Reoperation for ascending aorta false aneurysm using deep hypothermia and circulatory arrest

Bachar El Oumeiri\textsuperscript{a,*}, Yves Louagie\textsuperscript{b}, Michel Buchea\textsuperscript{b}

\textsuperscript{a}Department of Cardiac Surgery, ULB Hospital Universitaire Erasme, Brussels, Belgium
\textsuperscript{b}Department of Cardio-Vascular and Thoracic Surgery, Cliniques Universitaires UCL de Mont-Godinne (Université Catholique de Louvain), Yvoir, Belgium

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Abstract

Objectives: Ascending aorta false aneurysms after cardiac surgery are uncommon. Resternotomy is hazardous and may result in massive and uncontrollable hemorrhage if the false aneurysm is entered. Here we report our experience with the use of deep hypothermia and circulatory arrest to avoid this risk. Methods: From March 2000 to December 2007, seven patients (mean age 50 years) were reoperated for an ascending aorta false aneurysm. Three patients had undergone an aortic valve replacement \((n=2)\) or an aortic valve repair \((n=1)\). Three had undergone an ascending aorta replacement with a valved conduit \((n=2)\) or an aortic valve repair \((n=1)\) for type A dissection. One had undergone a coronary artery bypass grafting. Mean delay to reoperation was 133 months (range 22–324 months). Two patients had positive blood cultures (\textit{Staphylococcus} species). Cardiopulmonary bypass was established by extramediastinal access. Patients were cooled to 18 °C. Results: Resternotomy was performed uneventfully under total circulatory arrest in all patients. Four patients underwent an ascending aorta replacement with a valved conduit \((n=2)\) or a dacron conduit \((n=2)\) associated with a mitral valve replacement in one patient. Direct suture was performed in two patients and in one patient the aorta was repaired using a saphenous vein patch. There was one hospital death. Mean follow-up was 53 months (range 14–90 months). Conclusion: Resternotomy under circulatory arrest and deep hypothermia is a safe technique well-adapted to patients with an ascending aorta false aneurysm.

Keywords: Aorta; False aneurysm; Dissection; Hypothermic circulatory arrest

1. Introduction

Aortic false aneurysm (FAA) can be secondary to trauma [1], infection [2] or previous cardiac surgery [3]. The last etiology is the most frequent cause [3]. False aneurysms occur in <0.5% of all cardiac surgical cases [4]. Without an operation, false aneurysms progressively expand, compress and erode the surrounding structures, or are a source of persistent infection and systemic embolism.

Despite advances in endovascular techniques, treatment remains surgical in the majority of cases. The procedure represents a surgical challenge and authors report a high-operative mortality rate ranging from 29% to 46% [3]. Mortality is frequently a consequence of fatal hemorrhage or cerebral air embolism during sternal re-entry.

In this report, we describe our surgical approach and results of repair of FAA in patients who had previous cardiac surgery.

2. Materials and methods

2.1. Patients

From March 2000 to December 2007, seven patients were reoperated on at our institution Mont-Godinne hospital for ascending aorta false aneurysm. The patients had previously undergone a total of eight cardiac procedures. Eight of the initial operations were performed at other centers and one was performed at our institution. During the same time interval, 3785 patients underwent a cardiac procedure at our institution, thus the local incidence of false aneurysm was 0.03%. The mean age was 50±9 years (43–68 years), and included five males and two females. The time interval between redo surgery and prior operation was 133±96 months (22–324 months). The FAA was caused by previous surgery in all cases.

All patients data have been reviewed retrospectively. No FAA had ruptured before operation. One patient was asymptomatic; the FAA was discovered on routine follow-up. The preoperative symptoms were dyspnea \((n=1)\), chest pain \((n=2)\) and fever \((n=2)\). The signs were heart failure \((n=1)\), superior vena cava syndrome \((n=1)\), cutaneous lesions due to septic emboli \((n=1)\), and transient ischemic attack \((n=1)\).

Two patients had a mycotic false aneurysm the causative organism being \textit{Staphylococcus aureus} in one patient and \textit{Staphylococcus epidemidis} in the other. Both patients had a history of native valve endocarditis and mediastinitis.

The diagnosis of FAA was confirmed by various imaging techniques including angiography, transesophageal echocardiography, computed tomographic (CT)-scan or CT-angio-
The surgical history of patients FAA site and the method of surgical repair are described in Table 2. In all the patients, the FAA eroded the back side of the sternum (Fig. 1).

2.3. Follow-up

All surviving patients underwent transthoracic echocardiography before discharge. Mean clinical follow-up was 53±28 months (range 14–90 months) and was 100% complete. Survival and functional status were obtained by telephone contact with the patients, their relatives, or the referring physician and from review of hospital records.

