the mitral leaflets, resulting in a stenosis. These are mechanical irritation of the leaflets, with a super-imposed endocarditis. He used an electocoagulation method for his first step, placing one electrode beneath the animals back, and the other being used for the coagulation. The aseptic electrode is introduced through the ventricle, the tip being approximated to the mitral valve by invaginating the auricle with the other hand. The bipolar current of a high frequency, is started, which results in considerable trauma to the valve.

Two strains of streptococcus were used to engraft the endocarditis upon the valve. The first strain was Strepto viridans, isolated from the myocardium of a rheumatic case, and the other, the Strepto. cardioarthritis of Small (40). The technique of the innoculation was to use thirty to fifty cubic centimeters of a

twenty-four hour broth culture, and followed four days later by the injection of seventy to one hundred cubic centimeters of a similar broth culture.

In the series of experiments in which this procedure was tried, seven animals showed clinical mitral stenosis. These were induced by using S. viridans for innoculation, the S. cardioarthritis being not as effective. It required about three months for the animals to reduce the bacteriema, and if they survived that stage, they usually recovered. By doing successive autopsys upon the dogs at different times, a rather complete pathological change was noted. If the animals developed no resistances to the bacteriema, they evidenced acute bacterial endocarditis. In those surviving the acute stage, the vegetative thromus became organized, fibrosis occurred, and the valves became thickened and sclerotic. Fibrocartilage is deposited about the base of the ring the orifice constricts, and the valve action becomes impaired. In the favorable cases, the end result is experimental mitral stenosis, comparable in its gross clinical and mechanical pathology to the stenosis seen in man.

Powers (41), however, believes the lesions are created differently in man than in dogs, the end results being similar. His experiments show that with the healing of acute vegetative endocarditis, fibrosis

and cicatrization follow. In man, the chronological development is reversed, for some form of valvular disease must be present before vegetative endocarditis may occur. Swift also supports this view. The pathological results also differ some in the human cases, for they have a vascular organization of the vegetative thrombus, resulting in a more diffuse complete involvement of all the segements of the valves, and a shortening of the chordae tendinae. This pathology in animals results from an avascular organization with a patchy sclerosing.

In Power's later group of experiments, fifty-seven dogs were used to produce experimental mitral stenosis, thirty-eight surviving. Eight were used as controls, to see the evidence of the trauma. Several of these showed large areas of necrosis, due to the electrocoagulation, others showed small scars at the site of the trauma, but no thickening of valve leaflets, or stenosis of the valves. Seven animals recieving no previous trauma, were innoculated with S. viridans. After the bacteriema had quieted down, they were sacrificed, but no evidence of endocarditis remained. Of the thirty dogs receiving trauma by electrocoagulation, and injected with either S. viridans or S. cardioarthritis, twenty-eight developed

mitral lesions comparable with the stenosis of rheumatic origin in man.

Wilson (48) of Edinburgh, at the same time as Power's work, developed a new type of mitral obstruction. He used strips of parietal pericardium, which had been preserved, and attached them to sutures. They were inserted beneath the atrioventricular ring, keeping away from the large cornary arteries, through the left ventricle. They were so placed that they constricted the mitral orifice, and stabilized the valve cusps. The end of the strips protruded so that they plugged the openings, and were sutured to the viseral pericardium. The effects of this procedure were to obstruct the mitral orifice, and to reduce motility in the leaflets. The experimental animals demonstrated some degree of mitral stenosis and insufficiency. Autopsy of these animals revealed a definite obstruction, and one animal developed some right heart hypertrophy. Thus, experimental mitral stenosis was established.

APPROACH TO THE PERICARDIUM

The approach to the pericardium was by the transpleural route, in most of the early procedures (17). This produced an adequate surgical field for opening the pericardium, and for manipulation of the heart. (p. 42)

These surgical approaches were used in most of the animal experiments, because of the peculiar shape of the chest, and accessability to the heart. Allen (1) used this approach in his work upon animals, and in his first human cases. His method was to make an oblique incision to the left of the mid-line, resecting the ribs, as needed. Then, by opening the pleura, he approached the pericardium. The lungs were protected by warm saline packs. Later, Allen made an osteoplastic flap of the ribs, and entered in the same manner.

Cutler (19) advocated the mid-sternal approach, which consists of an incision slightly to the left of the mid-line. The xiphoid process is removed, and the sternum split upward to the second interspace, where a transverse section is made. The pleural sacs are spread apart, opening the mediastinum to the pericardium. The incision is continued inferiorly, which opens the peritoneal cavity. The anterior pericardium is opened, continuing into the inferior paricardium and diaphragm, for six centimeters. Cutler believes this to be the best approach, as it does not open the pleural spaces, yet permits sufficient exposure in case of hemorrhagic accidents, and does not harm any midline structures as nerves and blood vessels.

A parasternal incision may be used, which runs

obliquely, laterally and inferiorly, from the sternum, turning back an osteoplastic flap and attempting to enter between the pleural spaces. Cutler believes this approach is dangerous, as the surgical field is not large enough in case of accidents, and there are great chances of entering the pleural fields. He disbelieves in Allen's oblique transpleural approach, as it causes some collapse of the already over-burdened lungs. With mitral stenosis, the ventilating capacity is reduced, and this added collapse will further diminish the oxygenating action of the lungs.

