Original Article

Survival following acute type A aortic dissection: a multicenter study

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Background: While surgery is almost always indicated for acute type A aortic dissections (ATAADs), the extent of surgery is often debated, with some surgeons preferring a conservative option and others preferring a more radical option This study aims to assess the outcome after surgery for ATAAD and the prognostic impact of surgical strategy (with *vs.* without aortic arch replacement).

Methods: Data was gathered between 1 January 2005 and 31 December 2021 and retrospectively analyzed with multivariable logistic and Cox regression to ascertain risk factors and survival respectively.

Results: A total of 601 patients underwent type A aortic dissection repair across the recruiting centers with an operative mortality of 24.3% (146 patients) which was considerably linked with the clinical condition at presentation. In-hospital mortality was 23.1% for ascending and root replacement alone *vs.* 28.7% for arch involvement. Overall survival was 73.3% after the first year, 68.2% at 5 years, and 53.5% at 10 years. The median follow-up period was 2.5 years [interquartile range (IQR), 6.6 years]. Aortic arch replacements were more often carried out in younger patients and those without adverse clinical conditions, although outcomes for patients who underwent either surgical option were comparable throughout apart from a higher rate of cerebrovascular complications in the arch group (7.6% *vs.* 21.9%) (P=0.01).

Conclusions: Surgery for ATAAD still confers a relatively high mortality. In our study, there was a higher stroke rate associated with patients who underwent arch replacements at the time of dissection despite them being younger. The choice of repair with or without arch replacement should be individualized to the patient and the severity of clinical status presentation.

Keywords: Acute type A aortic dissection (ATAAD); aortic root and arch repair; valve-sparing aorta replacement; ascending aorta replacement (AAR); total arch replacement procedure (TARP)

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Introduction

Acute aortic syndrome (AAS) is caused by a life-threatening clinicopathological entity involving the aortic wall and should be clinically suspected in patients with a history of hypertension presenting with severe chest pain. Approximately 90% of patients with AAS have an aortic dissection while an intramural hematoma occurs in the remainder (1). AAS can be aggravated by poor multi-visceral perfusion, uncontrollable pain, and hypertension. In some cases, an aneurysm of the aorta coexists. Although AAS is an infrequent entity reaching roughly 3.5–6.0 per 100,000 patient-years, timely diagnosis and treatment is nevertheless essential as an emergency procedure addressing surgery must be considered in most patients (1).

Clinically, AAS may present with the features of acute type A aortic dissection (ATAAD) necessitating emergency surgery. Despite recent progress achieved in surgical techniques and improved management, ATAAD is still linked with significant morbidity and mortality (2-5). Two objectives are essential during the surgery of ATAAD. The first is to save the life of the patient, treating and preventing life-threatening complications e.g., aortic rupture, cardiac tamponade, aortic valve regurgitation, and malperfusion syndrome. The secondary objective is to resect the primary entrance or tear to decrease the flow of blood to the false lumen and to obtain the most complete and stable aortic repair possible to avoid the evolution of the aneurysm, the appearance of secondary aortic regurgitation and reduce the risk of long-term aortic reoperation.

In the majority of cases, the main tear is identified within the ascending aorta, therefore ascending aorta replacement (AAR) is the most frequent surgical technique of repair for ATAAD (6). Usually, an extensive aortic replacement is justifiable if the primary tear is in the aortic root or beyond the ascending aorta. However, resection of the primary tear alone is called into question because even after its resection, residual perfused false lumens are noted at follow-up, with an increased risk for late aortic events (7).

The use of extensive aortic replacement of the aortic root (Ao-R), aortic arch, and descending aorta is constantly debated. It is mandatory to balance the benefits of decreased long-term distal aortic events and the risk of increased early mortality. Recent studies appear to show that a more aggressive approach is associated with better long-term survival and fewer aortic distal events and reinterventions compared with the conservative approach (8-11).

In this study, we investigated the outcome after surgery for ATAAD and assessed the prognostic impact of surgical strategy with and without aortic arch replacement. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1137/rc).

Highlight box

Key findings

- Acute type A aortic dissection (ATAAD) repair using ascending aorta replacement with hemiarch or root-sparing repair leads to favorable early outcomes in patients with urgent and emergency 1 clinical status at presentation.

What is known and what is new?

- Ascending aorta replacement with hemiarch techniques or root replacement and more extensive total arch repair lead to consistently less operative mortality in urgent and emergency 1 patients.
- A conservative approach is recommended in grade 2 emergency and salvage patients due to the increased risk of perioperative mortality.

What is the implication, and what should change now?

- Mortality rates for ATAAD remain high, with a strong association with presentation acuity. The surgeon and centre experience should determine the extent of repair weighing in the additional risks associated with more extensive surgery against the need for further reintervention.

Methods

Study design and oversight

The data consists of patients operated on between 1 January 2005 and 31 December 2021 from three heart surgery institutions (Centre Cardiologique du Nord, Hôpital Henri-Mondor AP-HP, and University of Genoa) and were retrospectively analyzed. The protocol mandated continuous monitoring and checking of the database by analysts, and clinical information within each unit was systematically validated with internal and external audits. During the hospital stay, preoperative and postoperative variables were recorded. For the survival follow-up analysis, there were no missing data. Data integrity was updated annually through an accurate review process of the correspondence of the electronic medical records of the patients by the referring units. Alternatively, follow-up was obtained by directly contacting the referring doctors, the patients themselves, or the family members. This study complied with the Declaration of Helsinki (as revised in 2013). Patient consent was obtained after the assigned ethics approval from the institutional review board of Montpellier University

Hospital (IRB approval No. 202201173) in accordance with the research guidance. The other institutions are informed and agreed with the study.

Patients

A total of 601 patients were operated on during the study period and included in the study. Baseline characteristics, demographics, and follow-up data were evaluated. The target population was adults (aged >18 years) with ATAAD or intramural hematoma. Specific inclusion criteria included the presence of the lesion involving the ascending aorta, symptoms within 7 days of surgery, and patients referred for primary surgical repair of ATAAD based on recommendations. In addition, any other major cardiac surgical procedures needed during ATAAD and retrograde extension of ATAAD were considered. Patients who were <18 years old, had previous ATAAD procedures or who had delayed presentation (AAS >7 days prior), traumatic aortic dissections, and endocarditis were also excluded.

The patients were segregated into five categories of increasing hemodynamic severity. In patients requiring "urgent" intervention, the procedure was performed within 24 hours of hospital admission during the initial hospitalization. Patients in this category were paucisymptomatic with stable hemodynamics and did not exhibit any signs of malperfusion. Patients in the "emergency 1" category were symptomatic but stable from a hemodynamic standpoint. They had no signs of malperfusion and/or rupture and surgery was recommended within hours after admission. The "emergency 2" category included patients who required prompt intervention immediately after hospitalization or those who rapidly deteriorated clinically. These patients were characterized by hemodynamic instability refractory to the administration of inotropes and/or malperfusion. These categories of patients require cardiopulmonary resuscitation. "Salvage 1" and "salvage 2" categories included hospitalized patients requiring cardiopulmonary resuscitation by means of either external chest compressions and/or open cardiac massage. These patients were induced and initiated on cardiopulmonary bypass in critical condition. "Salvage 1" patients underwent the surgical procedure with timely initiation of cardiopulmonary bypass due to worsening clinical conditions after anesthesia induction. They either had a cardiac tamponade, acute heart failure, and/or sudden rupture of the aorta. "Salvage 2" patients required cardiopulmonary resuscitation with external chest compressions during transport to the operating room or before anesthesia induction. For these, prompt initiation of cardiopulmonary bypass was required, which was often preceded by cardiac massage after median sternotomy. The surgical procedure was performed without knowledge of genuine aortic rupture or severe organ damage (12).

