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Original Research

Minimally invasive aortic arch surgery: Early and late outcomes

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HIGHLIGHTS

- The technique of minimally invasive aortic arch surgery through partial upper sternotomy is described.
- Early morbidity and mortality are at the lower range compared to published conventional series.
- Late outcomes are not adversely influenced by the less invasive approach.

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ABSTRACT

Background: We analyzed our experience with the aortic arch operations performed through a minimally invasive approach, with emphasis on safety and feasibility, early and late outcomes.
Material and methods: We reviewed the medical records of 71 adult patients with aortic arch aneurysm (58, 82%), dissection (10, 14%) or porcelain aorta (3, 4%) who underwent primary arch surgery through a partial upper sternotomy.
Results: The aortic arch was replaced partially in 45 (63%), or totally in 26 (37%) patients. The repair was further extended with the elephant trunk procedure, conventional in 8 (11.3%) or frozen in 15 (21.1%) patients. No conversion to full sternotomy was needed. New permanent renal failure occurred in 1 (1.4%), temporary neurologic deficit in 2 (2.8%) and permanent neurologic deficit in 3 (4.2%) patients. Early mortality was observed in 4 (5.6%) patients. Actuarial survival was 79.2 ± 8.3% at 4 years and cumulative reoperation-free survival was 76.4 ± 9.4% at 4 years.
Conclusion: Minimally invasive aortic arch surgery is safe and feasible. Early outcomes are at the lower range compared to other published series. Late outcomes are not adversely influenced, as the desired extent of aortic resection can be achieved, producing a durable aortic repair.

1. Introduction

Several minimally invasive approaches in cardiac surgery have been introduced [1,2]. Smaller incisions are not only appealing to the patients, as reports showed benefits like earlier extubation, reduced bleeding, transfusion, operative time and costs in primary and reoperative surgery [3–6]. Nevertheless, to date, there are only occasional reports of minimally invasive aortic surgery [7–11].

During the last two decades, aortic arch surgery underwent several advancements, most notably being the popularization of antegrade cerebral perfusion (ACP) [12,13], which allowed for improvement of neurologic outcomes [14] and survival [15]. Performing the arch surgery through a less invasive approach may lead to even further reduction of the invasiveness of the procedure, translating into improved outcome. In this report we review our experience with minimally invasive aortic arch surgery performed through a partial upper sternotomy (PUS), with emphasis on safety, feasibility, early and late outcomes.

2. Materials and methods

Between 2006 and 2016, 71 adults with aortic arch pathology underwent less invasive operative treatment through PUS using

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selective ACP and moderate systemic hypothermia. The study was approved by the local ethic committee and individual consent was waived.

2.1. Operative and perfusion technique

Our standardized protocols for aortic surgery have been previously described in detail [16,17]. Through a skin incision of 8–10 cm, the sternum was partially divided down to the left fourth intercostal space. The right axillary artery was cannulated with 18F cannula and the right atrium (Fig. 1) with 28F double-stage venous cannula (Edwards Lifesciences, Irvine, CA). The cardiopulmonary bypass (CPB) was started, cooling was initiated and the innominate and left common carotid arteries were encircled with silicone elastomer loops. Cooling was limited to 28 °C. Following cardioplegic arrest and resection of the ascending aorta, the supra-aortic branches were occluded with the elastomers, the cross clamp was removed and the ACP was initiated. After opening the aortic arch, the left subclavian artery was blocked with a Fogarty catheter. Selective cannulation of the carotid artery was performed in patients with bilateral ACP. The ACP was conducted with a perfusate temperature of 28–30 °C with perfusion pressure kept at values greater than 75 mm Hg. At this point, the arch resection (Fig. 2) and repair was performed. In patients with aneurysms extending into the proximal descending aorta, conventional or frozen elephant trunk was employed [18,19]. After completion of the arch repair and deairing, the graft was clamped, followed by reconstitution of full body perfusion. Proximal aortic repair followed during the rewarming period.

2.2. Data analysis

Study endpoints were early morbidity and mortality, as well as long-term survival. To investigate liver and renal protection, we looked at the course of GOT (glutamic-oxaloacetic transaminase), GPT (glutamic-pyruvic transaminase), γ-GT, serum lactate, serum creatinine and blood urea nitrogen (BUN) at preoperative time point, at 12 and 24 h postoperatively. The whole body acid-base balance was investigated in all patients by analysis of the base excess, bicarbonate, pH and serum lactate. The definitions of temporary neurologic dysfunction (TND), permanent neurologic deficit (PND) and early mortality have been published previously [16]. Survival and freedom from reoperation were calculated using the Kaplan-Meier analysis with the "R" Software (Ver. 3.2.2, R Foundation). Survivors were followed in our outpatient unit, and a computer tomography scan of the aorta was performed in every patient annually.

