An Evaluation of the Transventricular Approach to the Aortic Valve *

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The trend in cardiovascular surgery today is toward direct vision repair of acquired valvular abnormalities. As it is now feasible to treat calcific aortic stenosis in adults by the open heart method, it was decided that a review of the results obtained by blind instrumentation of this valve would be of value at this time.

Fifty-nine patients have been treated by transventricular dilatation since 1953. All patients in this series were adults. Our purpose is to review the type of patient operated upon, the essential investigation required, and the risks and results of this particular method of surgery.

We were never tempted to change from the transventricular method originally described by Bailey to the transaortic route. Death during operation has not been a significant problem in spite of the poor myocardium often encountered.

We have been impressed by the many differences between patients with pure aortic stenosis and those who have combined aortic and mitral valve disease. These two groups of patients have been analysed separately. Forty-two patients were operated upon for pure aortic valvular stenosis and 15 for a combination of aortic stenosis and mitral valve disease. There were two with subvalvular stenosis.

Pure Aortic Stenosis

1. Selection of Cases. The patients ranged in age from 21 to 60 with an average age of 43 (Fig. 1). Thirty-nine were men and three were women. A history of rheumatic fever was obtained in 42 per cent.

In recent years it has become increasingly obvious that aortic stenosis is a lesion which has produced extremely serious effects on the myocardium before it makes itself evident to the patient. The physical signs of the disease are present long before the symptoms appear and even the slightest symptom must be considered as highly significant. Most of these patients were conscious of distressing symptoms for only a few months prior to operation, although a careful history usually indicated the presence of minor symptoms for periods up to four years.

The classical symptoms are fatigue, dyspnea on exertion, faintness of syncope, and angina. The symptoms of systemic congestion do not appear until a late stage in the disease. In this series dyspnea on exertion was the most common symptom, (81%), angina was present in two thirds (62%), and syncope in one half (45%). One quarter of the patients had progressed to the stage of systemic congestion at the time of operation. Hemoptysis and systemic emboli were not common (Fig. 2). As will be shown later, our classification of cases has been based mainly on symptoms.

On careful fluoroscopy by cardiologists, calcium was noted in the aortic valve in 94 per cent. The typical systolic murmur was present in every case and a systolic thrill was recorded in 69 per cent.

One half of the cases (48%) were re-

* Submitted for publication September 17, 1959.

ported to have a short high pitched diastolic murmur at the left sternal border. In none of these was significant aortic regurgitation thought to be present. Our criteria of significant aortic regurgitation has been the presence of the typical murmur associated with a pulse pressure of over 60 mm. Hg, or a diastolic pressure of under 50 mm. Hg. Recently we have assessed the amount of regurgitation by the reflux dye test.[2] Dye is injected at various levels in the aorta from the arch to the lumbar region and is recorded by an oximeter on the right ear. This test has given a reliable index of aortic regurgitation. All cases with significant insufficiency have been excluded from operation by the transventricular method.

2. Electrocardiograms. Electrocardiographic evidence of left ventricular hypertrophy was a most valuable adjunct to the diagnosis. This finding was present in 84 per cent of cases. Some degree of heart block is frequently found in aortic stenosis and is believed to be related to the heavy calcification in the valve ring interfering with impulse conduction. It was present in seven of the 42 cases. There were two cases of left bundle branch block, one case of right bundle branch block, and four cases of atrio-ventricular block. Of these four

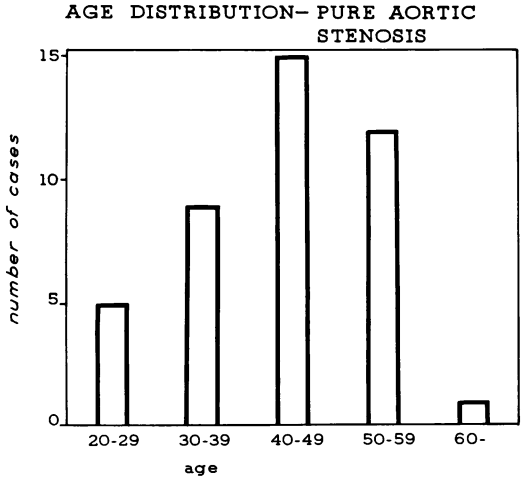

FIG. 1. The age distribution of 42 cases of pure aortic stenosis.

