Original Article

Safety of open limited surgery for septuagenarian and octogenarian acute type A aortic dissection patients: a retrospective cohort study

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Background: Surgical strategies in older adult patients with acute type A aortic dissection (aTAAD) are crucial. We investigated the safety and efficiency of open limited surgery for septuagenarian and octogenarian patients with aTAAD.

Methods: Between 2011 and 2019, 1,092 patients diagnosed with aTAAD underwent open surgery in Nanjing Drum Tower Hospital. Patients were divided into two groups based on age: <70 years (n=956) and ≥70 years (n=136). Preoperative baseline characteristics, operative data, and postoperative outcomes were compared between the two groups. To investigate the safety and efficiency of the surgical approach for those aged ≥70 years, we separated these patients into two groups: (I) those who underwent root-sparing surgery and less-invasive arch surgery (Limited group; n=86); and (II) all others (Extensive group; n=50).

Results: Mortality was significantly higher in those aged ≥70 years than in those <70 years (20.6% *vs.* 13.2%; P=0.000), with age being a strong risk factor for postoperative mortality [odds ratio (OR) 1.619; 95% confidence interval (CI): 1.015–2.582; P=0.043]. Patients aged ≥70 years tended to receive less invasive surgery, and the rates of root replacement and arch replacement were lower. Patients in the limited surgery group had a higher rate of pericardial tamponade, and the durations of surgery, hypothermic circulation arrest, cardiopulmonary bypass, and aortic clamp were all significantly shorter than in the extensive group. Mortality and postoperative complications were also lower in the limited surgery group.

Conclusions: Although older age was a risk factor for open surgery for aTAAD, limited surgical techniques could lower the mortality and morbidity regardless of the need for extensive surgery.

Keywords: Acute type A aortic dissection (aTAAD); octogenarian; septuagenarian; surgery

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Introduction

Acute aortic dissection is a life-threatening cardiovascular disease that is associated with significant morbidity and mortality. Unless immediate surgery is performed, patients usually die from complications related to the dissection, including rupture of the aorta, pericardial tamponade, aortic regurgitation, malperfusion, or acute heart failure (1-4). According to the Stanford classification of aortic dissections, those that involve the ascending aorta are referred to as acute type A aortic dissection (aTAAD) (5). Traditionally, the surgical strategy for repairing aTAAD has been directed toward preventing or treating the immediate life-threatening complications of ascending aortic dissection. This has led to the current paradigm of emergency replacement of the ascending aorta for most patients with aTAAD, with root reconstruction or extended arch replacement indicated when the intimal tear extends into the root or the arch (1).

The overall mortality of aTAAD remains high (6,7), and advanced age is still considered a strong independent risk factor for early postoperative mortality (4,8). Whether an operation should be performed in patients of advanced age remains contentious. Even after successful surgery, there is a greater tendency for complications in older adult patients (9). However, the nonsurgical treatment of patients with aTAAD is associated with high mortality (10). For these reasons, surgical strategies in older adult patients are crucial. Surgical techniques have improved considerably in the past decade and can be generally divided into two types: limited surgery and extensive surgery. Limited surgery normally includes root-sparing and less-invasive arch procedures, whereas extensive surgery includes root replacement and total arch surgery (11).

The world's progressively aging society presents a global medical challenge. Due to improved perioperative management and surgical techniques, older age is no longer a surgical contraindication, especially when nonsurgical treatments have poor outcomes relative to surgical interventions. Nonetheless, considering the range of clinical comorbidities in septuagenarian and octogenarian patients, surgeons may be unsure whether to perform limited surgery to minimize surgical damage or extensive surgery to manage all the problems in a single procedure.

This study was designed to investigate the safety and efficiency of open limited versus extensive surgery for septuagenarian and octogenarian patients with aTAAD. We present the following article in accordance with the STROBE reporting checklist (available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-533/rc).

Highlight box

Key findings

- Limited surgery strategies are safe for septuagenarian and octogenarian aTAAD patients.

What is known and what is new?

- Older age was a risk factor for open surgery for aTAAD; the choice of surgical strategy in older adult patients remains crucial.
- Limited surgery strategies could lower the mortality and morbidity, regardless of the need for extensive surgery in septuagenarian and octogenarian aTAAD patients.

What is the implication, and what should change now?

