Successful Surgical Repair of a Ruptured Aneurysm of the Sinus of Valsalva

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A patient is described in whom an aneurysm of the right coronary sinus of Valsalva ruptured into the right atrium. A new method of surgical closure is presented along with pertinent physiologic data obtained before and after operation.

AN EXPERIMENTAL method for the surgical repair of ruptured sinus of Valsalva aneurysm has previously been described. In these experiments, acute cardio-aortic fistulas were produced in dogs and subsequently closed by means of a plastic prosthesis introduced through the aorta during a brief period of occlusion of inflow. We have recently had the opportunity to perform this operation in a patient in whom an aneurysm of the right coronary sinus had ruptured into the right atrium.

CASE REPORT

N. H., a 27-year-old soldier, was first admitted to the National Heart Institute in March 1956. His past health had been excellent and several physical examinations prior to his illness had revealed no evidence of heart disease. While sitting at his desk on January 9, 1956, the patient noted the sudden onset of chest pain, shortness of breath, and epigastric discomfort. These symptoms persisted and he was admitted to an Army Hospital, where his acute symptoms subsided following administration of digitalis and sodium restriction. The patient was subsequently referred to the Walter Reed Army Hospital. Physical examination at that time revealed bounding peripheral pulses and a blood pressure of 130/0 mm. Hg. Systolic and diastolic thrills were palpable along the left sternal border. A loud continuous murmur was heard over the precordium. There were also right pleural effusion, hepatomegaly, and pretibial edema. A right heart catheterization revealed a left-to-right shunt at the level of the right atrium. With these findings a diagnosis of ruptured aneurysm of the sinus of Valsalva was made and the patient was transferred to the National Heart Institute for study.

On March 6, 1956, a no. 9 Lehman catheter was passed from the right ulnar artery into the ascending aorta and its tip was positioned just above the aortic valve. Simultaneous pressures were recorded from this catheter and a Courmand needle in the femoral artery (fig. 1). The pressure pulses were similar to those seen in moderately severe aortic insufficiency. The catheter was then passed from the aorta into the right atrium, establishing the presence of an aortic-right atrial communication. Following this, the catheter was again positioned above the valve and 60 ml. of 70 per cent acetrizoate (Urokon) were injected as biplane x-rays were made at the rate of 4 per second. These films demonstrated dilatation of the right coronary sinus of Valsalva from the base of which dye passed into the right atrium (fig. 2).

Following aortography the patient returned to Walter Reed Army Hospital, where he was maintained on digitalis, sodium restriction, and mercurial diuretics. In spite of these measures, evidence of right heart failure persisted.

He returned to the National Heart Institute on July 4, 1956. At that time he was emaciated and orthopneic, with bounding pulses and a blood pressure of 120/50-0. There were moist rales at the left base and dullness at the right base. The apical impulse was diffuse, and cardiac dullness extended to the left anterior axillary line. There was a regular rhythm. Systolic and diastolic thrills were palpable along the left sternal border. A loud continuous murmur was heard over the entire precordium, with maximum intensity in the fourth left intercostal space. The liver was enlarged and tender, and there was demonstrable ascites. Moderate pretibial edema was present. Upon admission to the hospital, the patient was given 0.5 mg. of digoxin daily and his diet was restricted to 200 mg. of sodium. He lost 8 Kg. during the ensuing 4 weeks. This was accomplished by means of a thoracentesis, paracentesis, and a course of acetazolamide (Diamox) followed by ammonium chloride and mercurhydren.

The hematocrit value was 46 mm. and the white cell count was 8,000. The blood urea nitrogen was 17 mg. per cent and the total protein was 6.7 mg.
SURGICAL REPAIR OF RUPTURED ANEURYSM OF SINUS OF VALSALVA

Fig. 1. Preoperative and postoperative central aortic and femoral artery pulse tracings. The femoral/central pulse pressure ratio was 1.7 preoperatively and 1.0 postoperatively.

Fig. 2. Thoracic aortogram 1 second after the injection of 60 ml. of 70 per cent Urokon. The right coronary sinus is deformed and a jet of dye is seen entering the right atrium near the tricuspid valve.

Fig. 3. Preoperative and postoperative electrocardiograms.

per cent, with an albumin of 2.9 mg. and a globulin of 3.8 mg. per cent. Urinalysis was normal. The electrocardiogram showed a normal sinus rhythm and a vertical electric position with a prolonged P-R interval (fig. 3). Films and fluoroscopic examination of the chest showed marked cardiac enlargement both to the right and left with active aortic pulsations. There were bilateral pulmonary congestion and pleural effusion extending to the level of the fourth right interspace anteriorly (fig. 4). The phonocardiogram revealed a clear first sound that was followed by a crescendo systolic murmur enveloping the second heart sound. The second sound was followed immediately by a diastolic murmur that gradually decreased in intensity throughout diastole (fig. 5). Cardiac catheterization revealed moderate pulmonary hypertension and marked elevation of the right atrial pressure. A nitrous oxide test performed in the right atrium revealed a Calloway index of 0.6, indicating the presence of a large left-to-right shunt at this level. This shunt was calculated to be 7.7 L. per minute (table 1).