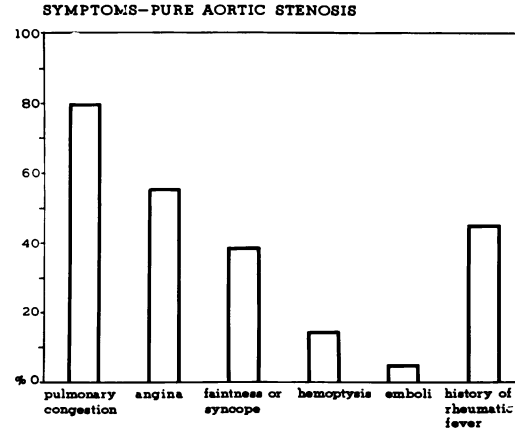

FIG. 2. The symptoms exhibited by 42 cases of pure aortic stenosis.

patients, three had first degree block and one had complete heart block.

Atrial fibrillation was an uncommon finding in pure aortic stenosis and was present in only one patient. Evidence of previous myocardial infarction was present in five patients.

3. Left Heart Catheterization. Left heart catheterization has not been performed routinely in all cases. Although trans-thoracic left heart catheterization has been used in this hospital on over 300 patients without mortality, it is now used only as an aid in assessing the severity of stenosis in those patients with mild symptoms and in ruling out the possibility of associated mitral valve involvement. This procedure was used in 24 of the 42 cases. The average gradient across the aortic valve was 82 mm. Hg with a range between 120 mm. Hg and 35 mm. Hg.

4. Brachial Artery Tracing. Brachial artery tracings are considered of some value and have been performed in 20 cases of pure aortic stenosis. They were found to be compatible with the diagnosis in 18 tracings. The significant features were a delayed upstroke of over 0.20 seconds, a deep anacrotic notch, and a lengthened systolic period.

5. Operation. The patients are placed on the operating table in the dorsal posi-

TABLE 1. *Classification of Cases with Pure Aortic Stenosis*

Group 1	No symptoms
Group 2	Dizziness, syncope, and/or angina (may have mild exertional dyspnea)
Group 3	Left heart failure
Group 4	Congestive failure

tion and the chest is entered through the left fifth interspace with an anterior incision. The pericardial fat is dissected off the pericardium and reflected with a broad pedicle base superior and medially. The pericardium is then opened widely with a medial extension through the pericardium at the base of the heart, so that insertion of the hand around the base of the aorta during transventricular dilatation does not unduly compress the heart.

Under the protection of a purse string suture, a very small stab wound is made near the apex to accommodate cannula for recording direct pressure measurements on withdrawal from aorta to ventricle. The incision is then enlarged and the dilator is inserted. The direction in which it should go is judged by the left thumb and forefinger which are placed around the aortic valve ring. The instrument can be palpated through the wall of the aorta distal to the valve and the correct degree of insertion assessed. It is usually opened at two levels so one can be sure that the sudden sensation of "giving way" of the fused valve cusps is not mimicked by the head of the valvulotome slipping out of the valve orifice. The anesthetist occludes the carotid arteries during this procedure.

After withdrawing the dilator, the stab wound is closed with two or three interrupted sutures and postoperative pressures are recorded by passing a recording cannula between the stitches into the left ventricle and aorta. After splitting the valve, there is often a progressive fall in the systolic gradient across the valve which may continue for one half hour or more. Thus the valve should not be re-entered immediately if the fall is not considered adequate. This progressive fall is not clearly understood and is probably the result of several factors.

We have observed the gray, streaky, fat-infiltrated appearance of the myocardium frequently described. The action of the heart is characteristically poor with what may be called "isometric contractions." The ease with which sutures tear out in advanced cases has caused the term "cheesy" to be applied to the myocardium.

It has been found unwise to attempt to resuture the fibrous pericardium in these cases. For that reason the previously prepared pericardial fat is drawn over the heart and sutured to the posterior cut edge of the fibrous pericardium. This acts as a slight restraint and is also considered as a means of possibly revascularizing the myocardium.