- Older adult patients with aTAAD may be given priority for limited surgery strategies when a patient's condition permits it.

Methods

Patient enrollment

Between 2011 and 2019, 1,172 patients were diagnosed with aTAAD (including the ascending aorta, arch, and descending aorta) and 1,092 underwent open surgery in Nanjing Drum Tower Hospital. To be eligible for inclusion in this study, patients had to have confirmed aTAAD and have undergone surgery in Nanjing Drum Tower Hospital between 2011 and 2019. Patients were divided into two groups based on age: <70 years (n=956, 87.5%) and ≥70 years (n=136; 12.5%). Preoperative baseline characteristics, surgical data, and postoperative outcomes were compared between these two groups. To investigate the safety and efficacy of the surgical approach for patients aged ≥70 years, this group was separated into two groups: a limited group, in which patients underwent root-sparing surgery and less-invasive arch surgery (n=86) and the extensive group, which consisted of patients undergoing all other surgeries (n=50). The enrollment of the study population is shown in *Figure 1*. Among the patients, 80 did not undergo surgery, and 31 (38.8%) were ≥70 years of age.

Definitions

We retrospectively reviewed clinical records and data and extracted information regarding patient demographics, preoperative baseline characteristics, surgical data, and postoperative outcomes. Postoperative morbidity included

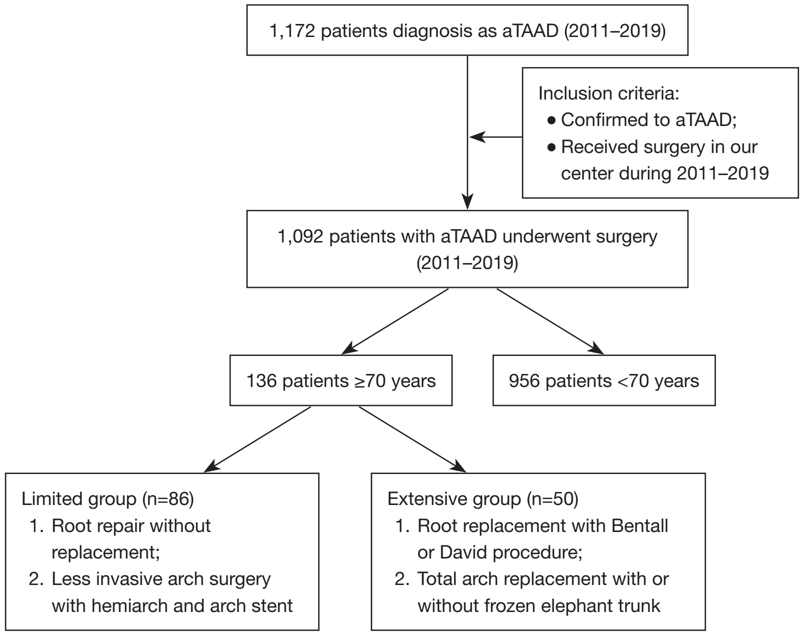

Figure 1 Flowchart of patient enrollment. aTAAD, acute type A aortic dissection.

re-exploration, mechanical ventilation (h), reintubation, tracheotomy, intracranial hemorrhage (ICH), stroke, paraplegia, gastrointestinal bleeding, bowel ischemia, acute renal failure [creatinine >353.6 μmol/L as per the Kidney Disease Improving Global Outcomes (KDIGO) criteria], continuous renal replacement therapy (CRRT), and deep sternal wound infection. Postoperative mortality was assessed as 30-day or in-hospital mortality. Postoperative mortality was used as the primary outcome to investigate the safety and efficacy of the surgical strategy.

Treatment strategy

If a patient presented with unstable symptoms, such as tamponade or organ malperfusion, when arriving at the hospital, the patient was directly transferred to the operating theater; stable patients were transported to the cardiovascular intensive care unit for a thorough preoperative evaluation and preparation. All patients with aTAAD underwent urgent or emergency repair.

