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Physical activities and surgical outcomes in elderly patients with acute type A aortic dissection

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Abstract

Objective: Although elderly patients undergoing surgery for acute type A aortic dissection (ATAAD) is increasing, their physical activities are not fully understood. We report the physical activities and surgical outcomes in the elderly patients who underwent ATAAD. Methods: From 2009 to 2019, 103 consecutive patients underwent surgery for ATAAD at our institution. Surgical outcomes along with pre- and postoperative physical activities in 52 elderly patients ([?]70 years old) were compared with those in 51 younger patients (<70 years old). Postoperative walking difficulty was defined as taking [?]30 days to regain the ability to walk 200 m postoperatively or as the inability to walk at discharge. Results: It took longer for elderly patients to regain the ability to walk 100 or 200 m postoperatively. ROC analysis revealed the AUC of the duration for walking 200 m postoperatively as a prognostic indicator for late deaths was 0.878, with the highest accuracy at 30 days (sensitivity = 83.3%, specificity = 91.8%). Hospital mortality within 30 days was 3.8%, and 1-, 3-, and 5-years survival rates were 92%, 84.7%, 84.7%, respectively, for elderly patients, with no significant differences between groups. Cox proportional hazard analysis showed postoperative walking difficulty was an independent risk factor for late mortality in all cohorts (P = 0.017). Conclusions: Elderly patients undergoing surgical ATAAD repair showed acceptable surgical outcomes. However, they were more likely to decrease their physical activities postoperatively. Postoperative difficulty in walking was an independent risk factor for the late mortality in patients with ATAAD.

ORIGINAL ARTICLE

Physical activities and surgical outcomes in elderly patients with acute type A aortic dissection

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Abstract

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Methods: From 2009 to 2019, 103 consecutive patients underwent surgery for ATAAD at our institution. Surgical outcomes along with pre- and postoperative physical activities in 52 elderly patients ([?]70 years old) were compared with those in 51 younger patients (<70 years old). Postoperative walking difficulty was defined as taking [?]30 days to regain the ability to walk 200 m postoperatively or as the inability to walk at discharge.

Results: It took longer for elderly patients to regain the ability to walk 100 or 200 m postoperatively. ROC analysis revealed the AUC of the duration for walking 200 m postoperatively as a prognostic indicator for late deaths was 0.878, with the highest accuracy at 30 days (sensitivity = 83.3%, specificity = 91.8%). Hospital mortality within 30 days was 3.8%, and 1-, 3-, and 5-years survival rates were 92%, 84.7%, 84.7%, respectively, for elderly patients, with no significant differences between groups. Cox proportional hazard analysis showed postoperative walking difficulty was an independent risk factor for late mortality in all cohorts ($P = 0.017$).

Conclusions: Elderly patients undergoing surgical ATAAD repair showed acceptable surgical outcomes. However, they were more likely to decrease their physical activities postoperatively. Postoperative difficulty in walking was an independent risk factor for the late mortality in patients with ATAAD.

KEYWORDS

aortic dissection, rehabilitation, elderly patients, surgery, physical activities

INTRODUCTION

Acute type A aortic dissection (ATAAD) is a serious and lethal cardiovascular event, and surgical repair is essential to help these patients.[1] Old age is a risk factor for in-hospital mortality in cardiovascular surgery,[2] and according to the data of The International Registry of Acute Aortic Dissection (IRAD), age [?]70 years is a significant predictor of in-hospital surgical mortality in ATAAD.[3] In contrast, it has been reported that octogenarian patients showed satisfactory surgical outcomes and survival rates, which suggests a confident approach toward emergency repair in elderly patients.[4] Physical activities are important prognostic factors for late mortality in elderly patients with cardiovascular disease.[5] Cassiatore et al reported that walking ability is strongly related to mortality and morbidity in elderly patients after cardiac coronary artery bypass grafting.[6] However, there are few studies that investigated the rehabilitation outcomes and postoperative physical activities for ATAAD in elderly patients.[7, 8] The specific types and intensities of rehabilitation that may be both safe and beneficial postoperatively for patients who underwent ATAAD is still controversial.[7]

We report our experience with ATAAD surgery in patients aged [?]70. The outcomes of our rehabilitation program based on walking exercise and the surgical outcomes of ATAAD repair in these patients were

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compared with those in patients aged <70 years. We also assessed how postoperative physical activities impact late mortality in the patients with ATAAD.