The intercostal nerves supplying the incision area are injected posteriorly with a long lasting anesthetic; the chest is closed with drainage.

The postoperative care is not as vigorous as that for mitral stenosis and the patients are not mobilized as quickly. Those with advanced myocardial involvement are started on anticoagulant therapy on the third postoperative day; they are maintained on it for a minimum of two weeks.

6. Classification of Cases. As yet, there is no standard classification of patients with aortic stenosis. As various studies of the natural life history of this disease have shown that death soon follows the development of myocardial failure, we have based our classification on this fact. Although syncope and angina are serious symptoms and suggest marked aortic stenosis, the prognosis for life is better than in those patients who exhibit left ventricular failure. The patients have been divided into four groups (Table 1).

Group I. This group consists of patients who exhibited signs of aortic stenosis but had no symptoms.

Group II. This group consists of patients with symptoms of dizziness, syncope or angina. They may or may not have had mild exertional shortness of breath. Cases exhibiting nocturnal dyspnea, orthopnea, or shortness of breath on minimal exertion were excluded.

Group III. These patients may or may not have the symptoms of dizziness, syncope or angina, but definitely exhibited signs and symptoms of pulmonary congestion. They had marked shortness of breath on exertion, orthopnea, nocturnal dyspnea, or frank pulmonary edema.

Group IV. This group consists of patients with any of the above symptoms plus the signs and symptoms of systemic congestion as evidenced by ascites, hepatomegaly, or peripheral edema.

Results of Operation

1. **Hospital Mortality.** The hospital mortality rate was found to vary greatly depending on the stage of the disease. (Table 2).

Group I. There was one case and no mortality.

Group II. There were 15 cases with a hospital mortality of 6.6 per cent.

Group III. There were 16 cases with a hospital mortality of 12.5 per cent.

Group IV. There were ten cases with a hospital mortality of 40 per cent.

The over-all mortality rate was 16.7 per cent. Only one patient died on the operating table (the first case operated upon).

2. **Cause of Hospital Death.** Of the seven deaths, one occurred during the surgical procedure. Four patients died suddenly during the postoperative period, presumably from cardiac arrest; in only one of these was a calcium embolus found in a coronary artery. Two patients died of congestive failure.

TABLE 2. *Hospital Mortality of 42 Cases with Pure Aortic Stenosis Operated on by the Transventricular Method*

Over all mortality	16.7%
Group 1	0%
Group 2	7%
Group 3	13%
Group 4	40%

The cause of death was thus varied and sometimes not known. A postmortem examination was obtained in six of the seven cases. The coronary arteries were free from atheroma in all but one. One patient had a bicuspid valve and associated coarctation of the aorta.

The weights of the hearts with pure aortic stenosis varied from 590 to 860 Gm., with an average weight of 680 Gm.

3. **Complications.** There has not been a significant incidence of operative hemorrhage. Only three instances of ventricular fibrillation occurred during operation, and two of these recovered permanently. Postoperative complications have been rare. Two patients developed mild intermittent claudication on walking, suggesting peripheral embolization. One patient was hemiplegic postoperatively, presumably due to a cerebral calcium embolus and has since recovered almost completely. One patient returned to hospital several months later complaining of a persistent draining sinus; a silk suture from the wall of the ventricle was removed without incident. It has been a distinct impression that the "postcommissurotomy" or "reactivation" syndrome has not been as frequent following this type of operation as in that for mitral stenosis.

An important problem facing the surgeon in aortic stenosis is the postoperative incidence of aortic regurgitation. In this series of 42 cases we believe that significant aortic regurgitation was produced in two. Considering the nature of these heavily calcified valves, this complication would ap-

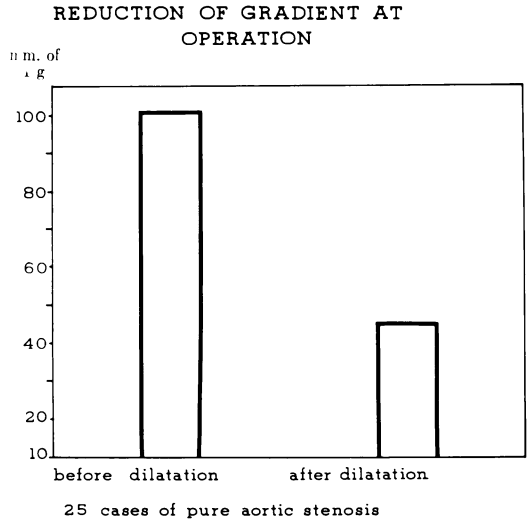

FIG. 3. Reduction of systolic gradient across the aortic valve in 25 cases with pure aortic stenosis—both gradients measured at time of operation.

pear to be almost unavoidable with this or any other method.