3. Results

3.1. In hospital events

The sternal re-entry was safe in all the patients without massive hemorrhage despite the fact the FAA was entered directly in five patients. No cardiac injuries were documented. There was one operative death (14.2%). The patient had Marfan syndrome with a critical preoperative state: he was intubated, ventilated for superior vena cava syndrome with a FAA reaching a 60-mm diameter and coagulation disorders [international ratio (INR) >4]. He underwent an emergency operation. His first operation was a repair of aortic dissection type A by Bentall procedure. At the second procedure, we discovered multiple false aneurysm sites: proximal anastomosis, distal anastomosis and coronary button anastomosis. Despite multiple attempts to repair we could not achieve the hemostasis due to tissue fragility. Overall postoperative complications included cerebrovascular accident (n=1), reoperation for bleeding (n=1), need for intra-aortic balloon pump for CPB weaning (n=1), renal failure requiring dialysis (n=1), sepsisemia (n=1), need for pacemaker implantation (n=1) and forearm fasciotomy for compartment syndrome (n=1).

The mean intensive care unit stay was 6.6±6.7 days, and the mean hospital stay was 26±25 days.

3.2. Late events

Two patients died during follow-up. The first patient was in excellent condition but was killed 14 months postoperatively. The second patient died suddenly 72 months later.

Table 1. Preoperative characteristics of patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Number (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (years)</td>
<td>50±9</td>
</tr>
<tr>
<td>Hypertension</td>
<td>4</td>
</tr>
<tr>
<td>Mean EF (%)</td>
<td>64.5±7.6</td>
</tr>
<tr>
<td>NYHA III/IV</td>
<td>2</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>3</td>
</tr>
<tr>
<td>Renal failure (creatinine level &gt; 2 mEq/100 ml)</td>
<td>1</td>
</tr>
<tr>
<td>COPD</td>
<td>1</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>1</td>
</tr>
<tr>
<td>Smoking history</td>
<td>1</td>
</tr>
<tr>
<td>False aneurysm diameter &gt; 55 mm</td>
<td>5</td>
</tr>
</tbody>
</table>

EF, ejection fraction; NYHA, New York Heart Association functional class; COPD, chronic obstructive pulmonary disease.

The concept of resternotomy under deep hypothermia and circulatory arrest has been described previously [4–6]. After institution of full flow cardiopulmonary bypass (CPB) through the femoral vessels or the combination of subclavian artery and femoral veins, the rectal temperature is lowered to 18°C. As soon as this level of temperature is obtained, resternotomy is performed under circulatory arrest. Even in the case of the direct entry of the false aneurysm there is no danger of massive haemorrhage or cerebral air embolism.

Depending on the location of the false aneurysm, the repair of the aortic lesion can be performed under circulatory arrest or after cross-clamping of the distal ascending aorta and resuming of CPB. There was no case of left ventricle distention requiring apical venting. Femoral artery and vein cannulation were performed in five patients, subclavian artery, femoral vein and artery in one patient, and subclavian artery and femoral vein in another patient. Mitral valve replacement was performed in one patient. The mean CPB time and circulatory arrest time were 333±103 and 29±48 min, respectively.

Table 2. Surgical features

<table>
<thead>
<tr>
<th>Patient</th>
<th>Surgery 1</th>
<th>Surgery 2</th>
<th>Infection</th>
<th>False aneurysm site</th>
<th>Surgical repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type A dissection</td>
<td></td>
<td>No</td>
<td>Distal suture line</td>
<td>Tube graft</td>
</tr>
<tr>
<td>2</td>
<td>Aortic valve</td>
<td></td>
<td>No</td>
<td>Aortotomy suture line</td>
<td>Valved conduit</td>
</tr>
<tr>
<td>3</td>
<td>Comissurotomy</td>
<td></td>
<td>No</td>
<td>Aortotomy suture line</td>
<td>Tube graft</td>
</tr>
<tr>
<td>4</td>
<td>Aortic valve</td>
<td></td>
<td>No</td>
<td>Aortotomy suture line</td>
<td>Primary closure</td>
</tr>
<tr>
<td>5</td>
<td>Replacement</td>
<td></td>
<td>S. aureus</td>
<td>Cardioplegia needle</td>
<td>Patch repair +</td>
</tr>
<tr>
<td>6</td>
<td>Type A dissection</td>
<td>Tube graft replacement +</td>
<td>S. epidermidis</td>
<td>Proximal suture line</td>
<td>Valved conduit +</td>
</tr>
<tr>
<td>7</td>
<td>Repair</td>
<td>mitral valve repair</td>
<td>No</td>
<td>Distal and proximal</td>
<td>Primary closure</td>
</tr>
</tbody>
</table>

CABG, coronary artery bypass grafting.
Several authors proposed variants using heart port-access technology (Cardiovations, Ethicon/J&J, Somerville, NJ, USA) avoiding long circulatory arrest and profound hypothermia. The right axillary artery was cannulated and an endoclamp (Cardiovations) balloon was inflated into the ascending aorta [12], or at the level of the disrupted aortic anastomosis [13]. However, these techniques are associated with specific risks: the endoclamp can migrate and occlude the innominate artery, tear or disrupt the fragile aorta, and the oscillating saw may deflate the balloon at stenotomy. Endovascular therapy for FAA after surgery were reported [14] new endovascular endeavors must be considered in the context of conventional treatment options, hybrid procedures, and novel branched devices. Patient factors, such as specific anatomical issues. The endovascular method requires suitable ‘landing zones’ 2 cm of normal aortic wall for endovascular stent graft fixation, comorbid diseases, and functional levels must play an important role in the determination of therapeutic options. Endovascular treatment by coils injection is limited to small and non-infected false aneurysm.