Shipley (44) mentions the advantages of the oblique approach, as it requires less time to enter and close the operative field, and it does not enter the peritoneal cavity. The disadvantages were, the opening of the pleural spaces, and too small a surgical field. Shipley thought the median sternotomy, known also as the Duval-Barasty median thoracoabdominal pericardiotomy, is the most adaptable. Cutler modified this approach as described, in doing his work with mitral stenosis. Matas reported three operations performed by French surgeons for removal of foreign bodies, by this approach.

The median sternotomy approach has two advantages which cannot be overlooked in surgery upon the

heart. Firstly, it allows easy access to all parts
of the heart, especially the posterior portion.
Secondly, the pleural cavities are not opened, and
should prevent some of the pulmonary adhesions. Ship-
ley states, "I have had no experiences with this ap-
proach on the living patient, but in the dead house,
it gives wonderful access to the heart and pericardium
without injury to any large vessels, and without open-
ing either pleura.

CARDIAC INCISIONS

The surgical incision into the heart has been
advocated in two places, the auricular appendix and
the anterior ventricular wall (19). The first experi-
menter to use the ventricular approach was Burton (11),
in 1902. He found the ventricle could be handled eas-
ily, and very little hemorrhaging occurred. The aur-
icle was mentioned as a means of entrance by a slight
rotation to the right, but no statement was made that
it had ever been used. Cushing (17), in 1908, used the
venticular incision in his early valvular surgery, with
very good results. They easily demonstrated that the
plan was feasible for future references. Cutler (18),
in 1923, used this incision in his first human valvu-
lotomy with rather good results. Cutler (19) believes
this apical incision is the best, because of the thicker

walls making easier repair, better control of hemorr-
hages, and the best approach from the interpleural
section.

The auricular entrance was mentioned by Bur-
ton (11) and Bernheim (8), but Allen (1), in 1922,
first mentioned the usefulness of this incision. He
cites the advantages of using the auricular appendage
in valvular surgery, as the entire heart need not be
exposed, the appendix is non-functioning, and has no
vital centers. When the operative procedure was com-
pleted, the appendix could be amputated, causing no
ill effects. Furthermore, there was no ligature left
in the heart, and the endocardium was approximated
together. Allen's (2) criticism of the ventricular
approach, was the high mortality, death occurring in
fifty percent of the experimental animals. He also
believes the high pressure of systole may cause hemorr-
hage and heart tamponade.

Cutler's (19) rebuttal of Allen's criticism was
good, stating that results were obtained if the inci-
sion were kept away from the base of the anterior papil-
lary muscle, as he found this to be a vital area. He
did not believe the auricular approach would be success-
ful, as the dilatation caused by mitral stenosis, caused
a thinning of the auricular wall and would tear easily.

Also, the formation of antimortem thrombi was encouraged in the auricle by the slowed circulation of the blood, and any injury to the intima could induce thrombi formation. He concludes that manipulation of a dilated auricle containing a thrombus, may give off showers of emboli, and may prove fatal.

Allen and Barker (3) exploded Cutler's advocation of transventricular incision, by making electrocardiograms before and after surgical and valvular experiments. Their results pointed towards auricular approach as having the least deleterious effects. The findings in the auricular incision demonstrated a moderate number of auricular extra systoles, a few ventricular extra systoles, and no auricular fibrilations or deaths. The ventricular incision increased the number of auricular and ventricular extra systoles and premature beats. There were two deaths in this series, one from an atrio-ventricular block, and the other from ventricular fibrilation.

In answer to Cutler's question of the strength of the left auricle in cases of mitral stenosis, Allen (20) secured several warm hearts from autopsy material and attaching a manometer to the left auricle, filled them with water. Before the auricles ruptured, they supported a column of water twenty-three feet high,

which is equivalent to five hundred millimeters of mercury. This pressure is about fifty to one hundred times the normal in that chamber.

Souttar (45) used the auricular approach in his human case, making an incision and inserting his finger, which he used to dilate the mitral ring. Dmitrieff (25) used the auricular incision in his finger dilatation in animals, and planned to incise the auricle, through which the interauricular septum was to be perforated for relief of mitral stenosis.

In the period between 1925 to 1929, Cutler began to use the auricular incision as a means of approach to the mitral valve. Cutler and Beck (21), in 1929, acknowledged the approach was easier from the auricular side, as the instrument was guided into the funnel-shaped mitral valve. The ventricular approach was much more difficult, unless engaged at the first try, for the valve would deflect the tip of the instrument to the side. However, they believed a transpleural approach was necessary, because of the straight instrument, or if the interpleural approach was used, a curved instrument was necessary, as it must turn downward and forward to reach the mitral valve.

Lockwood (37) did not believe that the problem was of the site of the incision as much as of the ex-

perience of operative approach. He considered the
auricular incision the best, as shown by operative
recoveries, and the least mortalities in animal experi-
ments. Wilson (48), in 1930, concluded that the auri-
cular incision was the most advantageous, for manipu-
lations of the auricle are not as harmful, easier to
tie in the surgical instrument, and the fish mouth
cavity forms a guide to the valve.