MATERIALS AND METHODS

Patients

We retrospectively reviewed 103 consecutive patients who were admitted to the emergency ward of Yokosuka General Hospital Uwamachi from January 2009 to December 2019 and underwent surgical repair for ATAAD. The patients were grouped by age; 52 patients aged [?]70 years were assigned to the elderly group (median age, 78 years [74–83]; range, 70–94) and 51 patients aged <70 years were assigned to the control group (median age, 61 years [52.5–65.5]; range, 41–69). Surgical outcomes and physical activities before and after surgery were compared between the groups. In addition, rehabilitation outcomes in the patients regaining ambulatory autonomy at discharge were compared between the groups (30 patients in the elderly group vs 37 patients in the control group). Our selection process and the number of selected patients are shown in Figure 1. The Institutional Review Board approved this retrospective observational study. Approval included a waiver of informed consent.

Methods

Computed tomography angiography and echocardiography were used to provide a definitive ATAAD diagnosis. After the diagnosis was confirmed, the patient was promptly transferred to the operating room. The ATAAD was confirmed by intraoperative findings. Variables were collected from patient's medical records and preoperative examination. Preoperative characteristics including sex, body mass index (BMI), comorbidities, type of aortic dissection, malperfusion, shock (systolic blood pressure (sBP) level <80 mmHg), and pre- and postoperative physical activities were compared between the groups. Surgical variables including operation time, cardiopulmonary bypass time, surgical procedure, postoperative complications, intensive care unit (ICU) and hospital stay, hospital death within 30 days, use of walking aids at discharge, late mortality, and aortic reintervention were also compared between the groups. In the patients who regained ambulatory autonomy at discharge, rehabilitation outcomes including duration to ability to walk 100 and 200 m postoperatively, blood pressure levels before and after rehabilitation, antihypertensive drug administration during rehabilitation, intervention of speech and swallowing therapy after extubation, and duration of ICU and hospital stay were also compared between the groups. Long-term outcomes were obtained through patient follow up. We examined patients at our outpatient clinic. The median follow-up period for the entire cohort was 49 months (19.5–90.5), and the follow-up rate was 100%.

We applied the same surgical strategies for the elderly patients and the young patients. Our surgical procedure comprised median sternotomy with standard cardiopulmonary bypass. The subclavian artery, left ventricular apex, or femoral artery was used for arterial cannulation. Antegrade or retrograde of cold blood cardioplegic solution was infused for myocardial protection. Surgery was performed under hypothermic circulatory arrest (bladder temperature, 20degC–26degC), and open distal anastomosis was performed under circulatory arrest with or without antegrade selective cerebral perfusion. In general, a tear-oriented surgical strategy was conducted.[9] Ascending replacement was performed in patients for whom the entry site was located in the ascending aorta or was not found in the ascending aorta or aortic arch (DeBakey IIIb retrograde dissection). Total or partial arch replacement was performed in patients whose entry site extended to or was located in the aortic arch. Although aortic valves were preserved whenever possible, we performed aortic root replacement when the intimal tear extended to the sinus of Valsalva or when we observed root dilation associated with annuloaortic ectasia.

Rehabilitation program

Our rehabilitation program began on day 1 postoperatively. Range of motion exercise and respiratory rehabilitation were performed on the bed during intubation on day 1. After extubation, patients with hoarseness and dysphagia proactively underwent speech and swallowing therapy. Physical rehabilitation was carried out in a seated position on the bed and included foot stepping, standing by the bedside, and walking

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50 m. Afterward, walking distance was gradually increased from 100 to 200 m, depending on the patient's condition. Patients who walked at discharge were confirmed to be able to walk >200 m before discharge. Patients who were unable to walk postoperatively due to paraplegia or major cerebral infarction did not participate in the rehabilitation program. Systolic and diastolic blood pressure (dBP) levels were monitored before and after rehabilitation. According to the guidelines for rehabilitation in patients with cardiovascular disease,[10] patients with communicating and noncommunicating aortic dissection after surgery had sBP level maintained at [?]120 mmHg and [?]130 mmHg, respectively, during rehabilitation with antihypertensive drugs including calcium blockers, angiotensin II receptor blockers (ARBs), angiotensin-converting-enzyme (ACE) inhibitors, or beta blockers. Postoperative computed tomography angiography was performed within 7 days to assess whether the false lumen of descending aorta or below was thrombosed or not. During rehabilitation, patients who presented with leg fatigue, dyspnea, or who were evaluated by physical therapists to be at risk of falling were discontinued from walking. We followed the discontinuance criteria of the rehabilitation described in the guidelines for rehabilitation in patients with cardiovascular disease (JCS 2012).[10].