Endpoints

The primary endpoint of the study was operative mortality (OM) reported as both 30-day and in-hospital mortality. Secondary endpoints included cerebrovascular events including strokes, resulting in permanent neurological deficit (PND), spinal cord injury (SCI), post-operative dialysis dependency, intensive care unit (ICU) stay, respiratory failure requiring tracheostomy, a combination of major adverse events (MAE) including surgical mortality, cerebrovascular accident, new dialysis requirement or tracheostomy initiation and late survival. The primary and secondary endpoints were evaluated alongside the type of surgery performed and the portion of the aorta restored. In addition, the disabling status of the patients at the time of hospital admission was considered.

Surgical technique

Sternotomy was performed for all the patients. The lead surgeon of each institution directed the operative strategy regarding the preferred cannulation site. Arterial cannulation was performed in either the right common femoral artery, brachiocephalic trunk, axillary artery, or centrally via the aortic lumen. Surgical preference also took priority in dictating the degree of systemic cooling. Cardiopulmonary bypass was initiated alongside systemic cooling. Potassium-rich antegrade cardioplegia solution was directly injected into the coronary ostium to achieve diastolic arrest. Alternatively, when ATAAD caused aortic regurgitation or when patients required more radical aortic root replacement (ARR) procedures or extensive repairs involving the aortic arch, the use of a coronary sinus perfusion cannula was placed to deliver the cardioplegic solution retrogradely. The sinotubular junction was the landmark for the resection of the ascending aorta. Thrombus was normally found occupying the false lumen of the Ao-R and/or of the ascending aorta and evacuated to appreciate the extent of the aortic injury. Subsequently, the anatomical integrity of the aortic root and aortic leaflets was evaluated with careful inspection. 4-0 or 5-0 sutures with Teflon pledgets were used to approximate the tunica intima of the commissures to the adventitia to reinforce each commissure for resuspension. This technique has been used both in patients undergoing root sparing-AAR and in those receiving root replacement—AAR if the intimal detachment extended into the sinuses of Valsalva resulting in commissural collapse. Normally neo-media biological glue was used during the reconstruction of the aorta, while the use of felt was driven by surgical preference. A 4-0 or 5-0 polypropylene suture may be used to seal the proximal suture line and this anastomosis also buttressed the two intimal and adventitial walls to ensure solid continuity. Some surgeons used felt as the neo-media or utilized horizontal felt-mattress sutures arranged circumferentially to obtain a continuous outer ring of felt reinforcement. ARR was performed using either biological or mechanical composite valve graft or performing a valve sparing-ARR procedure dictated by the sinuses of Valsalva on computed tomography using 4.5 cm as the cut-off, or if intimal tears were noted in the sinus of Valsalva and patients with connective tissue disease (CTD). Conversely, the preferred surgical option in patients presenting with non-dilated aortic roots but poor-quality valve leaflets was the concomitant replacement of the aortic valve with a bioprosthetic or mechanical prosthesis with the interposition of a Dacron graft.

In patients requiring total arch replacement procedure (TARP), deep hypothermic circulatory arrest (DHCA) was used with continuous antegrade cerebral perfusion or retrograde cerebral perfusion with systemic cooling to a temperature of 19 and 25 ℃ dictated by surgical preference. Symmetrical cooling and re-warming of the brain were continuously monitored using near-infrared spectroscopy. And, 80.5% of patients who had TARP required a protocol for antegrade brain protection which was ensured either by endoluminal technique or with direct insertion of the cannula into the brachiocephalic trunk or left common carotid artery or right axillary artery. A different flow rate was delivered ranging from 800 to 1,000 mL/min when the temperature was fixed at 28 or 36 ℃ and the systemic arterial pressure was maintained between 40–60 mmHg. The remaining TARP (19.5%) utilized DHCA by retrograde cerebral perfusion via a superior vena cava cannula. The delivery of the solution was set at 200–350 mL/min at 18 ℃ and a target central venous pressure of between 25–35 mmHg.

TARPs included partial or total resections. 1- and 4-branch grafts were used both in total excision of the aortic tissue up to zone 2—including the left common carotid artery (total hemiarch) and in less extensive excisions (partial hemiarch) in patients receiving reimplantation of the brachiocephalic trunk only. TARP with reimplantation of the entire great vessel block was the primary surgical option in patients with extensive arch aneurysms or a large intimal lesion involving the inner arch. Patients with CTD or significant dislocation of the great vessels underwent debranching and selective implantation. The same category of subjects were ideal recipients of the frozen elephant trunk (FET) option and received selective debranching/vessel implantation or insular reimplantation. The advantage offered by the 4-branch grafts was the possibility of restoring antegrade cardiopulmonary bypass through the reperfusion arm (lateral branch) of the graft used. Finally, systemic warming was ensured by maintaining a temperature gradient (core blood and internal temperature) of 10 ℃ while performing surgical hemostasis. In this phase, the residual suture line was made and strengthened according to the formerly described procedure. After reaching a body temperature of 36 ℃, cardiopulmonary bypass was discontinued.

Statistical analysis

Descriptive statistics

Categorical variables were compared using Pearson's chi-squared test or Fisher's exact test as appropriate. Non-parametric continuous variables were compared using the Mann-Whitney U test. Operative (pre, intra and post) variables were compared across the subgroups, to establish an association with the extent of aortic replacement and with the urgency at presentation (as described earlier) (11). Kaplan-Meier curves with log-rank tests were used to assess survival between the groups. P value <0.05 was accepted as significant without adjustment for multiple testing.

Risk adjustment

Risk factors for mortality, during initial hospitalization and subsequent follow-up, were initially evaluated by univariate regression. Continuous variables were factorized according to recognized classification systems. Anemia was classified according to hemoglobin (Hb) levels as per World Health Organization (WHO) guidelines: Hb >110 g/L, grade 0; Hb 95–109 g/L, grade I; Hb 80–94 g/L, grade II; Hb 65–79 g/L, grade III; Hb <65 g/L, grade IV (13). The renal function was classified using the WHO classification for chronic kidney disease because the baseline levels of estimated glomerular filtration rate (eGFR) (i.e. before the dissection occurred) were not captured by the database: eGFR >90, normal; eGFR 80–90, stage 1; eGFR 60–79, stage 2; eGFR 30–59, stage 3; eGFR 15–29, stage 4; eGFR <15, stage 5 (14). Thrombocytopenia was classified: >150,000/mcL, normal; 100,000–150,000 mcL, mild; 50,000–100,000 mcL, moderate; <50,000/mcL, severe (15). Lactate levels were classified as: <2 mmol/L, normal; 2–4 mmol/L, lactic acidosis; >4 mmol/L, severe lactic acidosis (16). Variables with an association of P<0.2 with in-hospital or follow-up mortality, or with recognized clinical significance were retained respectively for the multivariable logistic and the Cox regression models. Multi-collinearity was evaluated with variance inflation factor analysis, and excluded by a value ≤3.

Statistical software

R studio, with appropriate packages, was utilized for the statistical analysis.

Results

Our analysis is summarized in this section, but detailed in the referenced tables and figures to avoid duplication of information.

Overall sample

During the study period, 601 patients received ATAAD repair across the recruiting centers. Clinical variables are detailed in *Table 1*. Males in their 60 s were the most common presenting demographic. The women in our cohorts were significantly elder, anaemic (P<0.001), and with reduced eGFR compared to men (P<0.001). About half of the patients were operated on in an urgent setting and the remaining half as emergency or salvage cases. The aortic valve was moderate to severely regurgitant in more than a third of cases. Evidence of malperfusion was present in one-quarter of patients, with the brain being the most affected site. AAR (367, 61.1%) was the most commonly performed procedure. Proximal (i.e., root) and distal (i.e., arch) extension of the repair occurred in an equal number of cases (both 105, 17.5%). A root-to-arch extension was used in 24 patients (4.0%). Male patients were more likely to receive AAR and partial or total arch repair compared to women who were more likely to receive a ‘conservative’ procedure undergoing ascending aorta, replacement using an interposed Dacron graft (34,9% P<0.01). The yearly volume by type of repair is detailed in *Figure 1*. The OM was 146 patients (24.3%) with a steady decrement from 34.3% in 2010 to 27.8% in 2021, despite a substantial correlation with the severity of clinical conditions at hospital admission observed. Stroke was the most common morbidity (75, 12.6%). *Table 1* survival at 1-, 5-, and 10-year was 73.3%, 68.2%, and 53.5%, respectively.