CLOSURE OF THE PERICARDIUM

The closure of the pericardium was debatable,
because of the dangers of the slight oozing of blood,
and traumatic pericarditis with effusion, resulting in
heart tamponade. Bernheim (8) felt that it should not
be closed because of this danger. In some of his ani-
mal cases, it was partly closed, and in others it was
left open, with no harmful effects. However, Allen (1)
closed the pericardium, leaving no drainage, and did
not record any deaths from heart tamponade in his ani-
mal experiments.

Cutler (19) feels that closure of the pericar-
dium is advisable. Although the insecurity of hemos-
tasis, and the common occurrance of effusion producing
intrapericardial pressure, it is better to close, as
the drainage promotes adhesions, which are of graver
consequences than the dangers of occasional heart

tamponade. He used a continuous silk suture throughout the entirety of the incision. Wilson (48) is adverse to this opinion, and believes gaps of one centimeter should be left between sutures, as this allows the fluid to escape into the pleural sacs.

TRAUMA OF THE HEART

It had been demonstrated by Rhen (19), Cushing (17), and Carrel (15), that the heart could be handled without serious effects. Allen (1) found most cases withstood the handling well, but a traumatic pericarditis with effusion and adhesions, almost invariably followed the operation. Cutler (19) believed that slight trauma was stimulative rather than deleterous, and had an immunizing effect. However, Allen (3) pointed out that more cardiac arrhythmias followed ventricular than auricular manipulation, and they were often more serious. He used rest and massage to restore the rhythm, if the heart became irregular.

Cutler (19) allowed a pause for the heart to restore the rhythm, and if this did not restore the desired results, some therapy was tried. He used a small concentration of epinephrin in a normal saline solution, dripping it on the heart, which usually restored the rhythm. If the heart should stop, an injection of one cubic centimeter of a one to one thousand

solution of epinephrin may revive the organ. If no vital centers are involved, massage will restore the beat, the purpose being to replenish the cornary circulation.

Cutler used digitalis to study and quiten the heart beat during an operative procedure. They were fully digitalised prior to the surgery, so the drug could become immediately effective. Post-operatively, caffeine was to improve the circulation. It was given orally, intramuscularily, rectally, with effacious results. He did not use epinephrin postoperatively to raise the blood pressure, as it soon dropped to a lower level.

Wilson (48) concluded that trauma was the exciting cause of auricular flutter, and partial heart block in his animal experiments. This excitation is gradually reduced with the operation. Anoxemia of the heart muscle should be guarded against by massage of the ventricles, and frequent inflation of the lungs to relieve the congestion. He also used a weak solution of epinephrin to stimulate the heart, but found that warm saline packs increased the adhesive pericarditis.

Beck (5), in 1937, concluded the causes of arrhythmias in cardiac surgery were local pressure and surface stimulation. To avoid these effects, he

suggested three methods. First, they may be prevented by the least possible touching of the heart with the hands or instruments. Second, allow rest periods in the manipulations, so the heart may restore its regular rhythm. Third, the application of procaine or metycaine to block all surface stimulation. These methods give good results, the last being very helpful and effective.

Ventricular fibrilation is almost always fatal in man. The method of restoring the regular rhythm up to this time, has been ineffective and cumbersome. Beck and Mautz's work with procaine and metycaine has been startling, and they hope it will be a success. The ventricles usually fibrilate sometime before they finally stop, but during this period, no blood is expelled, and consequently, anoxemia results. The rhythm can not be restored until every last bit of fibrilatory twitching has ceased. Mautz used a weak solution of procaine or metycaine dripped upon the ventricles, then by sending an electrical shock through the heart, the fibrilatory movements are stopped, and massage can restore the rhythm. Epinephrin may be injected into the ventricles at this time. Either drug may be used, as the only difference being that metycaine is much stronger and more toxic.

Other medication, which helped maintain the
cardiac rhythm, was one percent calcium chloride with
heparin and epinephrin, into the right ventricle.
They used quinidine sulphate routinely, on all cardiac
cases in which frequent ventricular systoles occurred.
The method of restoring a fibrilating ventricle has
been rather effective. Beck and Mautz have been able
to restore hearts that have been fibrilating or at a
stand still, for as long as thirty minutes.

OPERATIVE PROCEDURE

Allen's (1) method of surgical procedure in a
valvulotomy was to make an oblique incision over the
heart, and resecting an osteoplastic flap. The peri-
cardium was opened by a similar incision, and the auri-
cular appendix exposed by the slight pressure on the
right heart. The appendix was clamped by a rubber-
covered weak-jawed forceps, and a small incision made
at the apex. The cardioscope was inserted, and tied
in place by a ligature around the edge of the auricu-
lar appendage. The forceps were released, and the
cardioscope approximated to the mitral valve. After
the leaflet was sectioned, the cardioscope was with-
drawn into the appendix. The forceps were applied to
the auricular appendix, after which it was ligated
and amputated. Wilson (48) modified it by tying the

sheath into the appendix and then fitting the instrument.