Cardiopulmonary bypass (CPB) and deep hypothermic circulatory arrest were used for surgical management. Peripheral cannulation for CPB was femoral or axillary artery cannulation, or both. Antegrade perfusion of the coronary artery plus retrograde perfusion from the coronary sinus was used for intraoperative myocardial protection. Circulatory arrest was instituted once adequate cooling was achieved. Unilateral selective antegrade cerebral perfusion was performed via the right axillary artery, or retrograde cerebral perfusion was started via the superior vena cava cannula. The extent of aortic replacement was determined according to the patient's anatomic and clinical characteristics, as well as on the experience of the operating surgeon such as Wang, Zhou, Pan, *et al.*, who performed more than 50 TAAD operations every year. A frozen elephant trunk (MicroPort Medical, Shanghai, China) was used at the same time for total arch replacement. Otherwise, partial aortic arch replacement or an antegrade-implanted arch stent was used (2 kinds of stents had been previously introduced in Nanjing Drum Tower Hospital). The proximal root underwent the Bentall procedure or the root reinforcement technique, after which the ascending aorta was replaced.

Limited surgery included root repair without replacement or less-invasive arch surgery with a hemiarch and arch stent (12-14). Extensive surgery included root replacement with the Bentall or David procedure and total arch replacement with or without the use of the frozen elephant trunk.

Statistical analysis

Statistical analyses were performed with SPSS 24.0 (IBM Corp., Armonk, NY, USA). Categorical and dichotomous data are presented as absolute numbers and simple percentages, and were compared using the chi-squared test. For counts less than 5, Fisher exact test was used to compare groups. Normally distributed continuous variables are presented as the mean ± SD and were compared between groups using Student *t*-test or the Mann-Whitney test. Multivariable logistic regression was used to assess risk factors for 30-day mortality and calculate 95% confidence intervals (CIs). Statistical significance was set at P<0.05.

Ethics statement

We prospectively collected clinical data for patients from their admission to until their discharge from hospital. In addition, data were retrieved from hospital records and reviewed retrospectively. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Institutional Review Board of Nanjing Drum Tower Hospital (No. 2020-185-01). Because of the retrospective nature of the study, the requirement for informed consent was waived.

Results

Baseline characteristics

Patients were divided into two age groups: those aged ≥70 and <70 years. Baseline characteristics are presented in *Table 1*. Besides age and age-related cardiovascular disease such as stroke and coronary artery disease, younger patients

Table 1 Comparison between group <70 and ≥70 years

Variables	<70 years (N=956)	≥70 years (N=136)	P value
Baseline characteristics			
Age (years)	49.8±10.8	75.0±4.1	0.000
Male	742 (77.6)	74 (54.4)	0.000
BMI (kg/m^2)	25.8±4.7	24.0±3.9	0.000
Hypertension	703 (73.5)	104 (76.5)	0.466
Marfan	26 (2.7)	0 (0.0)	0.052
Diabetes	31 (3.2)	9 (6.6)	0.050
Smoke	232 (24.3)	18 (13.2)	0.004
Alcohol	154 (16.1)	13 (9.6)	0.0047
End stage kidney disease	22 (2.3)	1 (0.7)	0.234
Stroke history	18 (1.9)	13 (9.6)	0.000
CAD history	19 (2.0)	8 (5.9)	0.006
COPD history	7 (0.7)	4 (2.9)	0.016
AF history	7 (0.7)	3 (2.2)	0.092
Organ malperfusion	300 (31.4)	42 (30.9)	0.907
Hypotension	55 (5.8)	9 (6.6)	0.688
Pericardial tamponade	108 (11.3)	23 (16.9)	0.059
Operation data			
OP duration	8.0±2.2	7.6±1.9	0.028
HCA	30.6±11.4	28.2±8.6	0.004
CPB	241.9±77.3	227.1±66.1	0.035
X-clamp	168.1±62.4	158.1±50.4	0.075