Subgroup analysis I: aortic segments

Patients who received less invasive procedures based on root sparing with replacement of ascending aorta, were on average 8 years older than patients receiving extensive repairs (root and/or arch repair). Preoperative clinical and biochemical risk factors were similar across the subgroups. Congenital bicuspid and regurgitant/insufficient aortic valves were more common in patients who underwent root replacement/repair. The extent of repair did not affect OM and MAE, with the exception of a stroke rate that was lowest in the “+ root” group (7.6%) compared to the “+ arch” group (21.9%) (P=0.01). The incidence of stroke (P=0.01), chordal injury (P=0.57), tracheostomy (P=0.67), renal failure requiring dialysis (P=0.35), and MAE (P=0.11) were not significant (*Tables 2,3* and *Figure 2*).

Subgroup analysis II: urgency status

No substantial differences were found in demographics between groups. However, biochemical markers were considerably affected by urgency status. For example, Hb and creatinine levels reflected the worsening of presentation, from “urgent” (Hb 116 g/dL, Cr 82 mg/dL) to “salvage 2” (Hb 99 g/dL, Cr 145 mg/dL) (P<0.01). Other preoperative factors and the aortic valve status were similar across groups. The incidence of stroke, cord injury, and tracheostomy was not statistically significant between groups, whilst renal failure requiring dialysis significantly correlated with “emergency 2” 18.6% and “salvage 1” 12.5% (P<0.01). Malperfusion was associated with worsening hemodynamic status classification (urgency: “urgent” and “emergency 1” groups (0.0%) compared to “emergency 2” group (79.5%) (P<0.01). OM and MAE were significantly correlated with the urgency status, rising from urgent to salvage 2 (P<0.01) (*Table 4*).

Survival

In the overall sample, the rate of survival was 73.3% at 1-year, 68.2% at 5-year, and 53.5% at 10-year follow-up

Table 1 Pre/intra/post-operative variables in the overall sample

Variables	Data
Demographics	
Age (years)	64.4 (20.1)
BMI (kg/m^2)	25.8 (5.2)
Female	180 (30.0)
Biochemistry	
Creatinine (mg/dL)	88.4 (29.1)
Hemoglobin (g/dL)	121.0 (28.5)
Platelet count (×10^{9}L)	220.0 (194.5)
Arterial lactate (mmol/L)	2.2 (2.3)
Cardiac biomarkers increase	150 (25.0)
Comorbidities and presentation	
Diabetes	36 (6.0)
Cerebro-vascular accident	32 (5.3)
Pulmonary disease	33 (5.5)
Extracardiac arteriopathy	21 (3.5)
Poor mobility	49 (8.2)
Moderate-to-severe frailty	3 (0.5)
Recent myocardial infarction	19 (3.2)
Preoperative cardiac massage	26 (4.3)
Status	
Urgent	304 (50.6)
Emergency 1	107 (17.8)
Emergency 2	161 (26.8)
Salvage 1	24 (4.0)
Salvage 2	5 (0.8)
Aortic valve	
Bicuspid	12 (2.0)
Moderate or severe regurgitation	212 (35.2)
No trace	203 (33.8)
Malperfusion	147 (24.5)
Cerebral	80 (13.3)
Spinal	12 (2.0)
Renal	61 (10.1)
Mesenteric	33 (5.5)
Peripheral	32 (5.3)

Table 1 (*continued*)

Table 1 (*continued*)

Variables	Data
Aortic segments replaced	
Ascending only	367 (61.1)
Ascending + root	105 (17.5)
Ascending + arch	105 (17.5)
Ascending + root & arch	24 (4.0)
Type of root procedure	
Modified Bentall	121 (20.1)
David procedure	5 (0.8)
Yacoub procedure	3 (0.5)
Type of arch procedure	
Hemi-arch	26 (4.3)
Total arch	52 (8.7)
Total arch + FET	51 (8.5)
Type of cerebroplegia	
Antegrade	248 (41.3)
Retrograde	117 (19.5)
CPB time (minutes), median (range)	P value <0.1
Overall (N=601): 143.00 (127.00–167.00)	
Conservative (n=367): 135.00 (124.00–153.50)	
Extensive (n=234): 164.00 (143.00–179.50)	
Cardiac ischemia time (minutes), median (range)	P value <0.1
Overall (N=601): 88.00 (73.00–110.50)	
Conservative (n=367): 80.00 (70.75–94.00)	
Extensive (n=234): 115.00 (94.00–139.50)	
Adverse events	
Stroke	76 (12.6)
Spinal cord injury	25 (4.2)
Tracheostomy	27 (4.5)
Hemodialysis	63 (10.5)
In-hospital mortality	146 (24.3)
Major adverse events	240 (39.9)
ICU stay (days)	9.0 (17.0)

Data are presented as median (IQR) or n (%) unless otherwise stated. Pre/intra/post-operative variables after type A aortic dissection repair. Major adverse events include composite of in-hospital mortality and stroke, spinal cord injury, tracheostomy, and hemodialysis. BMI, body mass index; FET, frozen elephant trunk; CPB, cardiopulmonary bypass; ICU, intensive care unit; IQR, interquartile range.

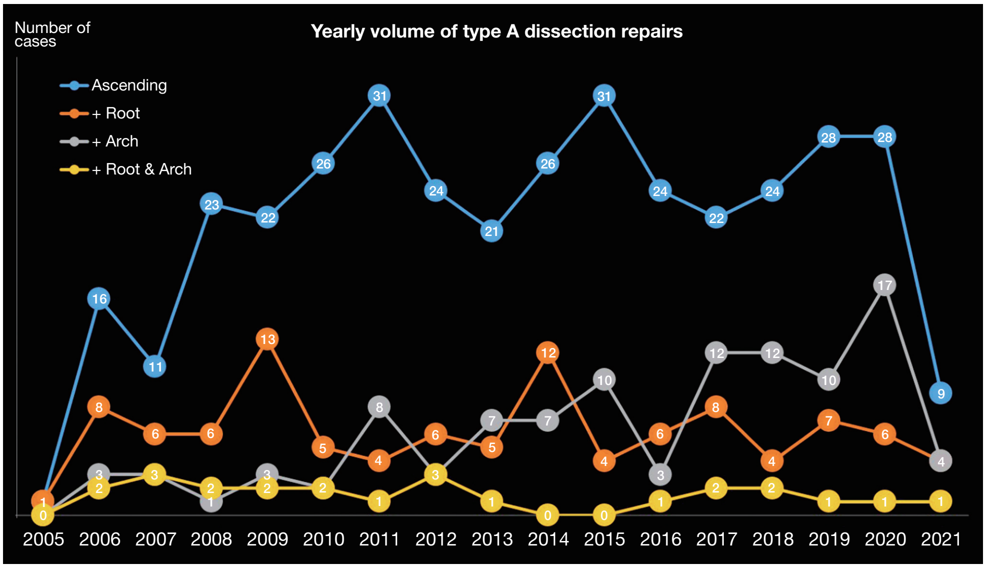

Figure 1 The yearly volume of type A acute aortic dissection repairs. The curves are color-coded according to the aortic segment replaced. The y-axis shows the year, x-axis shows the number of cases.