Cutler's (19) transventricular valvuloectomy employed the median sternotomy approach, which made a large surgical field. The heart was raised and a suture was placed through the apex, for ease of handling. Two control sutures were placed about one centimeter apart, near the apex of the left ventricle. When the ends are crossed, they form a purse string suture to control any hemorrhage. Between these two sutures, a small incision was made through which the surgical instrument was inserted. Cutler's cardiovalvulotome could be pushed in deeply, and rotated freely, with no fear of hemorrhage, as long as the tension of the control sutures was sufficient. After the excision was completed, the cardiovalvulotome was withdrawn. The tension on the control sutures being increased as the instrument left the ventricle. Two or three silk sutures, or a mattress suture, closed the incision, preventing any hemorrhage. The median sternotomy incision was closed in the regular way.

Souttar's (45) digital exploration method was very similar to Allen's procedure. Using an oblique incision, he turned back a rib flap, and made a transpleural approach to the pericardium. The left auricular

appendix was exposed and the finger inserted through
an incision at the apex. He had planned to incise the
mitral leaflet with a small knife, but it was not done
in this case. The valve was easily palpated with the
finger, and sufficient dilatation was performed. The
finger was withdrawn and the appendix was clamped,
ligated and amputated. The incision was closed in
the same manner as Allen's method.

RESULTS OF CARDIAC VALVULAR SURGERY

Cutler's (18) first valvulotomy case recovered,
the patient being relieved of some of her symptoms.
However, Cutler did not feel it was a complete success,
but it seemed very encouraging. An Editorial (28) in
the British Medical Journal stated that the experience
gained in the first successful attempt upon cardiac
valvular surgery has provided technical improvement,
which should render any subsequent attempt less danger-
ous, and more likely to be followed by satisfactory re-
sults. Cutler (19) performed three other operations
in the next year, all dying in a short time, post-
operatively of pneumonia. He questions whether the
insufficiency produced was incompatable with life.
If the regurgitation is too severe, the lungs are un-
able to withstand the congestion, cyanosis occurs and
death results, similar to hypostatic pneumonia in the

aged.

Allen's (20) method of attaining the correct
amount of insufficiency was to attach a straight tubed
manometer to the cardioscope, take the mean blood pres-
sure, make a small incision in the valve, read the
manometer, incise again until a near normal mean blood
pressure is reached. Lockwood (37) recalls the early
post-operative death of Cutler's second to seventh
valvulotomy and valvuloectomy patients. He thinks it
may suggest too great an alteration in the circulation,
the incision or excision being great enough to make the
insufficiency incompatable with life. He suggests
that perhaps dilatation is the correct solution.

Cutler (21), in 1929, began to consider some
other procedure than excision, as a means of reliev-
ing mitral stenosis. He was rather impressed with
Souttar's case, in which the mitral valve was dilated
by the finger, and thought it should be warranted some
discussion. Although he had no experience with the
dilatation method, he thought it worthy of a trial.

Cutler expressed his beliefs as, "It may be
that we already have the evidence that the success in
the finger dilatation method was due to the fact that
only a slight change was in the size of the orifice of
the valve. It may be that the cardio-valvulotome with
its actual removal of a piece of valve, creates a too

sudden change. We know that all the changes made by
nature are slow and gradual, could we return a steno-
tic valve to the insufficiency type by a gradual pro-
cedure, we might achieve success."

After Powers (40-41) and Wilson (48) had suc-
ceeded in producing experimental mitral stenosis in
animals, the question of surgery of the mitral valve
seemed about to be answered. Wilson took a series of
animals with stenotic mitral valve, and performed val-
vuloectomies on each. All of them demonstrated evi-
dence of their inability to withstand the sudden change
from stenosis to insufficiency. The normal animals
could compensate easily enough when insufficiency was
produced by this same method.

Wilson believes excision is the only possible
way of relieving stenosis of the mitral valve. In-
cision does not seem probable, as the valves are very
hard and brittle, with a limited motility. Dilatation,
though possible, has not proven any more successful
to-date. Wilson's experiments gave some proof that
the sudden changing of a long standing mitral stenosis
to insufficiency, can not readily be tolerated, nor will
it be beneficial. Perhaps we must go back to Cutler's
(21) suggestion of 1929, of dilatation. The use of a
small dilating instrument similar to Kollman's dilator

of the urologists, which could be inserted into the
stenotic mitral orifice, and the latter dilated. In
Cutler's (22) paper of August, 1932, he believed the
logical course was upon the stenotic mitral valve,
and hoped the procedure would be perfected. The var-
ious methods and results of cardiac valvular surgery
appear on pages forty-seven and forty-eight.

Of the twelve cases, ten were mitral stenosis,
the other two being stenosis of the pulmonary and aor-
tic valves. Three of these patients recovered from
the operation and were able to leave the hospital.
One (case Number Three) died four and one-half years
afterward of heart failure. The mortality rate is
rather high, at eighty-three percent, which might be
expected, as Cutler (20) pointed out in the high mor-
tality in other new surgical fields. He quoted W. W.
Keen in the Cartwright Lectures as saying that his
first twenty-eight gastrotomies all died. Until 1896,
the mortality rate for pylorectomies was seventy-two
and seven-tenths percent. He also mentioned that
Cushing stated that his first ten patients in brain
surgery were made worse, or died.