Table 1 *(continued)*

Table 1 *(continued)*

Variables	<70 years (N=956)	≥70 years (N=136)	P value
Root procedure			0.060
No	15 (1.6)	2 (1.5)	
Root reconstruction	664 (69.5)	104 (76.5)	
Root reconstruction + cusp repair	31 (3.2)	9 (6.6)	
Wheat's	19 (2.0)	2 (1.5)	
Bentall	210 (22.0)	18 (13.2)	
VSRR	17 (1.8)	1 (0.7)	
Arch procedure			0.015
Sub-arch	164 (17.2)	53 (39.0)	
Total arch + FET	480 (50.2)	34 (25.0)	
Arch stent	311 (32.5)	49 (36.0)	
Mortality & morbidity			
30-day mortality	126 (13.2)	28 (20.6)	0.000
Mechanical ventilation	56.8±81.9	51.4±54.9	0.486
Reintubation	59 (6.2)	11 (8.1)	0.393
Tracheotomy	34 (3.6)	10 (7.4)	0.035
ICH	8 (0.8)	7 (0.7)	0.903
Stroke	52 (5.4)	7 (5.1)	0.888
Paraplegia	22 (2.3)	1 (0.7)	0.234
GI bleeding	9 (0.9)	4 (2.9)	0.044
Limb ischemia	13 (1.4)	0 (0.0)	0.171
Bowel ischemia	11 (1.2)	5 (3.7)	0.022
Surgical site infection	35 (3.7)	2 (1.5)	0.187
Acute renal failure	302 (31.6)	37 (27.2)	0.301
CRRT	106 (11.1)	21 (15.4)	0.139
Re-exploration	57 (6.0)	6 (4.4)	0.468
ICU stay (days)	7.0±7.9	8.2±10.2	0.217
Hospital stay (days)	20.9±12.5	19.7±16.6	0.425

Data are shown as n (%) or mean ± standard deviation. BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; OP, operation; HCA, hypothermic circulatory arrest; CPB, cardiopulmonary bypass; X-clamp, aortic clamp; VSRR, valve sparing root reconstruction; FET, frozen elephant trunk technique; ICH, intracranial hemorrhage; GI, gastrointestinal; CRRT, continuous renal replacement therapy; ICU, intense care unit.

had higher rates of being overweight, smoking, and drinking. There was a lower prevalence of male patients in the group ≥70 years than that <70 years (54.5% *vs.* 77.6%). Although in those aged ≥70 years here was a higher prevalence of diabetes (6.6% *vs.* 3.2%), chronic obstructive pulmonary disease (2.9% *vs.* 0.7%), atrial fibrillation (2.2% *vs.* 0.7%), and preoperative pericardial tamponade (16.9% *vs.* 11.3%), the differences did not reach statistical

Table 2 Multivariate regression analysis to compare preoperative risk factors

Variables	OR	95% CI	P value
≥70 years	1.619	1.015–2.582	0.043
Organ malperfusion	1.540	1.076–2.202	0.018
Pericardial tamponade	3.059	2.001–4.677	0.001

OR, odds ratio; CI, confidence interval.

significance. Preoperative organ malperfusion had a considerable effect on the outcome of aortic dissection, but is not part of our discussion in this study; the occurrence rate of preoperative organ malperfusion was similar in both age groups (30.9% *vs.* 31.4%; P=0.907).

Operative data

Patients aged ≥70 years had a lower proportion of total arch replacement + frozen elephant trunk than did those aged <70 years (25.0% *vs.* 50.2%; P=0.015). Patients aged ≥70 years tended to receive root reconstruction or no root procedure at all when possible. Although not statistically significant, patients aged ≥70 years had a lower proportion of Bentall and valve-sparing root replacement procedures than did patients aged <70 years (13.2% *vs.* 22.0% and 0.7% *vs.* 1.8%, respectively; P=0.060). The overall duration of surgery, hypothermic circulation arrest (HCA), CPB, and aortic clamp (X-clamp) time were all significantly shorter in the ≥70 years group.

Perioperative outcomes

The 30-day mortality rate was significantly higher in the ≥70 years than in the <70 years group (20.6% *vs.* 13.2%; P=0.000). Multivariate regression analysis revealed that age ≥70 years was a strong risk factor for early postoperative mortality [odds ratio (OR) 1.619; 95% confidence interval (CI): 1.015–2.582; P=0.043; *Table 2*]. A larger proportion of patients aged ≥70 years required a tracheotomy (7.4% *vs.* 3.6%; P=0.035) and experienced gastrointestinal bleeding (2.9% *vs.* 0.9%; P=0.044) and bowel ischemia (3.7% *vs.* 1.2%; P=0.022). There were no significant differences between the two groups in other in-hospital outcomes, including prolonged mechanical ventilation, reintubation, ICH, stroke, paraplegia, limb ischemia, surgical site infection, acute renal failure, need for CRRT, re-exploration for bleeding, or prolonged intensive care unit stay/hospital stay.