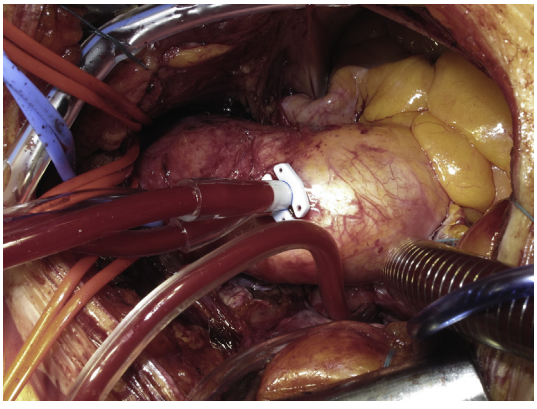

Fig. 1. Exposure of the ascending aorta and aortic arch through a partial upper sternotomy.

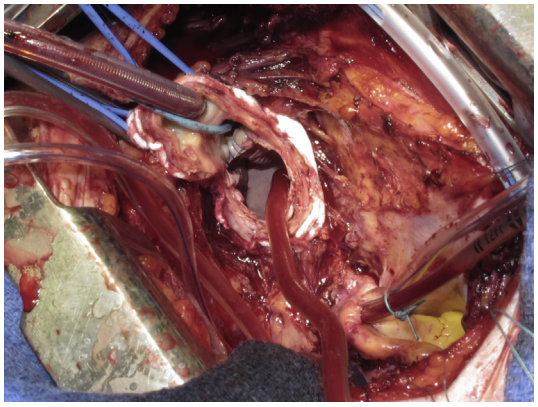

Fig. 2. Subtotal aortic arch and ascending aorta resection through a partial upper sternotomy. A woven polyester vascular graft is placed and sutured in the proximal descending aorta to serve as a landing zone for future endoaortic stent grafting. The suture line is reinforced with Teflon felt in preparation for a distal aortic anastomosis.

3. Theory

Minimally invasive aortic arch surgery is safe, feasible and can be performed with acceptable early and late outcomes.

4. Results

4.1. Early outcomes

There were 38 (53.5%) men and 33 (46.5%) women, with mean age of 68 ± 11 years. The indication for operation and the patients' comorbidities are shown in Table 1. A hemiarch replacement was performed in 45 (63.4%) patients; the remaining 26 (36.6%) patients received total arch replacement, with addition of conventional in 8 (11.3%) or frozen elephant trunk in 15 (21.1%) patients with extensive aortic pathology involving the proximal descending aorta (Table 2). Intraoperatively, three patients underwent second pump run due to residual bleeding after a Bentall procedure in one, bleeding of the left atrial appendage after ligature in another patient, and right ventricular distention requiring additional reperfusion in the last one. There was no need for conversion to full sternotomy in any patient.

Most common complication was respiratory insufficiency in 6 (8.5%) patients. The other causes of early postoperative morbidity are listed in Table 3. Bleeding in the initial 8 h after the operation was 420 ± 211 ml and three patients required reopening for persistent bleeding in two and for tamponade in one, all of them performed through the same incision. Deep wound dehiscence was

Table 1
Demographics of the study patients.

N	71
Degenerative Aneurysm (n, %)	58 (81.7)
Chronic type A aortic dissection (n, %)	10 (14.1)
Porcelain aorta in patients with aortic valve disease (n, %)	3 (4.2)
Marfan syndrome (n, %)	3 (4.2)
Arterial hypertension (n, %)	63 (89)
Chronic obstructive pulmonary disease (n, %)	18 (25.4)
Chronic renal failure (n, %)	9 (12.7)
on permanent dialysis (n, %)	1 (1.4)
Chronic peripheral arterial disease (n, %)	4 (5.6)
Extracranial carotid disease (n, %)	4 (5.6)
Preoperative neurologic dysfunction (n, %)	3 (4.2)
Aortic valve stenosis (n, %)	7 (10)
Aortic valve insufficiency (n, %)	26 (36.6)