VARIOUS METHODS AND RESULTS OF CARDIAC VALVULAR

SURGERY

Case	Author	Date	Diagnosis	Treatment	Results
1	Doyen	1913	Congenital pulmonary stenosis. Patent interventicular septum.	Tenotome	Died a few hours after operation.
2	Tuffier	1914	Aortic stenosis	Finger dilatation.	Recovery-improved
3	Cutler and Levine.	1923	Mitral stenosis.	Tenotome	Died four years and six months after operation.
4	Allen and Graham	1923	Mitral stenosis.	Cardioscope.	Operative death.
5	Cutler Levine and Beck	1923	Mitral stenosis.	Tenotome	Died ten hours after operation.
6	Cutler Levine and Beck	1924	Mitral stenosis.	Tenotome	Died twenty hours after operation.
7	Cutler Levine and Beck	1924	Mitral stenosis	Cardio-valvulo-tome	Died sixth day after operation.
8	Cutler Levine and Beck	1924	Mitral stenosis.	Cardio-valvulo-tome.	Died third day after operation.
9	Souttar	1925	Mitral stenosis.	Finger dilatation.	Recovery living and improved.

Case	Author	Date	Diagnosis	Treatment	Results
10	Pribram	1925	Mitral stenosis and aortic vegetative endocarditis.	Cardiovalvulotome.	Died sixth day after operation.
11	Cutler and Beck.	1926	Mitral stenosis.	Cardiovalvulotome.	Died fifteen hours after operation.
12	Cutler and Beck	1928	Mitral stenosis.	Cardiovalvulotome.	Died three hours after operation.

Data compiled by Cutler and Beck (21).

PART TWO

RATIONAL OF TOTAL THYROIDECTOMIES

Interest in cardiac valvular surgery began to diminish in 1930, after Wilson's results with experimental mitral stenosis. Although the desire to relieve mitral stenosis was just as great, in the minds of the medical profession, an unintentional operation started a new movement. This case might have been sacrificed, were it not for the keen observation of two men who began to study their observations. These men were Blumgart and Berlin. The results of their observations attracted the attention of Beck, Levine, Cutler and others, who had so greatly contributed to the surgery of the mitral valve.

When Blumgart and Berlin (6) focused the attention of the medical profession on the thyroid gland in relation to blood velocity, it aroused considerable interest. It was reasoned that a decreased metabolic rate would consequently decrease the oxygen demand, and slow the heart rate. Thus it seemed that congestive heart failure of angina pectoris could be reduced or eliminated. It was known that in thyrotoxicosis, there was an accompanying tachycardia, and conversely, in hypothyroidism, there is a bradycardia. Lourie (38) explains the rational of the procedure as the lowering of the metabolic rate, which makes the inefficient

heart efficient. However, he adds that the lowered metabolic rate reduces the oxidative processes of the myocardium, and causes it to suffer, lessening its action or ability to become more efficient.

Theodore Kocher of Bern, in 1883, performed several total thyroidectomies which resulted in myxedema. He termed the condition, cachexia strumapriva. In a few of the cases who were cardiac "cripples", they would again compensate after the operation. Dr. F. C. Newton, in 1927, performed a subtotal thyroidectomy on a patient having congestive heart failure (35). This patient compensated and remained that way for four years, after which, the thyroid gland regenerated, and he died of cardiac failure.

An unintentional total thyroidectomy on another cardiac patient, pointed out the possibilities of removing the thyroid and controlling the metabolic rate by the administration of thyroid extract (9). Blumgart, after doing considerable work in blood velocity, believed the time was right for the first human case. Elliot Cutler, who did such epoch-making work in the surgery of the mitral valve, did the first intentional total thyroidectomy on December 15, 1932, at the Peter Brent Brigham Hospital in Boston (36).

Lourie (38), in his discussion of the ratical of total thyroidectomy, mentions the possibility of the

heart failing because of the lowered metabolic rate.
He considers the failing myocardium to be the result
of the reduced oxidative processes, which are manifested
in these cases. Therefore, he concludes that regardless,
the rational is not logical. Blumgart and Levine (6)
believe the principal is sound, and a feasible plan can
be evolved. They insist that a total thyroidectomy
must be performed on every successful case, for the
smallest piece of thyroid tissue will regenerate.
Roentgen rays have no effect in destroying the resi-
dual tissue.

Levine (36) stated that total thyroidectomies
acted in two ways, in congestive heart failure and
angina pectoris. It diminished the basal metabolic
rate and made the system less sensative to adrenalin.
The first was known by the recorded lowering of the
B.M.R., while the latter was demonstrated by injections
of the drug. In patients with a known angina pectoris,
adrenalin was given, noting the reaction. After the
total thyroidectomy, an equal injection of adrenalin
was administered with very little reaction.