Table 2 Pre/intra/post-operative variables according to aortic segment replaced

Variables	Ascending only (N=367)	+ Root (N=105)	+ Arch (N=105)	+ Root & arch (N=24)	P value
Demographic characteristics					
Age (years)	67.4 (20.6)	61.7 (19.8)	61.1 (16.5)	59.7 (11.4)	<0.01
BMI (kg/m^2)	25.9 (5.4)	25.6 (4.3)	25.6 (4.5)	25.4 (4.0)	0.64
Female	128 (34.9)	23 (21.9)	25 (23.8)	4 (16.7)	<0.01
Biochemistry					
Cr (mg/dL)	88.5 (32.4)	88.0 (19.9)	88.4 (33.0)	81.0 (7.0)	0.50
Hb (g/dL)	122.0 (28.5)	122.0 (31.0)	120.0 (28.0)	112.5 (29.5)	0.16
PLT (×10^{9}L)	211.0 (166.0)	250.0 (182.5)	199.0 (224.0)	281.0 (186.2)	0.05
Lactate (mmol/L)	2.2 (2.4)	2.1 (2.0)	2.0 (2.4)	2.5 (1.9)	0.80
Enzymes increase	90 (24.5)	81 (77.1)	32 (30.5)	20 (83.3)	0.41
Comorbidities and presentation					
Diabetes	21 (5.7)	6 (5.7)	9 (8.6)	0 (0.0)	0.42
Cerebro-vascular accident	19 (5.2)	7 (6.7)	5 (4.8)	1 (4.2)	0.91
Pulmonary disease	25 (6.8)	5 (4.8)	1 (1.0)	2 (8.3)	0.12
Extracardiac arteriopathy	18 (4.9)	1 (1.0)	2 (1.9)	0 (0.0)	0.12
Poor mobility	37 (10.1)	7 (6.7)	5 (4.8)	0 (0.0)	0.12
Moderate-to-severe frailty	3 (0.8)	0 (0.0)	0 (0.0)	0 (0.)	0.59
Recent myocardial infarction	9 (2.5)	6 (5.7)	3 (2.9)	1 (4.2)	0.40
Cardiac massage	14 (3.8)	6 5.7)	6 (5.7)	0 (0.0)	0.51
Intubated/sedated	100 (27.2)	32 (30.5)	37 (35.2)	10 (41.7)	0.23

Table 2 (*continued*)

Table 2 (*continued*)

Variables	Ascending only (N=367)	+ Root (N=105)	+ Arch (N=105)	+ Root & arch (N=24)	P value
Status					0.06
Emergency 1	77 (21.0)	18 (17.1)	12 (11.4)	0 (0.0)	
Emergency 2	98 (26.7)	29 (27.6)	30 (28.6)	4 (16.7)	
Salvage 1	12 (3.3)	6 (5.7)	6 (5.7)	0 (0.0)	
Salvage 2	4 (1.1)	1 (1.0)	0 (0.0)	0 (0.0)	
Urgent	176 (48.0)	51 (48.6)	57 (54.3)	20 (83.3)	
Aortic valve					
Bicuspid	4 (1.1)	6 (5.7)	1 (1.0)	1 (4.2)	0.02
Regurgitation					<0.01
No trace	135 (36.9)	10 (9.5)	57 (54.3)	1 (4.2)	
Mild	147 (40.2)	8 (7.6)	29 (27.6)	1 (4.2)	
Moderate	59 (16.1)	17 (16.2)	12 (11.4)	7 (29.2)	
Severe	25 (6.8)	70 (66.7)	7 (6.7)	15 (62.5)	
Malperfusion	89 (24.3)	27 (25.7)	27 (25.7)	4 (16.7)	0.81
Cerebral	47 (12.8)	15 (14.3)	16 (15.2)	2 (8.3)	
Spinal	7 (1.9)	3 (2.9)	2 (1.9)	0 (0.0)	
Renal	37 (10.1)	11 (10.5)	12 (11.4)	1 (4.2)	
Mesenteric	25 (6.8)	4 (3.8)	3 (2.9)	1 (4.2)	
Peripheral	18 (4.9)	5 (4.8)	7 (6.7)	2 (8.3)	
Outcomes					
Stroke	43 (11.7)	8 (7.6)	23 (21.9)	2 (8.3)	0.01
Spinal cord injury	12 (3.3)	6 (5.7)	6 (5.7)	1 (4.2)	0.57
Tracheostomy	16 (4.4)	6 (5.7)	5 (4.8)	0 (0.0)	0.67
Dialysis	33 (9.0)	11 (10.5)	15 (14.3)	4 (16.7)	0.35
In-hospital mortality	89 (24.3)	20 (19.0)	31 (29.5)	6 (25.0)	0.37
Major adverse events	130 (35.4)	39 (37.1)	51 (48.6)	10 (41.7)	0.11
ICU stay (days)	7.0 (15.0)	10.0 (22.0)	11.0 (17.0)	15.5 (13.2)	<0.01

Data are presented as median (IQR) or n (%). Pre/intra/post-operative variables after type A aortic dissection repair. Major adverse events include composite of in-hospital mortality and stroke, spinal cord injury, tracheostomy, and hemodialysis. BMI, body mass index; Cr, creatinine; Hb, hemoglobin; PLT, platelets count; ICU, intensive care unit; IQR, interquartile range.

(*Table 5*). Median follow-up period was 2.5 years (IQR, 6.6 years). The extent of the surgical repair had no bearing on survival (*Table 5*, *Figure 2*). Survival was strongly affected by status at presentation (P<0.01). At the 1-year, the rate of survival of the "urgent" group was double the rate of survival of the "salvage 2" group (P<0.01). At the 5-year mark, the rate of survival was 80.2%±2.4% and 50%±10.2% respectively for the "urgent" and "salvage 1" groups. At the 10-year mark, the rate of survival was 66.8%±3.9% and 35.9%±5.6% respectively for the "urgent" and "emergency 2" groups (*Table 5*, *Figure 3*).

Predictors of in-hospital and follow-up mortality

Age, intubation at hospitalization, raised lactate levels, and "emergency/salvage" status at admission were independent predictors of mortality. While in-hospital mortality was forecasted by "poor mobility" status, follow-up mortality

Table 3 Pre/intra/post-operative variables in the conservative *vs.* extensive surgery groups

Variables	Conservative (N=393)	Extensive (N=208)	P value
Demographic characteristics			
Age (years)	66.9 (20.4)	61.1 (17.4)	<0.01
BMI (kg/m^2)	25.9 (5.6)	25.7 (4.3)	0.53
Female	137 (34.9)	43 (20.7)	<0.01
Biochemistry			
Cr (mg/dL)	88.4 (31.6)	88.0 (25.7)	0.86
Hb (g/dL)	122.0 (29.0)	119.0 (27.0)	0.22
PLT (×10^{9}L)	212.5 (168.0)	230.0 (204.7)	0.12
Lactate (mmol/L)	2.2 (2.3)	2.3 (2.2)	0.85
Enzymes increase)	95 (24.2)	55 (26.4)	0.61
Comorbidities and presentation			
Diabetes	22 (5.6)	14 (6.7)	0.71
Stroke	7 (1.8)	7 (3.4)	0.35
Pulmonary disease	26 (6.6)	7 (3.4)	0.14
Extracardiac arteriopathy	18 (4.6)	3 (1.4)	0.08
Poor mobility	39 (9.9)	10 (4.8)	0.04
Moderate-to-severe frailty	3 (0.8)	0 (0.0)	0.59
Recent myocardial infarction	10 (2.5)	9 (4.3)	0.34
Cardiac massage	14 (3.6)	12 (5.8)	0.29
Intubated/sedated	107 (27.2)	72 (34.6)	0.07
Status			0.10
Emergency 1	79 (20.1)	28 (13.5)	
Emergency 2	108 (27.5)	53 (25.5)	
Salvage 1	12 (3.1)	12 (5.8)	
Salvage 2	4 (1.0)	1 (0.5)	
Urgent	190 (48.3)	114 (54.8)	
Aortic valve			0.04
Bicuspid	4 (1.0)	8 (3.8)	
Regurgitation			<0.01
No/trace	143 (36.5)	60 (28.8)	
Mild	153 (39.0)	32 (15.4)	
Moderate	69 (17.6)	26 (12.5)	
Severe	27 (6.9)	90 (43.3)	
Malperfusion	98 (24.9)	49 (23.6)	0.78
Cerebral	52 (13.2)	28 (13.5)	
Spinal	8 (2.0)	4 (1.9)	
Renal	41 (10.4)	20 (9.6)	
Mesenteric	26 (6.6)	7 (3.4)	
Peripheral	22 (5.6)	10 (4.8)	
Outcomes			
Stroke	48 (24.9)	28 (23.6)	0.75
Spinal cord injury	13 (3.3)	12 (5.8)	0.22
Tracheostomy	18 (4.6)	9 (4.3)	>0.99
Dialysis	37 (9.4)	26 (12.5)	0.30
In-hospital mortality	97 (24.7)	49 (23.6)	0.84
Major adverse events	148 (37.7)	92 (44.2)	0.14
ICU stay (days)	8.0 (15.0)	11.0 (22.0)	0.03