Operation was performed on August 1, 1956. Following induction of Pentothal and nitrous oxide anesthesia, the patient was immersed in a bath of ice and water until the esophageal temperature fell to 33 C. With the patient in a supine position, a median sternotomy was made and combined with an incision through the right fourth intercostal space (fig. 6). The pericardium was opened anterior to the phrenic nerve. On opening the pericardium, the right atrium was found to be markedly enlarged...
and a continuous thrill was easily palpable over its surface. Upon reflection of the right atrial appendage, the right coronary sinus was found to be enlarged and the wall of the aorta appeared to be thinner than normal. Temporary traction ligatures were then placed around the superior and inferior venae cavae. Digital exploration of the right atrium revealed a grossly enlarged chamber and a normal tricuspid valve. A thin-walled balloon-like structure, approximately 3 cm in diameter, projected into the atrium just above the septal leaflet of the tricuspid valve. A continuous jet of blood was palpable from a 4 to 5 mm. opening in the tip of this aneurysm. Digital occlusion of this opening resulted in a pronounced rise in the patient’s diastolic blood pressure and a marked slowing of the heart rate. The adventitia of the ascending aorta was then excised and a mattress suture was placed in the anterolateral wall of the aorta approximately 3.5 cm. above the aortic valve. A malleable probe was introduced into the aorta through a stab wound within this mattress suture and with the finger again in the

**TABLE 1.** — Preoperative Right Heart Catheterization

<table>
<thead>
<tr>
<th>Samples location</th>
<th>Pressures mm. Hg.</th>
<th>O₂ content vol. %</th>
<th>Body surface area—1.65 M²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Syst./diast. Mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVC</td>
<td>27/15</td>
<td>8.1</td>
<td>Nitrous oxide test</td>
</tr>
<tr>
<td>RA—low</td>
<td>12.8</td>
<td>13.4</td>
<td>Location</td>
</tr>
<tr>
<td>RA—mid</td>
<td>13.4</td>
<td>13.7</td>
<td>Blank Sample</td>
</tr>
<tr>
<td>RA—high</td>
<td>14.0</td>
<td>14.0</td>
<td>O₂</td>
</tr>
<tr>
<td>RV—inflow</td>
<td>63/29</td>
<td>13.9</td>
<td>SVC</td>
</tr>
<tr>
<td>RV—mid</td>
<td>16.2</td>
<td>16.2</td>
<td>RA—SVC</td>
</tr>
<tr>
<td>RV—outflow</td>
<td>13.8</td>
<td>16.0</td>
<td>FA—SVC</td>
</tr>
<tr>
<td>PA I</td>
<td>13.4</td>
<td>16.9</td>
<td>Nitrous index:</td>
</tr>
<tr>
<td>PA II</td>
<td>1.51</td>
<td>13.7</td>
<td>RA—SVC</td>
</tr>
<tr>
<td>FA I</td>
<td>1.58</td>
<td>16.2</td>
<td>FA—SVC</td>
</tr>
<tr>
<td>FA II</td>
<td>1.20</td>
<td>16.0</td>
<td>Pulmonary flow—10.7 L/min.*</td>
</tr>
<tr>
<td>Capacity FA</td>
<td>1.53</td>
<td>15.7</td>
<td>Systemic flow—3.0 L/min.*</td>
</tr>
<tr>
<td></td>
<td>1.53</td>
<td>8.5</td>
<td>L-R shunt—7.7 L/min.</td>
</tr>
</tbody>
</table>

**Ventilation** L/min/M² | **O₂ Consumption** ml/min/M² | **R.Q.** | **Pul. flow** L/min/M² | **% Sat.**
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Rest I</td>
<td>4.62</td>
<td>130</td>
<td>.78</td>
<td>6.54</td>
</tr>
<tr>
<td>Rest II</td>
<td>4.62</td>
<td>162</td>
<td>.85</td>
<td>7.4</td>
</tr>
</tbody>
</table>

* Average of 2 determinations.
A malleable probe was introduced through a stab wound in the aorta and advanced through the fistula and subsequently through the right atrial wall. A ligature was then drawn through the fistula and out of the aorta.

Right atrium as a guide, it was passed through the fistulous tract and out into the right atrium. The tip of the probe was subsequently advanced through the right atrial wall and a ligature of heavy silk threaded into the eye of the probe (fig. 6). The probe was then withdrawn from the aortic incision and the mattress suture tied down to control hemorrhage from the small aortic incision. The ligature thus passed into the aorta, through the fistulous tract and out through the wall of the right atrium. A number of compressed polyvinyl prostheses had previously been prepared and sterilized by boiling. One of these with a head of 2.5 cm. and a shaft of 9 mm. in diameter was selected. The tail of this prosthesis was sutured to the end of the ligature emerging from the aorta (fig. 7). Incisions were then made in the aorta and right atrium following the application of partially occluding clamps.