Dinnerstein (24) believed there was an addi-
tional change in the physiology of the body, following
a total thyroidectomy. There was an interference with
the sympathetic nervous system, as shown by some of the

unexplainable results. One of these phenomena was
the dosage of digitalis needed to recompensate a heart.
Before the surgery, a standard dose could be given,
while afterwards, only a small amount was required to
produce the same results. Another fact observed, was
the water retention, in some cases, which was not re-
lieved by thyroid extract, but regressed with mercury
diuretics. A few patients exhibited peripheral poly-
neuritis following the total thyroidectomies, and could
not be explained in any other way. Because of these
unusual experiences, Dinnerstein and his co-workers
believed the sympathetic system was deranged. Thus,
the destruction of the thyroid tissue seems to relieve
the body of certain other functions than metabolic
control.

SELECTION OF CASES

The selection of the case must be considered,
in order to have a successful operation. Levine (36)
believes it should never be used in those patients
who do not need to work, and can relax, for the pro-
cedure at the best, does not give complete relief.
In the congestive heart failure class, those with mi--
tral stenosis and hypertension are preferred, as they
have cyclic remissions. For this same reason, auri-
cular fibrilation can be considered. He does not believe

it can be successful in bacterial endocarditis or acute rheumatic fever. In those cases having renal insufficiency, cirrhosis of the liver, and other abnormalities, the prognosis should be guarded.

Berlin (7) added to Levine's criteria of the selection of patients, the value of the B.M.R. If the basal metabolic rate is below fifteen, it would be risky to operate, and if below twenty, total thyroidectomy is definitely contra-indicated. Berlin (6) believes every successful case should have some cardiac reserve, and his test for this is the patient's ability to compensate with digitalis and bed rest.

OPERATIVE TREATMENT

The removal of the entire thyroid gland is less difficult than a subtotal thyroidectomy, for the entire gland can be disected free, instead of partly resecting each lobe (6). This method is less bloody, as the friable gland hardly need be incised except when the recurrent laryngeal nerve and the parathyroid glands are exposed. After the recurrent laryngeal nerve has been disected, a laryngoscopic examination should be performed. Then, if one of the vocal cords are flaccid showing a damaged nerve, the other can be left intact to ensure the voice. The parathyroid glands must be left to prevent tetany, as they regulate

calcium metabolism. If they should be excised, they
may be transplanted to the sternocliedomastoid muscle.
Every piece of thyroid tissue must be excised, and one
should carefully look for an elongated pyramidal lobe.

The patients react better to a local anesthe-
sia than to a general, as the lungs are usually con-
gested (7). Pre-operative orders of barbiturates are
given as in any surgical procedure. It has been re-
commended by Barach, that the patients receive oxygen
post-operatively, to relieve the heart strain (6).

The patients' metabolic rates vary, some hav-
ing a negative reading before the operation is performed,
while others will still record a positive reading after
the operation (38). They attempt to give barely enough
thyroid extract to relieve the symptoms of myxedema,
thus the heart rate is at a minimum, and there is no
discomfort of hypothyroidism (6). It was found that
the average person had a negative B.M.R. of thirty
to forty (24). The ideal metabolic rate was a nega-
tive twenty, which gave the best results, consequently,
it was attempted to maintain the B.M.R. at this read-
ing by giving thyroid extract.

Dinnerstein's method consisted of accurate
checks of their basal metabolic rates, and in their
fifth post-operative week, were given thyroid extract

grains, one-fourth daily. With this regime, the
metabolic rate should be continued indefinitely,
and can be checked by frequent B.M.R. tests. Dinner-
stein reports that this has been done, the readings
of the basal metabolic rates being close to the pro-
posed standard.

RESULTS OF TOTAL ABALATION OF THE THYROID GLAND

Levine (36) reported the results of seven of
his cases of total thyroidectomies for the relief of
congestive heart failure, particularly mitral steno-
sis. Three of the patients had excellent results,
being able to continue their respective occupations.
In two patients, there were good results in that they
were relieved of the symptoms, but were unable to pur-
sue active vocations. In one, the operation was only
fairly successful, the patient being hardly benefitted.
One patient died of mesenteric thromus following the
surgical procedure, and the results could not be
evaluated. Only two cases showed slight improvement
in the ventilating capacity of the lungs. There was
no change in the size of the heart as shown by radio-
graphic studies, for the diminuation in size by the
reduced blood volume is offset by the dilatation seen
in a myxedematous condition. Those suffering of an-
gina pectoris were more relieved of symptoms than the

congestive heart failure cases.

Berlin (7) states that in the two and a half
years following Cutler's first intentional total thy-
roidectomy, ninety cases had been operated for either
angina pectoris or congestive heart failure. Very
few of these showed any signs of tetany, although in
several instances, one or more of the parathyroid
glands had been removed. In thirty-two selected cases
of congestive heart failure, which had total abalation
of the thyroid gland, thirty-eight percent of the pa-
tients had such a marked improvement that they were
able to continue an active life. Thirty-one percent
showed enough improvement that they were able to live
comfortably, with moderate activity. Twenty-two per-
cent could live comfortably, but were not active.
Only nine percent had no improvement.

Dinnerstein (24), in 1937, gave a very encour-
aging report of the progress of the relief of conges-
tive heart failure and angina pectoris, by total thy-
roidectomy. The mortality rate for this procedure
was very low, at six and nine-tenths percent. This
compared favorably with other reports in regard to
this operation. He concluded that eighty percent of
the congestive heart failures were benefitted by this
procedure. His six cases of mitral stenosis with con-
gestive heart failure, seemed hopeful. Four were enough

improved to be ambulatory, and could continue some
of their former habits. One died post-operatively
without known results, while the other showed no im-
provement. This emphasized the selection of cases,
for the last gave a history of progressive acute
cardiopathy, which is not suitable for relief by this
method.