International registry studies have confirmed that the incidence of aTAAD surgical mortality and morbidity is significantly higher in septuagenarian and octogenarian patients (7,15,16); even so, a surgical approach is better than nonsurgical therapy. Therefore, we compared limited and extensive surgery in patients with aTAAD aged ≥70 years to optimize surgical injury and improve survival in older adult patients with aTAAD.

Limited versus extensive surgery in patients aged ≥70 years

The baseline characteristics of the limited and extensive surgery groups are presented in *Table 3*; the characteristics were similar between the two groups, except for preoperative pericardial tamponade. With regard to surgical data, the duration of operation, HCA, CPB, and X-clamp time were all significantly shorter in the limited surgery group, as expected. The postoperative need for CRRT was significantly lower in the limited surgery group. In addition, 30-day mortality (17.4% *vs.* 26.0%) and other postoperative complications, including reintubation (4.7% *vs.* 14.0%), ICH (0% *vs.* 2.0%), paraplegia (0% *vs.* 2.0%), acute renal failure (23.3% *vs.* 34.0%), and re-exploration for bleeding (2.3% *vs.* 8.0%), were lower in the limited surgery group. Unexpectedly, the occurrence of postoperative stroke was greater in the limited compared with extensive surgery group (8.1% *vs.* 2.0%). This is probably closely related to the hemodynamic instability caused by preoperative pericardial tamponade. Patients who experienced a stroke were transferred to a chronic care facility and, during follow-up, there was no further increase in 30-day mortality.

Discussion

Old age remains a strong independent risk factor for increased early in-hospital death of patients with aTAAD that should be taken into consideration. Globally, populations are aging, which poses considerable medical challenges, especially for high-risk operations such as aTAAD. According to the International Registry of Acute Aortic Dissection (IRAD), septuagenarians and octogenarians had higher 30-day mortality rates than did younger patients (17). Neri *et al.* reported an 83% in-hospital mortality rate for octogenarians with aTAAD (18). Most centers report favorable results, with an approximate 13% thirty-day mortality rate in older adult patients (19,20). In addition, excellent surgical outcomes for patients aged

Table 3 Comparison between Limited surgery group and Extensive surgery group in Septuagenarian and Octogenarian group

Variables	Limited surgery (N=86)	Extensive surgery (N=50)	P value
Baseline characteristics			
Age (years)	75.3±4.1	74.5±4.2	0.285
Male	40 (46.5)	34 (68.0)	0.025
BMI (kg/m^2)	24.4±3.5	24.0±2.9	0.497
Hypertension	67 (77.9)	37 (74.0)	0.606
Diabetes	7 (8.1)	2 (4.0)	0.351
Smoke	13 (15.1)	5 (10.0)	0.398
Alcohol	9 (10.5)	4 (8.0)	0.639
End stage kidney disease	1 (1.2)	0 (0.0)	0.446
Stroke history	8 (9.3)	5 (10.0)	0.894
CAD history	4 (4.7)	4 (8.0)	0.425
COPD history	3 (3.5)	1 (0.7)	0.622
AF history	1 (1.2)	2 (4.0)	0.279
Organ malperfusion	19 (22.1)	17 (34.0)	0.131
Hypotension	4 (4.7)	5 (10.0)	0.228
Pericardial tamponade	19 (22.1)	4 (8.0)	0.035
Operation data			
OP duration	7.2±1.6	8.4±2.1	0.001
HCA	26.5±8.5	30.9±8.3	0.004
CPB	215.8±61.5	246.3±69.6	0.009
X-clamp	147.6±42.6	175.9±57.8	0.003
Mortality & morbidity			
30-day mortality	15 (17.4)	13 (26.0)	0.236
Mechanical ventilation	51.5±55.7	51.2±54.2	0.984
Reintubation	4 (4.7)	7 (14.0)	0.055
Tracheotomy	7 (8.1)	3 (6.0)	0.646
ICH	0 (0.0)	1 (2.0)	0.190
Stroke	7 (8.1)	1 (2.0)	0.144
Paraplegia	0 (0.0)	1 (2.0)	0.190
GI bleeding	2 (2.3)	2 (4.0)	0.579
Bowel ischemia	3 (3.5)	2 (4.0)	0.879
Surgical site infection	1 (1.2)	1 (2.0)	0.697
Acute renal failure	20 (23.3)	17 (34.0)	0.176
CRRT	8 (9.3)	13 (26.0)	0.010
Re-exploration	2 (2.3)	4 (8.0)	0.122
ICU stay (days)	7.8±7.7	9.0±13.5	0.941
Hospital stay (days)	19.6±15.9	19.9±17.7	0.522

Data are shown as n (%) or mean ± standard deviation. BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; OP, operation; HCA, hypothermic circulatory arrest; CPB, cardiopulmonary bypass; X-clamp, aortic clamp; ICH, intracranial hemorrhage; GI, gastrointestinal; CRRT, continuous renal replacement therapy; ICU, intense care unit.