Data are presented as median (IQR) or n (%). Major adverse events include composite of in-hospital mortality and stroke, spinal cord injury, tracheostomy, and hemodialysis. BMI, body mass index; Cr, creatinine; Hb, hemoglobin; ICU, intensive care unit; IQR, interquartile range; lactate, arterial lactate; PLT, platelets count; enzymes, cardiac enzymes.

was higher in patients with congenital bicuspid aortic valves. *Tables 6,7* indicate the univariate and multivariable predictors for operative and follow-up mortality respectively.

Discussion

In this extensive evaluation, we assessed the survival rates following surgical repair for type A acute aortic dissection. The study is founded on a 14-year experience [2008–2021] from a multicentre dataset of three reputable centres. The majority of patients opted for the 'conservative' approach, with root sparing-AAR administered using a Dacron graft interposition. Only a small fraction of patients underwent AAR conjoined with arch repair with or without root replacement. *Figure 4* shows a raw OM rate of 24.3%, with 1-, 5-, and 10-year survival rates of 73.3%, 68.2%, and 53.5%, respectively. Operative and follow-up mortality risk factors include age, arterial lactate standards, intubation

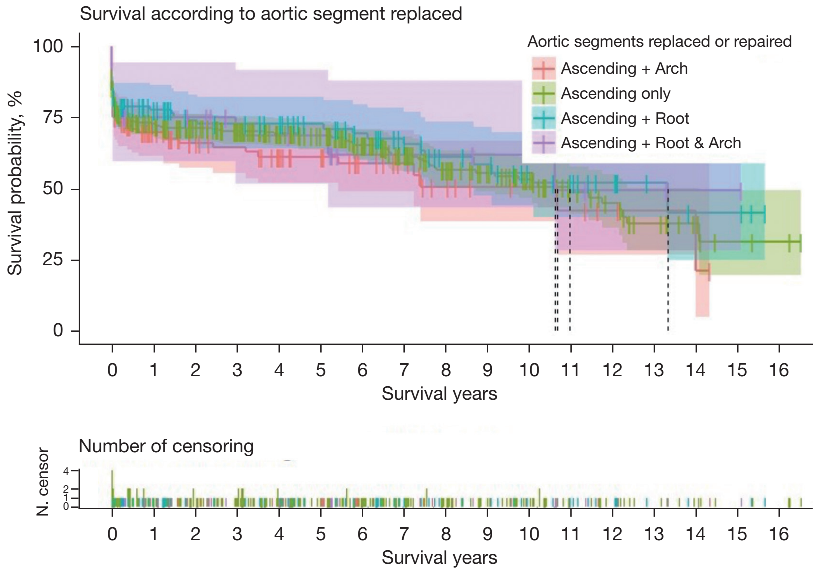

Figure 2 Survival according to the aortic segments replaced. Kaplan-Meier curves to assess survival after type A aortic dissection repair. The curves are color-coded according to the aortic segment replaced, and the relative shaded areas represent the 95% confidence interval. The censored patients are represented by the short vertical lines along the survival curves. The dotted black lines represent the estimated median survival, which can only be calculated if the survival has dropped <50% for the relative subgroup at the end of the study period.

Table 4 Pre/intra/post-operative variables according to urgency status at presentation

Variables	Urgent (N=304)	Emergency 1 (N=107)	Emergency 2 (N=161)	Salvage 1 (N=24)	Salvage 2 (N=5)	P value
Demographic characteristics						
Age (years)	64.2 (18.2)	64.0 (21.2)	63.4 (21.2)	67.1 (13.1)	73.2 (13.2)	0.41
BMI (kg/m^2)	25.8 (5.4)	26.8 (5.0)	25.7 (4.7)	25.3 (3.2)	24.2 (2.1)	0.41
Female	104 (34.2)	26 (24.3)	43 (26.7)	6 (25.0)	1 (20.0)	0.23
Biochemical analysis						
Cr (mg/dL)	82.0 (23.0)	94.1 (40.2)	96.0 (40.5)	88.0 (27.0)	145.0 (34.5)	<0.01
Hb (g/dL)	116.0 (25.0)	130.0 (26.0)	125.5 (28.0)	114.0 (18.0)	99.0 (28.0)	<0.01
PLT (×10^9/L)	254.0 (187.0)	198.0 (67.5)	207.5 (182.2)	166.0 (208.0)	128.0 (23.0)	<0.01
Lactate (mmol/L)	2.5 (2.5)	1.2 (1.3)	2.3 (2.0)	2.3 (4.5)	3.3 (6.0)	<0.01
Enzymes increase	82 (27.0)	14 (13.1)	41 (25.5)	12 (50.0)	1 (20.0)	<0.01
Patients status before surgery						
Diabetes	23 (7.6)	4 (3.7)	7 (4.3)	2 (8.3)	0 (0.0)	0.46
Cerebro-vascular accident	13 (4.3)	6 (5.6)	11 (6.8)	1 (4.2)	1 (20.0)	0.46
Pulmonary disease	17 (5.6)	8 (7.5)	6 (3.7)	1 (4.2)	1 (20.)	0.42
Extracardiac arteriopathy	6 (2.0)	8 (7.5)	6 (3.7)	1 (4.2)	0 (0.0)	0.12
Poor mobility	33 (10.9)	5 (4.7)	9 (5.6)	2 (8.3)	0 (0.0)	0.16
Moderate-to-severe frailty	2 (0.7)	0 (0.0)	1 (0.6)	0 (0.0)	0 (0.0)	0.93

Table 4 (*continued*)

Table 4 (*continued*)