Dinnerstein confirmed the convictions of Blum-
gart, Berlin, and Levine, by saying, "A group of pa-
tients suffering from cardiac decompensation or angi-
nal pectoris, intractable to the usual medical meas-
ures, can be distinctly helped by the total abalation
of the thyroid gland." The benefit produced is suf-
ficiently great in a large enough proportion of cases,
to justify such a radical surgical procedure. Such a
major operation can be carried out in a patient suffer-
ing from serious heart disease, with an astonishingly
low operative mortality rate.

SUMMARY

1. Cardiac surgery, which was once feared, is now considered a worthy procedure, and is essential to the management of some patients.

2. Insufficiency can be produced by instruments, in labratory animals, with operative recovery.

3. Experimental mitral stenosis is possible, by Power's and Wilson's methods.

4. The sudden change from a stenosis to an insufficiency was disastrous in labratory animals.

5. Not all cases of mitral stenosis, with interauricular fistula, have lived to the age of life expectancy.

6. Cardiac valvular surgery has been tried in twelve human cases, with three operative recoveries.

7. The finger dilatation has been the most satisfactory method of surgical treatment.

8. The mortality rate for all cardiac valvular surgery was eighty-three percent.

9. Congestive heart failure patients usually improve with the removal of the thyroid gland.

10. Patients may live comfortably with a metabolic rate as low as a negative twenty.

11. Total abalation of the thyroid gland has three effects upon the physiology of the human body:

(1) Reduces the metabolic rate;

(2) Diminishes the effect of adrenalin;

(3) Deranges the function of the sympathetic system.

12. The mortality rates for total thyroidectomies are low, at six and nine-tenths percent.

13. Eighty percent of the congestive heart failure cases should improve.

14. Total thyroidectomies seem to improve cases of angina pectoris, more than congestive heart failure.

15. The interest in cardiac valvular surgery was manifested by the bulk of literature from 1900 to 1930, after which it diminished, as most of the attention was centered upon the effect of lowering the metabolic rate. This topic is the commoner subject of the present day literature regarding mitral stenosis. Whether this method will fade, to be supplanted by another, or a return to the original idea of Burton, remains to be seen.

BIBLIOGRAPHY

1. Allen, Duff S., Graham, Evarts A.,

   "Intra Cardiac Surgery--A New Method"

   J.A.M.A. 79:1028 (Sept) 1922

2. Allen, Duff S.,

   "Intra Cardiac Surgery"

   Arch. Surg. 8:317 (Jan) 1924

3. Allen, Duff S., Barker, Paul S.,

   "Surgery of the Mitral Valves"

   Am. Heart J. 1:693 1925

4. Beck, Claude S., Cutler, E. C.,

   "A Cardiovalvulotome"

   J. Exp. Med. 40:375 (May) 1924

5. Beck, C. S., Mautz, F. R.,

   "Control of the Heart Beat by the Surgeon;

   with Special Reference to Ventricular Fibrila-

   tion Occurring during Operation"

   Ann. Surg. 106:927 (Oct) 1937

6. Berlin, D. D., Blumgart, H. L.,

   "The Treatment of Chronic Intractable Heart

   Disease by Total Thyroidectomies"

   New York State J. Med. 34:1047 (Dec) 1934

7. Berlin, D. D.,

   "Total Thyroidectomy for Intractable Heart Disease"

   J.A.M.A. 105:1104 (Oct) 1935

8. Bernheim, B. M.,

    "Experimental Surgery of the Mitral Valves"

    Bulletin: John Hopkins Hospital 20:107 (April)

    1909.

9. Blumgart, J. L., Berlin, D. D., Davis, David

    Riseman, J. E. F., and Weinstein, A. A.,

    "Treatment of Angina Pectoris and Congestive Fail-

    ure by Ablation of the Thyroid in Patients without

    Thyrotoxicosis"

    Ann. Int. Med. 7:1469 (June) 1934

10. Boyd, Wm.,

    "Pathology of Internal Diseases"

    1935 Lea and Febiger Philadelphia, p.49.

11. Burton, Sir Lauder,

    Correspondence

    Lancet 1:352 1902

12. Burton, Sir Lauder,

    Correspondence

    Lancet 1:547 1902

13. Carrel, Alexis,

    "Experimental Surgery of the Thoracic Aorta and

    the Heart"

    Trans. Am. Surg. A. 28:243 1910

14. Carrel, Alexis,

    "Technique of Intra Thoracic Operations"

    Trans. Am. Surg. A. 32:451 1914

15. Carrel, Alexis,

    "Experimental Operations on the Orifice of the

    Heart"

    Trans. Am. Surg. A. 32:462 1914

16. Coryllas, P., Edwards, D. J., Bagg, H. J.,

    "Intracardiac Irradiation of the Valves from

    Radium Emanation, Employing a Two Stage Opera-

    tive Technique"

    Pro. Soc. Exp. Bio. Med. 21:151 1923.