>70 years have been reported, with an in-hospital mortality rate below 3.7% (21). Overall, advanced age alone still has a considerable effect on higher early mortality rates compared with rates in young patients, which is consistent with the results of the present study. The mortality rate of older patients has decreased as a result of advances in medical care and surgical technology, but the survival rate after 30 days cannot be ignored. Bojko *et al.* reported that the survival rates at 5 years were 49.7% in septuagenarians and 34.2% in octogenarians (9), which are lower than rates in younger patients (22).

In addition to 30-day mortality and long-term survival rates, septuagenarian and octogenarian patients are likely to have a wide range of clinical comorbidities (23,24). Older adult patients have greater chance of underlying disease before the onset of aTAAD, which may contribute to postoperative comorbidities (17). The baseline characteristics of patients aged ≥70 years in the present study indicated a higher percentage of diabetes in this group, as well as higher histories of stroke, coronary artery disease, and chronic obstructive pulmonary disease. In addition, older adult (≥70 years) patients had a higher incidence of tracheotomy, gastrointestinal bleeding, and bowel ischemia compared with younger patients. Their relatively frail status makes it more difficult for older adult patients to withstand surgical trauma; thus, the value of extensive surgical repair remains contentious. This may make it more likely for families of older adult patients to refuse surgical treatment compared with families of younger patients.

International registration studies have confirmed that aTAAD surgical mortality and morbidity are significantly increased in septuagenarian and octogenarian patients (7,15,16); even so, surgical therapy is better than nonsurgical therapy. Data from the German Registry for Acute Aortic Dissection Type A (GERAADA) showed that nonoperative 30-day mortality in octogenarians was as high as 75%, whereas in those who underwent surgery, it was 35% (8). The IRAD reported a similar finding (4). However, the extent of an aortic dissection tear is unpredictable, and involvement of the root can be deadly. Given these conditions, surgery for septuagenarian and octogenarian aTAAD patients is still worth the risk. Therefore, minimizing surgical injury and improving survival in older adult aTAAD patients are of the utmost importance.

In the present study we compared limited and extensive surgery in septuagenarian and octogenarian aTAAD patients. We found that the latter are more likely to need CRRT. This may be due to the longer duration of surgery, HCA, CPB, and X-clamp time. There were no significant differences in mortality and morbidity between those undergoing limited and extensive surgery likely because the patients were not preselected and the patients' conditions determined the surgical options. Patients who underwent extensive surgery had higher rates of 30-day mortality, reintubation, stroke, and re-exploration although these different were not statistically significant. Based on our data, limited surgery was relatively safer than extensive surgery, regardless of the primary tear, in older adult patients, especially in patients with hemodynamic instability. Because readmission is not the main concern in older adult patients, limited surgery is safe and effective for septuagenarian and octogenarian aTAAD patients.

Limitations

This study has several limitations. First, it was a retrospective study conducted at a single institution. Second, patient selection bias was inevitable given that patients' treatments were sometimes selected on the basis of the patients' anatomic and clinical characteristics. We were also unable to assess the outcome of different surgical techniques, as we did not perform randomized surgical selection. Third, further studies are required to assess late outcomes in septuagenarian and octogenarian patients after aTAAD surgery.

Conclusions

Older age remains a risk factor for open surgery for aTAAD, but the mortality and morbidity of limited surgery techniques were found to be acceptable, regardless the need for more extensive surgery in certain older adult aTAAD patients.

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data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-533/rc

Data Sharing Statement: Available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-533/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-533/coif). The authors have no conflicts of interest to declare.

Ethics 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. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Institutional Review Board of Nanjing Drum Tower Hospital (No. 2020-185-01). Because of the retrospective nature of the study, the requirement for informed consent was waived.

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