Variables	Urgent (N=304)	Emergency 1 (N=107)	Emergency 2 (N=161)	Salvage 1 (N=24)	Salvage 2 (N=5)	P value
Recent myocardial infarction	7 (2.3)	3 (2.8)	7 (4.3)	2 (8.3)	0 (0.0)	0.44
Cardiac massage	0 (0.0)	0 (0.0)	0 (0.0)	21 (87.5)	5 (100)	<0.01
Intubated/sedated	95 (31.2)	15 (14.0)	59 (36.6)	9 (37.5)	1 (20.0)	<0.01
Aortic valve						
Bicuspid	3 (1.0)	4 (3.7)	5 (3.1)	0 (0.0)	0 (0.0)	0.30
Regurgitation						0.14
No trace	110 (6.2)	27 (25.2)	55 (34.4)	10 (41.7)	1 (20.0)	
Mild	96 (31.6)	36 (33.6)	47 (29.4)	5 (20.8)	1 (20.0)	
Moderate	36 (11.8)	27 (25.2)	27 16.9)	3(12.5)	1 (40.0)	
Severe	62 (20.4)	17 (15.9)	31 (19.4)	6 (25.0)	1 (20.0)	
Malperfusion	0 (0.0)	0 (0.0)	128 (79.5)	16 (66.7)	3 (60.0)	<0.01
Cerebral	0 (0.0)	0 (0.0)	66 (41.0)	47 (50.0)	1 (40.0)	
Spinal	0 (0.0)	0 (0.0)	8 (5.0)	4 (16.7)	0 (0.0)	
Renal	0 (0.0)	0 (0.0)	55 (34.2)	4 (16.7)	2 (40.0)	
Mesenteric	0 (0.0)	0 (0.0)	25 (15.5)	5 (20.8)	3 (60.0)	
Peripheral	0 (0.0)	0 (0.0)	30 (18.6)	2 (8.3)	0 (0.0)	
Aortic segments replaced						0.06
Ascending only	176 (57.9)	77 (72.0)	98 (60.9)	12 (50.0)	4 (40.0)	
+ Root	51 (16.8)	18 (16.8)	29 (18.0)	6 (25.0)	1 (20.0)	
+ Arch	57 (18.8)	12 (11.2)	30 (18.6)	6 (25.0)	0 (0.0)	
+Root & arch	20 (6.6)	0 (0.0)	4 (2.5)	0 (0.0)	0 (0.0)	
Adverse events						
Stroke	41 (13.5)	11 (10.3)	18 (11.2)	6 (25.0)	0 (0.0)	0.28
Spinal cord injury	8 (2.6)	6 (5.6)	9 (5.6)	2 (8.3)	0 (0.0)	0.35
Tracheostomy	16 (5.3)	3 (2.8)	8 (5.0)	0 (0.0)	0 (0.0)	0.63
Dialysis	24 (7.9)	6 (5.6)	30 (18.6)	3 (12.5)	0 (0.0)	<0.01
In-hospital mortality	48 (15.8)	27 (25.2)	56 (34.8)	12 (50.0)	3 (60.0)	<0.01
Major adverse events	99 (32.6)	35 (32.7)	79 (49.1)	14 (58.3)	3 (60.0)	<0.01
ICU stay (days)	11.0 (20.0)	5.0 (10.0)	8.0 (16.0)	3 (13.5)	1.0 (14.0)	<0.01

Data are presented as median (IQR) or n (%). Pre/intra/post-operative variables after type A aortic dissection repair. Major adverse events include composite of in-hospital mortality and stroke, spinal cord injury, tracheostomy, and hemodialysis. BMI, body mass index; Cr, creatinine; Hb, hemoglobin; PLT, platelets count; ICU, intensive care unit; IQR, interquartile range.

Table 5 Survival after type A aortic dissection

Survival	1-year	5-year	10-year
Survival: overall sample			
At risk	370	225	69
Events	157	22	33
Survival, %	73.3	68.2	53.5
SE, %	1.8	2	2.8
Survival according to aortic segments repaired			
Ascending, %	72.8±2.4	68.6±2.5	53.4±3.6
+ Root, %	80.0±4.0	72.7±4.5	55.6±6.4
+ Arch, %	70.0±4.5	61.3±5.2	At risk <10
+ Root & arch, %	75.0±8.8	68.7±10.1	At risk <10
P value		0.56	
Survival according to urgency status at presentation			
Urgent, %	84.0±2.1	80.2±2.4	66.8±3.9
Emergency 1, %	66.9±4.6	58.3±5.0	50.2±5.8
Emergency 2, %	62.1±3.8	56.9±4.0	35.9±5.6
Salvage 1, %	50±10.2	50±10.2	At risk <10
Salvage 2, %	40.0±21.9	At risk <10	At risk <10
P value		<0.01	

Data are represented as mean ± SE. Survival after type A aortic dissection repair in the overall sample, and across subgroups according to the aortic segment replaced and according to urgency status at presentation. SE, standard error.

state, and severity categories, such as emergency or salvage status at hospital admission (P<0.01).

The results of this 14-year study have advanced our understanding of the benefits of surgical management of ATAAD. Successful surgery for ATAAD involves four general principles. Firstly, the aortic replacement must restore a competent thoracic aorta. Secondly, the entire portion of the aorta involved in the dissection should be replaced to minimize the risk of further reoperation. Thirdly, the surgeon should ensure the lowest OM for the index procedure. Finally, achieving these results may require more complicated surgery, leading to longer operating times and an increased risk of prolonged organ and cardiac ischemia.

We observed a significant disparity in OM rates based on the urgency categories determined by an individual's clinical condition. The "urgent" patients exhibited a rate of 15.8%, while the "salvage 2" patients displayed a rate of 60%. The OM reported here is comparable to that which has been described in various national and international registries (3-5,17-20). Despite increased awareness of advances in accurate image processing, which leads to faster diagnosis and better perioperative care, the reported OM rate remains alarmingly high. The STS data from 2014 to 2016 showed an intra-hospital mortality rate of 26.9% in patients who underwent TARP, versus 16.3% of those managed with hemiarch repair (19). Comparable figures were recorded in the International Registry of Acute Aortic Dissection (IRAD) (5,17) and the German Registry for Acute Aortic Dissection Type A (GERAADA) (4,20) databases. In the IRAD registry, the overall mortality rate during hospital admission for ATAAD was 5.8% at 48 hours, with a significant contrast between non-surgical and surgical cohorts. In the non-surgical group, the death rate was 0.5% per hour (23.7% at 48 hours), which decreased significantly to 4.4% in the surgical group at 48 hours (17). The initial mortality rate reported in the UK National Adult Cardiac Surgery Audit (UK National Adult Cardiac Surgical Audit) for ATAAD procedures was 17.8%, which decreased over time from 22% in 2009 to 15% in 2018 (18) and was comparable to that observed in the Nordic Consortium for Acute Type A Aortic Dissection (NORCAAD) of 16% (3).

These findings highlight two key points to note. First, high-volume patient registries have demonstrated that severe neurological damage, renal failure, and postoperative complications are significant barriers to successful surgical recovery (3-5,18). Secondly, the average age across these registries (60–64 years) and the risk factors for inpatient mortality in our study coincide with those reported in similar registries, including clinical conditions such as preoperative resuscitation, mechanical ventilation, and coexisting comorbidities (e.g., advanced age) (3,18,20-24).

Varying outcomes in average OM have been found among individual centres, which have reported consistent figures of metric discrepancies ranging from rates as high as 20% and 24% (25) to as low as 5.5% (26). These discrepancies also take into account the scope of the necessary surgical intervention. Recently, a referral centre with extensive experience in ATAAD (27) procedures reported a mean OM of 5.6%. There were no significant differences observed between patients who received 'conservative' surgical repair involving root sparing or a limited hemiarch procedure and those who underwent the most frequent surgical option, which involved replacing the aortic root and/or a TARP. This disparity is especially evident in high-volume aortic centres of excellence (26-30). In these centres, patients with ATAAD who received

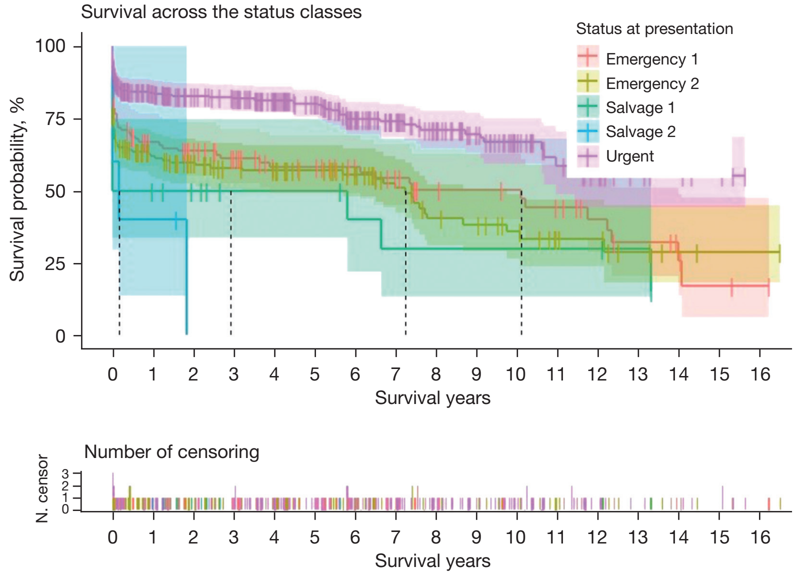

Figure 3 Survival according to urgency status. Kaplan-Meier curves to assess survival after type A aortic dissection repair. The curves are color-coded according to the urgency status at presentation, and the relative shaded areas represent the 95% confidence interval. The censored patients are represented by the short vertical lines along the survival curves. The dotted black lines represent the estimated median survival, which can only be calculated if the survival has dropped <50% for the relative subgroup at the end.

complex repairs experienced approximately half the OM reported in the GERAADA and NORCAAD registries (3,4). Specific surgical teams performing a higher volume of ATAAD procedures and with more experience in aortic surgery have highlighted this strategy for improving early outcomes and achieving successful surgical treatments for specific cohorts of patients (31-33).