17. Cushing, Harvey, Branch, J.R.B.,

    "Experimental and Clinical Notes on Chronic

    Valvular Lesions in the Dog and Their Possible

    Relationship to Future Surgery of the Cardiac

    Valves"

    J. Exp. Med. 17:471 1908.

18. Cutler, E. C., Levine, S. A.,

    "Cardiotomy and Valvulotomy for Mitral Stenosis"

    Boston Med. Surg. J. 188:1023 1923

19. Cutler, E. C., Levine, S. A., Beck, C. S.,

    "The Surgical Treatment of Mitral Stenosis"

    Arch. Surg. 9:689 (Nov) 1924

20. Cutler, E. C.,

    "The Surgical Aspect of Mitral Stenosis"

    Arch. Surg. 12:212 1926

21. Cutler, E.C., Beck, C. S.,

"The Present Status of the Surgical Procedures
in Chronic Valvular Diseases of the Heart"
Arch. Surg. 18:403 (Jan) 1929

22. Cutler, E. C.,
"Cardiac Surgery--Mitral Stenosis"
Maine Med. J. 23:156 (Aug) 1932

23. Da Costa, J. C., Jr.,
"Physical Diagnosis"
1932 W. B. Saunders Co. Philadelphia, p.451

24. Dinnerstein, M., Woodruff, I. O., Weeks, C.,
Tilley, A. R.,
"Total Thyroidectomy in Angina Pectoris and
Congestive Heart Failure"
Am. J. Surg. 36:421 (May) 1937

25. Dmitrieff, I. P.,
"Surgery of the Heart Valves"
J.A.M.A. 86:1737 1926

26. Drinker, C. K., Peabody, F. W., Blumgart, H. L.,
"The Effect of Pulmonary Congestion on the Venti-
lation of the Lung"
J. Exp. Med. 35:77 1922

27. Editorial,
"Mitral Stenosis"
Lancet 1:461 1902

28. Editorial

"Operative Treatment of Mitral Stenosis"

Brit. Med. J. (Sept) 1923 :530

29. Fisher, Theo.

Correspondence

Lancet 1:547 1902

30. Grant, R. T.,

"After Histories for Ten Years of a Thousand

Cases of Men Suffering of Heart Diseases"

Heart 16:275 (Sept) 1933

31. Holman, Emile,

"Congenital Intracardiac Fistula"

Arch. Int. Med. 36:516 1925

32. Holman, Emile, Beck, C. S.,

"The Physiological Response of the Circulatory

System to Experimental Alterations"

J. Exp. Med. 42:661 1925

33. Holmes, G. W.,

"Roentgen Interpretations"

1931 Lea and Febiger Philadelphia, p. 193

34. Lane, W. A.,

Correspondence

Lancet 1:547 1902

35. Levine, S. A., Cutler, E. C., Eppinger, E. C.,

"Thyroidectomy in the Treatment of Advanced Con-

gestive Heart Failure and Angina Pectoris"

New England J. Med. 209:667 (Oct) 1933.

36. Levine, S. A., Eppinger, E. C.,

    "Further Experiences with Total Thyroidectomies

    in the Treatment of Intractable Heart Diseases"

    Am. Heart J. 10:736 (Aug) 1935

37. Lockwood, A. L.,

    "Surgery of the Pericardium and Heart"

    Arch. Surg. 18:417 (Jan) 1929

38. Lourie, O. R.,

    "Is Total Thyroidectomy Rational as a Method of

    Treatment?"

    Can. M. A. J. 31:502 (Nov) 1934

39. MacCallum, W. G., McClure, R. D.,

    "Mechanical Effects of Experimental Mitral

    Stenosis and Insufficiency"

    Bulletin: John Hopkins Hospital 17:260 1906

40. Powers, John,

    "The Experimental Production of Mitral Stenosis"

    Arch. Surg. 18:1945 1929

41. Powers, John,

    "The Experimental Cardio-Valvular Disease in

    Dogs; and Subocute and Chronic Cardio-Valvular

    Disease in Man"

    Arch. Surg. 21:1 (July) 1930

42. Samway, D. W.,

    Correspondence

    Lancet 1:927 1898

43. Samway, D. W.,

    Correspondence

    <u>Lancet</u> 1:547 1902

44. Shipley, A. M.,

    "Operative Approach to the Heart and Pericardium"

    <u>Surg. Gyn. and Ob.</u> 54:280 (Feb) 1932

45. Souttar, H. S.,

    "The Surgical Treatment of Mitral Stenosis"

    <u>Brit. Med. J.</u> (Oct) 1925   :603

46. Tice, Frederick,

    "Practice of Medicine"

    W. F. Prior Co. Inc., Hagerston, Md., p.129

47. Tuffier, Theo., Carrel, Alexis,

    "Patching and Sectioning of the Pulmonary

     Orifice of the Heart"

    <u>J. Exp. Med.</u> 20:3 (May) 1914

48. Wilson, W. C.,

    "Studies in Experimental Mitral Obstruction

     in Relation to the Surgical Treatment of

     Mitral Stenosis"

    <u>Brit. J. Surg.</u> 18:259 1930