We believe that the Donaldson dilator can reduce the incidence of this mishap by being lightly screwed on its shaft, so that it can rotate and allow the fins to enter the proper commissures. The bi-bladed valvulotome, suggested by Glover, has not been used. We are currently operating on aortic stenosis in patients under the age of 40 (which we consider to be usually congenital in nature) by the open heart technic. One reason for this is the significant incidence of bi-cuspid valves. There is danger in blindly opening a bi-cuspid valve with a tri-finned or even a double bladed dilator, because of the increased possibility of producing regurgitation.

4. Reduction of Gradient. In 25 patients the systolic pressure gradient across the aortic valve was measured during the operation both before and after the valve was opened. The average value before the split was 101 mm. Hg. The average value on the last measurement before the chest was closed was 45 mm. Hg (Fig. 3). The surgeon must remember that the gradient may fall for some time after the valve has been opened. The valve should not be re-entered immediately if the fall is not considered adequate. In several of the poor risk patients we did not wait for this gradual fall to occur but took an immediate pressure and if this was satisfactory, the chest was closed.

5. Follow Up. Thirty-five patients have left the hospital and have been followed six months to six years. Twenty-one patients were considered to be markedly improved, ten moderately improved, and four unimproved (Fig. 4). Twenty-eight of these patients (80 per cent) are still alive and all are moderately or markedly improved. This is a surprising long term survival rate, considering the gross distortion and calcification of this valve.

In Group I there was only one patient; he is alive and well.

In Group II, of 14 who left hospital there were two late deaths. Seven of the twelve presently alive are markedly improved and five moderately improved.

In Group III, of the 14 who left hospital there have been two late deaths. Of the 12 presently alive, there are 11 with marked improvement and one with moderate improvement.

In Group IV, of the six who left hospital, there have been three late deaths. Of the three patients presently alive, two are

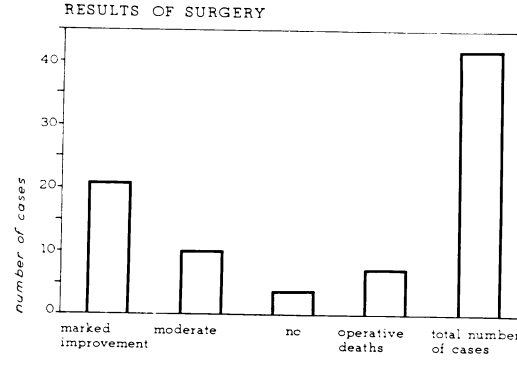

FIG. 4. The results of surgery in 42 cases of pure aortic stenosis.

markedly improved, and one moderately improved.

The four patients who were not improved by the operation have died since leaving hospital. The other three late deaths are all from the group which was moderately improved.

Combined Mitral and Aortic Stenosis

It has been mentioned that patients with combined mitral and aortic stenosis are different in many respects from those with pure aortic stenosis. Our group of 15 patients were mostly women and over 80 per cent had a history of rheumatic fever. The main complaint was usually exertional dyspnea, very few had angina, and none had symptoms of cerebral ischaemia. Hemoptysis and emboli were much more frequent in this group (Fig. 5).

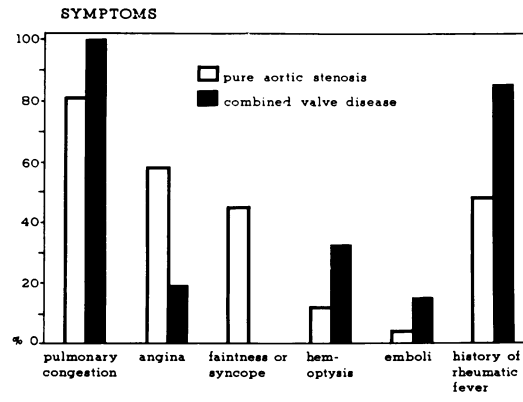

FIG. 5. Comparison of symptoms exhibited by patients with pure aortic stenosis and with aortic stenosis plus mitral stenosis.