About 20% of all false aneurysm patients presented with symptoms related to sepsis [7].

Two of our patients had an infectious etiology. Staphylococcus was the only bacteria species found at the time of the operation. It is considered as the most prevalent causative agent [5, 8]. Infection was caused either by direct extension of mediastinitis to the ascending aorta or by hematogenous spread. False aneurysm repair in infected patients was performed using two techniques: tube graft in one (aortic homograft was not available) and saphenous vein patch repair combined with omentoplasty in the other. In the presence of infected grafts, viable omentum and muscle flaps can be used [15]. Though, it is generally accepted that infection is associated with recurrence, we had no recurrence at follow-up.

In conclusion, despite the complexity and the major surgical risk, repair of false aneurysm is possible with acceptable results. Extramediastinal cannulation, deep hypothermia and circulatory arrest at resternotomy are recommended, especially in patients at risk of massive hemorrhage during sternal re-entry.

The other survivors were in the New York Heart Association function class (NYHA) I (n = 3) and NYHA II (n = 1) NYHA functional class. One patient suffers from mild neurological sequelae. There was no recurrence of FAA or infection.

4. Comments

Aortic false aneurysms are rare complications of surgical manipulation of the aorta occurring in <0.5% of cardiac surgical cases [4].

Mechanisms implicated include infection, poor anatomistic technique, and intrinsic aortic wall disease. The keystone of successful treatment are prevention of exsanguination caused by cardiac injury at chest opening and brain protection [7]. Villavicencio and colleagues [8] reported that a false aneurysm diameter >55 mm and emergency operation are predictors of massive hemorrhage during re-sternotomy. False aneurysms of the ascending aorta carry a much higher morbidity and mortality owing to the risk of exsanguination at sternal re-entry.

In our series, all patients (seven) had a FAA: five had a FAA >55 mm, three underwent an emergency operation and two had an infectious etiology. Our patients can thus be considered at major surgical risk. The patient who died had all the risk criteria reported by authors [8, 9]: FAA >55 mm, emergency operation and simple suture repair.

Our operative mortality of 14% compares favorably with that reported by others [3, 5, 10]. Atik et al. [7] reported a 6.7% hospital mortality. In the latter study including 60 patients with ascending and descending aorta false aneurysms, hypothermic low-flow CPB was instituted before re-sternotomy in 26 patients and was followed by deep hypothermic circulatory arrest in eight patients.

Bachet et al. [9] and Mohammadi et al. [11] advocate bilateral carotid cannulation to avoid death and neurological complications related to circulatory arrest. However, our operative mortality rate does not support this approach since these series disclosed a mortality of 20% and 17.2%, respectively. In a study of the Mayo clinic [8], univariate analysis failed to identify the need for circulatory arrest as a predictor of worse outcome. Furthermore, there was only one cerebrovascular accident with complete recuperation within 48 hours.
We read with interest El Oumeiri’s formidable experience of utilizing deep hypothermic circulatory arrest for re-do surgical repair of ascending aorta false aneurysms in seven patients [1]. Inadvertent breaching of the false aneurysm at sternal re-entry is a real and well-cited risk with potentially fatal catastrophic exsanguination. The strategy of instituting low flow hypothermic extra mediastinal cardiopulmonary bypass (CPB) prior to chest re-opening via axillary cannulation or more commonly via the femoral route affords a degree of safety [2].

The authors’ technique to perform sternal re-opening under deep hypothermic circulatory arrest only once the core rectal temperature has reached 18 °C clearly affords superior protection from cerebral air embolism and massive haemorrhage. It is fortunate they did not experience any episodes of deep hypothermia induced ventricular fibrillation with associated ventricular distension. This would be a serious problem with a closed sternum. Defibrillation is unlikely to be successful with a distended heart. Although persistent fibrillation per se is not a problem with hypothermic CPB, ventricular distention is detrimental to cardiac myocyte function.

One solution would be to emergently or prophylactically insert a left ventricle (LV) apical vent directly via a small left anterolateral thoracotomy, not dissimilar to the access utilized for a TAVI (transcatheter aortic valve implantation) procedure via the apical route. Several authors can attest to the value of an LV vent in this situation to control ventricular distension [3, 4].

References