Whole intimal tear resections associated with root-sparing aortic arch replacement (AAR) using interposition Dacron grafts with or without hemiarch repair remain the most commonly adopted surgical option for patients with ATAAD (5,17-20,23). Therefore, our findings emphasize the necessity of evaluating different surgical procedures, ranging from ascending aortic replacement to hemiarch repair or total arch replacement, based on thorough assessment of the aortic lesion. The surgical repair, excising the affected portion of the aorta, was determined by the location of the dissection entry tear. It is noteworthy that patients presenting with an entrance tear in the aortic arch aligned with the lesser curvature of the aorta receive conservative surgical treatment, where the ascending aortic replacement with an interposed prosthetic graft and hemiarch repair is prioritised. In contrast, patients with an entry tear near the supra-aortic branches require extensive surgery that involves replacement of the aortic arch. Similarly, in our series, the surgeon's decision to pursue extended surgical treatment was based on their clinical judgment, considering factors such as the patient's condition upon hospitalization, the severity of the aortic arch lesion, and the surgeon's technical expertise (1,34-36).

Significant advancements have been made in aortic surgery in recent years, making it advisable to refer patients to dedicated aortic centers with specialized expertise. The implementation of innovative technologies, improved surgical procedures, and greater employment of cerebral protection have facilitated more extensive surgical interventions to treat ATAAD. These may involve replacing the aortic arch, possibly including extensions into the proximal descending aorta, along with hybrid staged approaches (24-27,37). There are numerous advantages to expanding the initial ATAAD operation to encompass a larger section of the dissected aorta. The long-term risk of increased expansion and rupture of the resected aorta is lower; furthermore, a notable benefit for managing subsequent intravascular treatment options was observed. However, an anticipated medium to long-term benefit from a more extensive surgical option necessitates proper evaluation against the potential rise in morbidity and mortality related to greater complexity that must be managed in the primary procedure.

Table 6 Univariable logistic regression

Predictors	Mortality	
	Operative	Follow-up
Age	<0.01	<0.01
Body mass index	0.43	0.84
Female	0.37	0.24
Creatinine	<0.01	<0.01
Hemoglobin	0.07	0.15
Platelet count	0.13	0.46
Arterial lactate	<0.01	<0.01
Cardiac biomarkers increase	<0.01	0.48
Diabetes	0.61	0.60
Prior CVA	0.35	0.14
Pulmonary disease	0.01	<0.01
Extracardiac arteriopathy	0.64	0.16
Poor mobility	0.15	0.27
Moderate-to-severe frailty	0.13	0.32
Recent myocardial infarction	0.02	0.02
Preoperative cardiac massage	<0.01	<0.01
Intubated/sedated at arrival	<0.01	0.11
Status: emergency or salvage	<0.01	<0.01
Bicuspid aortic valve	0.46	0.14
Aortic regurgitation	0.65	0.53
Malperfusion	<0.01	<0.01
Cerebral perfusion	0.37	0.07
Root or arch replaced	0.98	0.99

Univariable predictors of operative mortality and follow-up mortality in patients who underwent repair of acute type A aortic dissection. Univariate logistic regression to determine the association between dependent (i.e., in-hospital and follow-up mortality) and independent variables. Predictors that presented an association with P<0.2 were entered into the multivariable models. CVA, cerebro-vascular accident.

The study shows that patients who underwent extensive surgical options including TARP procedures had a higher likelihood of experiencing adverse events. While previous studies have established the safety of TARP in elective procedures, the risk/benefit ratio has not yet been proposed. Surgical risks and potential benefits remain a topic of debate in the context of ATAAD. Studies have reported conflicting outcomes for open surgery and endovascular management (OM and PND). Consequently, the current data present contradictory findings that may misinform shared decision-making for ATAAD patients (24,25,27,38). One study revealed that there was an increased mortality rate associated with the extent of the procedure, which included the replacement of the aortic arch. The reported percentage of mortality ranged from 9.8% for a surgery limited to AAR, up to 21.6% for hemiarch repair and 28% for TARP (24). Another study similarly reported an OM of 13.4% in patients who received total arch replacement, and 9.7% in those who received hemiarch repair. It is worth noting that a higher incidence of PND was observed in TARP patients (22.7% *vs.* 6.3%) (39). However, two other studies contradict these findings. One report (25) noted that recipients of conservative surgical options had comparable rates of OM and PND to those managed with a more aggressive surgical option that included the use of TARP (24.1% *vs.* 22.6% and 9.1% *vs.* 7.5%). Similarly, another study (6) comparing the conservative approach of limited repair of the hemiarch with the more extensive treatment of FET showed no disparity in OM or PND.

In an ideal scenario, it is advisable to carry out thorough root and arch procedures on patients with low-risk, particularly those at a higher risk of reoperation. In the centers participating in the study, a modified Bentall procedure with a mechanical or bioprosthetic valve, was considered the gold standard intervention for TAAAD when the ARR needed a replacement for dilatation (larger than 4.5 cm), contains the intimal tear, or if the patient suffers by aortic valvulopathy or connective tissue disorder. The rare cases of valve-sparing aortic root replacement (VSARR) with reimplantation technique (David procedure) or remodeling technique (Yacoub procedure) were performed for younger patients by a surgeon with large experience with VSARR.

A recent meta-analysis (33) compared long-term outcomes of VSARR versus composite aortic valve graft replacement (CAVGR) shows well that VSARR has not any difference in terms of in-hospital mortality and long-term survival. Still, it presents a higher risk of reoperation and in the older population a higher risk of all-cause death.

This approach provides greater long-term survival benefits and reduces the likelihood of reintervention in patients who have received treatment for ATAAD. Sá *et al.* (33) noted a statistically significant variation in overall survival rates, suggesting that patients receiving an aggressive TARP approach had a better outcome (P=0.022), while those undergoing the aggressive surgical intervention were less likely to require reoperation (P=0.02) beyond

Table 7 Multivariable logistic regression

Predictor	Estimate	95% confidence interval		P value
		Lower limit	Upper limit	
Operative mortality				
Age	1.04	1.02	1.06	<0.01
Creatinine	1.00	0.99	1.01	0.17
Hemoglobin	0.99	0.98	1.01	0.51
Platelet count	1.00	0.00	1.00	0.57
Arterial lactate	1.37	1.20	1.58	<0.01
Cardiac biomarkers increment	1.14	0.64	1.98	0.65
Pulmonary disease	2.06	0.74	5.52	0.15
Poor mobility	3.03	1.20	7.52	0.02
Moderate-to-severe frailty	1.58	0.11	39.77	0.73
Recent myocardial infarction	1.81	0.54	5.67	0.31
Preoperative cardiac massage	1.30	0.45	3.69	0.62
Intubated/sedated at arrival	2.74	1.65	4.59	<0.01
Emergency or salvage	2.60	1.32	5.14	<0.01
Malperfusion	1.02	0.53	2.00	0.93
Follow-up mortality				
Age	1.03	1.01	1.04	<0.01
Creatinine	1.00	0.99	1.00	0.07
Hemoglobin	0.99	0.99	1.00	0.53
Arterial lactate	1.21	1.14	1.29	<0.01
Cerebro-vascular accident	1.47	0.80	2.70	0.21
Pulmonary disease	1.70	0.94	3.05	0.07
Extra-cardiac arteriopathy	0.92	0.45	1.90	0.83
Recent myocardial infarction	1.05	0.53	2.09	0.88
Preoperative cardiac massage	1.29	0.68	2.44	0.43
Intubated/sedated at arrival	1.68	1.21	2.32	<0.01
Emergency or salvage	2.04	1.37	3.04	<0.01
Bicuspid aortic valve	2.70	1.23	5.92	0.01
Malperfusion	0.82	0.54	1.25	0.37

Multivariable predictors of operative mortality and follow-up mortality in patients who underwent repair of acute type A aortic dissection. Only candidate variables with a P value ≤0.2 specifically for hospital or follow-up mortality were inserted respectively into the multivariable logistic regression and Cox regression models. The estimates express odds ratios for in-hospital mortality and hazard ratios for follow-up mortality.