The superior and inferior venae cavae were occluded and after a period of 1 minute, the clamps were removed from the aortic and right atrial incisions. Traction was made on the atrial end of the ligature and the prosthesis was drawn into the ascending aorta. The head of the prosthesis was guided into place behind the right coronary leaflet by means of a finger introduced through the aortic incision (figs. 8 and 9). The partially occluding clamp was then reapplied to the aortic incision and

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attention directed to the right atrium. The proximal portion of the prosthesis tightly occluded the fistulous tract while the remainder of the shaft projected into the atrial chamber. The thin wall of the aneurysm everted itself upon the shaft of the prosthesis. A purse-string suture was then placed around the base of the prosthesis securing it to the right atrial wall. The remainder of the shaft was cut off distal to this suture. The atrial clamp was then reapplied and circulation was re-established. The total period of caval occlusion was 4 minutes. During occlusion the patient’s esophageal temperature was 27° C. The aortic and atrial incisions were closed with continuous over-and-over sutures. Following decortication of the right lower lobe, drainage tubes were placed in the right pleural space and the chest was closed.

The patient’s course after operation was uneventful. The pulse rate ranged between 40 and 50 per minute for 3 days postoperatively and then gradually increased to normal. The murmur was no longer present and the diastolic blood pressure was 70 mm. Hg. He was discharged on August 31, 1956, entirely free of symptoms.

The patient returned for postoperative studies in October 1956. He continued to be asymptomatic and had gained 8 Kg. The electrocardiogram (fig. 3) and roentgenogram (fig. 4) confirmed the clinical improvement. Right heart catheterization revealed normal pressures and no evidence of a left-to-right shunt (table 2). Measurements of central and peripheral arterial pressures were now normal (fig. 1).

**DISCUSSION**

The sudden onset of heart failure in a previously well individual should suggest the diagnosis of ruptured aneurysm of the sinus of Valsalva. As illustrated in the case presented, the most definitive diagnostic study is thoracic aortography. Right heart catheterization affords an estimate of the magnitude of the shunt and the degree of cardiac disability.

This patient presented an unusual opportunity for the correlation of central and peripheral arterial pressures with a measurable degree of aortic regurgitation. Preoperatively the ratio of femoral-to-central aortic pulse pressure was 1.73—a value seen in moderately severe aortic insufficiency. From the calculation of systemic and pulmonary flows this abnormally high femoral-to-central ratio represents the regurgitation of 7.7 L. per minute with an effective forward systemic flow of only 3.0 L. per minute. It is realized, of course, that in this instance regurgitant flow occurred throughout the cardiac cycle as contrasted to true aortic insufficiency where regurgitation occurs only in diastole. The ratio of femoral-to-central pulse pressure was 1.0 postoperatively, a value within the normal range.
By the application of hydraulic formulas, the diameter of the fistula was calculated to be 6.8 mm. Although at operation it was difficult accurately to assess the diameter of the opening in the aneurysm, the derived figure was considered to be a close approximation. This assessment was further confirmed by the fact that the shaft of the prosthesis was 9 mm. in diameter and wedged itself tightly into the tract.

Edwards and Burchell have recently emphasized that the essential pathologic lesion of aneurysms of a sinus of Valsalva is a lack of continuity between the aortic media and the aortic ring. The method of closure described above would seem to satisfy the criteria suggested by these authors: “...it is obvious that for repair of the aneurysm the defect between the aortic media and the aortic valve ring must be bridged either directly or, more reasonably, indirectly by a prosthetic body.” Lillehei and Bahnson have recently successfully closed cardiac-aortic fistulas by sutures placed via the right heart during total cardiac by-pass. The technic employed in this patient would seem preferable, since the aortic defect is closed without tension and the aneurysm and fistulous tract are oblitered.

In retrospect, certain modifications in the operative technic would seem desirable. The combined median sternotomy and right thoracotomy did not provide ideal exposure of the ascending aorta. A bilateral anterior thoracotomy would be preferable. When the venae cavae were occluded, the heart did not empty well, since large volumes of blood were constantly returned to the right heart through the fistula. The fistula should have been closed digitally before the cavae were occluded. This would have prevented unnecessary blood loss when the atrium was opened. Although hypothermia afforded adequate time for the insertion and fixation of the prosthesis, the procedure could probably be performed more deliberately with extracorporeal circulation aided by either elective cardiac arrest or retroperfusion of the coronary sinus.

**Summary**

A patient is described in whom an aneurysm of the right coronary sinus of Valsalva had ruptured into the right atrium. The diagnosis was established by thoracic aortography and right heart catheterization. The cardio-aortic fistula was successfully closed by a plastic sponge prosthesis introduced via the aorta during a brief period of occlusion of inflow. Hemodynamic observations before and after operation are described.

**Summario in Interlingua**

Es describite un patiente in qui un aneurysmo del sinus dextero-coronari de Valsalva se habeva rupturate a in le atrio dextere. Le diagnose esseva establit per aortographia thoracica e catheterisation dextero-cardiac. Le fistula cardio-aortic esseva claudite a bon successo per medio de un prosthese consistente de un spongia de plastico introdusite via le aorta durante un breve periodo de occlusion del influso. Observationes hemodynamic ante e post le operation es describite.

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