Calcium was less often visible in the aortic valve (50%) and left ventricular hypertrophy less often noted in the electrocardiogram (64%). There was a high percentage of auricular fibrillation (66%).

These patients were operated upon through the left anterior fifth space incision described above. At operation the myocardium usually appeared to be of much better quality. The valve most seriously involved was opened first. If the mitral valve did not split readily on the first attempt of finger dilatation, a Dubost dilator was passed through the ventriculotomy and was guided into place by the right index finger which was within the left atrium. The hospital mortality in this group of 15 cases was 13.3 per cent. There have been two late deaths.

Discussion

1. Operative Technic. The series is unique in that all patients were adults. Likoff reports a four-fold increase in mortality in those cases over 40 years of age.[5] Our average age was 42. The experience of some authors,[3, 4] of extremely high mortality rates with the transventricular route has not been borne out by our series. Harken reports that he stopped using the transventricular method after 23 cases, in which ten hospital deaths occurred and ten subsequent deaths.[4] The mortality with the transventricular route in our series is similar to that reported in recent articles describing the use of the transaortic route (Harken—17% mortality rate, pure aortic stenosis [4]).

As in many other fields of surgery the best technic is very often one with which the surgeon has had the most experience. That may be so in these two blind technics. There are post operative complications from the aortotomy in the transaortic approach and the surgeon frequently ends up with a blunt dilatation of the orifice despite his ability to feel the valve. It is also very difficult even with palpation to distinguish a bicuspid from a tricuspid valve.

2. Open Heart Technic of Aortic Valvoplasty. We feel that pure hypothermia does not allow adequate time for a proper and careful plastic procedure upon the aortic valve. It is possible that in a series such as Dye [3] reported the valve dissection would not only be hurried but it may produce a higher incidence of aortic insufficiency than by the blind transventricular method.

Our cardiovascular division currently

operate upon most cases of aortic stenosis with cardiac bypass. We felt initially that only those with minimal calcification under 45 years of age should be accepted. The high incidence of fibrous subvalvular stenosis and bicuspid valves in the younger group were a clear indication for bypass surgery. However, with coronary perfusion allowing a longer time for dissection, removal of calcium and mobilization of cusps; and with leaflet or valve replacement possible when one encounters advanced calcification, our indications for bypass have been extended to most cases of aortic stenosis under the age of 60. There will always be the patient whose myocardial disease will prevent him from enjoying the benefits of radical aortic valve surgery, or one where massive calcification has extended into the aortic wall. For the time being they might be improved by a simple blind dilatation.

There have been five cases of aortic stenosis, aged 15 to 40, operated upon with a modified Cooley oxygenator, Pempco pump and 30° C. hypothermia. Four of these patients survived and are satisfactorily improved.* There was one further aortotomy for undiagnosed ventricular myocardial disease.

Although a recent report [1] has demonstrated the correction which may be produced by a careful direct vision procedure, the end results of the most careful surgical valvoplasty may be unsatisfactory. Cusp or valve replacement is required for the heavily calcified valves. Perhaps while we are developing, with enthusiasm new and better direct vision technics and until valve replacement has proven itself, it may be well to keep in mind the acceptable mortality rate and surprisingly good results obtained by the closed methods.

* To date and with the recent aid of coronary perfusion 14 adults have been operated upon with 2 deaths and satisfactory results.

Conclusion

This is a report of a six months to six years follow up of 42 cases of pure aortic stenosis in adults treated by transventricular dilatation. The mortality rate is lower and the long term follow up results better than one would expect in such a valve lesion. The cases with pure aortic stenosis are compared with 15 cases of combined aortic and mitral stenosis.

Like many surgical centres our unit is extending the indications for cardiac bypass surgery in aortic stenosis. The benefits of this inevitable progress in surgical therapy will be better assessed with full knowledge of the results which can be obtained by a simpler technic.

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