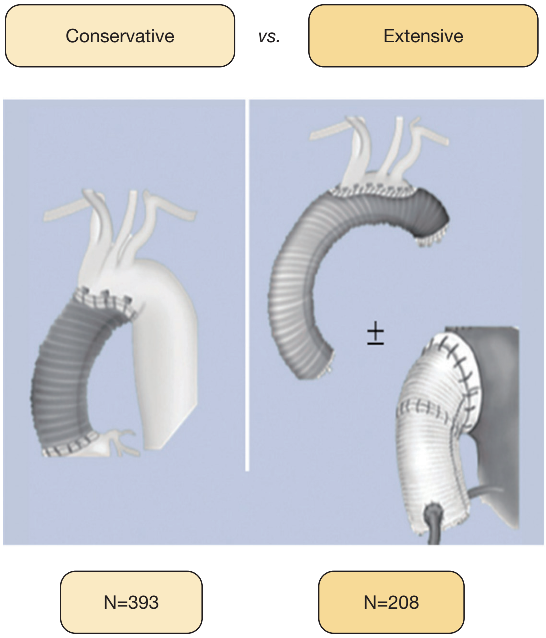

Figure 4 Ascending aorta replacement with hemiarch techniques or root replacement, and more extensive repair lead to consistently more less operative mortality in urgent and emergency 1 patients.

7 years. Our findings suggest that TARP should be performed taking into account the patient's clinical condition at the time of admission and following a precise evaluation of the lesion's size.

We acknowledge that our patient group has a lower proportion of individuals receiving the TARP procedure, at 17.2%, compared to other studies. This has resulted in a certain level of caution that has become a prevailing mindset among most surgeons, favouring simpler procedures. The conservative approach to surgery is rational, as using an interposition Dacron graft with or without hemiarch repair to replace the ascending aorta while preserving the root seems to be the favoured method over more daunting and intricate procedures. Benedetto and colleagues 18 recommended a comparable operative plan for patients referred for TARP surgery. This approach seems to be influenced by the existing UK policy that entails public reporting of individual surgeons' operative outcomes, which could encourage more cautious decisions like avoiding high-risk procedures that could result in poorer hospital outcomes. This is particularly relevant in the case of aortic arch replacement in the context of ATAAD (40-43).

In our analysis, we found that 21.7% of patients underwent total root replacement either with or without valve-sparing, and there was no difference in OM. Whilst the technical difficulty of ARR surgery in the setting of ATAAD may have a limiting effect, other studies with a vast number of patients have highlighted similar instances of OM, linked with lower rates of reoperation required for treatment of aortic root dysfunction (1,2,4,17,19). There have been reports stating TARP to be a priority surgical option for patients suffering from Ao-R destruction, simultaneous Ao-R aneurysm, bicuspid aortic disease, or a history of CTD (28,30,38,41,42). Recently, Lau and colleagues (23) found that a more extensive repair that included Ao-R and/or the entire aortic arch resulted in a higher predictive rate for repeat surgery compared to the less aggressive root sparing-AAR option with or without hemiarch surgery involvement (P=0.01) (27). Surgeons need to consider the anatomical extent of the aortic laceration when deciding on the appropriate surgical option. Our findings indicate that favorable outcomes were more influenced by the grade of the aortic lesion and the individual's deteriorating condition at admission rather than the percentage of surgical repair performed. Surgeons may inherently prefer less aggressive surgical options for subjects with multiple comorbidities and/or elderly individuals, compared to more extensive procedures aimed at low-risk and/or younger subjects. It is also necessary to establish clear and widely-shared criteria for evaluating the extent of aortic disease. Different assessment methods exist for determining the entry point and size of a laceration, while some may assess the extension of the dissected aorta. Nonetheless, these criteria play a crucial role in directing the most suitable surgical option to attain optimal results (27,30,31,38).

In our analysis, the use of cerebral perfusion as a strategy alone did not pose a risk in the multivariate analysis. When the strategy was taken into account, there was no discernible difference in postoperative mortality (P=0.37) or follow-up (P=0.07) between patients who underwent extensive surgery involving hemiarch and arch replacement. The study's findings align with those of the STS (19,23) and GERAADA (4,20) registries that examined unselected patients and conducted prospective single-center analysis. Both reports concluded that no correlation exists between the different cerebral perfusion approaches and outcomes. Further analysis suggests that various inherent biases may have influenced these outcomes.

Neuroprotective strategies were primarily based on the surgeon's discretion, with consideration for the patient's clinical condition and extensions during the resection of the dissected aorta. Cerebral perfusion strategies have shown notable advantages for patients undergoing complicated procedures with circulatory arrest for more than 30 minutes (20-22,30-32,38,41-46). Composite outcomes of significant adverse events were more frequent in the groups with worse clinical states (66.7% and 50.9% *vs.* 32.9% and 36.4%; P<0.01), indicating preoperative comorbidity rather than surgical technique (P=0.11). Despite extensive surgery and the anticipated prolonged operation time, careful preoperative patient selection, as observed in urgent and emergency 1 procedures, could reduce the added risk and improve the rates of early and late survival. The survival rates at 5 years (68.6% and 72.7% *vs.* 61.3% and 68.7%) and 10 years (53.4% and 55.6% *vs.* risk <10) were similar for both groups (P=0.56).

Although the comprehensive approach may serve as a substitute for high-risk populations with an inaccessible tear in the ascending aorta, CTD, or an existing large aneurysm that may indicate the requirement for further surgery, the patient's clinical condition upon admission ultimately determines the surgical option. While root replacement, TAR, and FET are potentially beneficial for these patients, their routine use may not be necessary or appropriate for most hemodynamically unstable patients exhibiting signs of malperfusions.

Our analysis has shown a significant association between mortality and compromised clinical condition upon hospital admission. The findings indicate that the rise in surgery-related fatalities may stem from exacerbated symptoms, unstable blood flow, and/or insufficient oxygen supply compounded by the need for emergency resuscitation.

Limitations

The study is limited by its retrospective design, which resulted in two groups of different sizes being compared for arch surgery versus surgery without arch involvement. Additionally, the multicentre nature of the study was impacted by variations in surgeon and centre preferences for cannulation and neuroprotective strategies, which could not be stratified. Furthermore, variances existed in the patient intake at each centre, which could have contributed to intangible factors including socioeconomic demographics and centre-specific experience.

Conclusions

Mortality rates for ATAAD remain high, with a strong association to the degree of presentation acuity. Outcomes for both operative and long-term treatment were primarily dependent on malperfusion, patient age, conscious state on arrival, and urgency, particularly within the emergency and salvage cohorts. The surgeon and centre experience should determine whether to include arch replacement as part of the repair, personalised to the patient and their presentation. This decision should weigh the additional risks associated with more extensive surgery against the need for further reintervention. Our study found that patients who underwent arch replacements during dissection had a higher stroke rate, despite being younger.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study complied with the Declaration of Helsinki (as revised in 2013). Patient consent was obtained after the assigned ethics approval from institutional review board of Montpellier University Hospital (IRB approval No. 202201173) in accordance with the research guidance. The other institutions are informed and agreed with the study.

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