Physical activity

The Barthel index and walking ability were assessed before surgery and at discharge in the patients with ATAAD. The Barthel index is a widely used instrument that assesses activities of daily living.[11] The Barthel index score ranges from 0 (completely dependent) to 100 (totally independent), which mean that lower scores reflect greater nursing dependence.[12]Walking ability was assessed in terms of the patients being able to walk without any aid; with assistive devices, such as a walker and crutches; needed a wheelchair; or were bedridden with all assistance. Postoperative walking difficulty was defined as patients who needed more than 30 days to be able to walk a distance of 200 m after surgery or were unable to walk at discharge.

Statistical Analysis

Continuous data are expressed as the median (25–75 interquatile range), although the Barthel index is expressed as mean +- SD. All continuous data were compared between the two groups using Mann–Whitney U test. Categorical data are expressed as frequencies (%) and evaluated using the chi-square test or Fisher's exact test. The prognostic value of the duration that patients could walk 100 m or 200 m after surgery was evaluated using receiver operating characteristic (ROC) curve for late mortality. Overall survival was defined as the time from surgery to death from any cause. Time-related survival was estimated using Kaplan–Meier method and compared using a log-rank test between the two groups. Cox proportional hazards analysis was used to determine the risk factors for late mortality. Predictors were entered into a univariable analysis, and any variable with a p value of [?]0.05 (and aged [?]70 years) was entered into the multivariable analysis. All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan) or Prism version 8.0 (GraphPad Software, San Diego, CA, USA). A p value of <0.05 was considered statistically significant. The overall survival and ROC curve figures were created using Prism version 8.

RESULTS

Patient characteristics

Preoperative clinical characteristics of the patients are presented in Table 1.

Significantly more patients in the elderly group were female ($P< 0.001$), and thus, BMI was significantly lower in the elderly group ($P < 0.001$). There were no significant differences for hypertension, hyperlipidemia, diabetes mellitus, chronic kidney disease, preoperative shock status (sBP > 80 mmHg), cardiac tamponade, and neurologic deficit between the groups. Interestingly, patients in the elderly group were significantly more likely to have undergone DeBakey type II dissection and noncommunicating dissection compared with the patients in the control group (DeBakey type II: $P = 0.0349$, noncommunicating aortic dissection: $P< 0.001$). There were no significant differences for malperfusion between the groups. Although preoperative walking ability was not significantly different between the groups, the Barthel index in the elderly group was significantly lower than the control group ($P = 0.008$).

Operative details and complications

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Operative details and complications are shown in Table 2. Ascending aortic replacement was more likely in the elderly group ($P = 0.065$). Arch replacement was less likely in the elderly group, but there was no statistically significant difference ($P = 0.091$). There was no significant difference in aortic root replacement, concomitant aortic valve replacement, and coronary artery bypass grafting between the groups. Because of more ascending aortic replacement and less arch replacement in the elderly group, pump run time, aortic cross-clamp time, and operation time were significantly lower in the elderly group (pump run time: $P < 0.001$; aortic cross-clamp time:$P = 0.003$; operation time: $P < 0.001$).

Among postoperative complications, stroke, pneumonia, mediastinitis, intestinal ischemia, long-term intubation (>3 weeks), and re-exploration for bleeding were not significantly different between the groups. Frequency of postoperative temporary or permanent hemodialysis were significantly lower in patients in the elderly group ($P = 0.015$). Postoperative dysphagia occurred significantly more frequently in elderly patients ($P = 0.017$). ICU stay was likely to be longer in the elderly group ($P = 0.094$); hence, the duration of hospitalization was significantly longer in the elderly group (P= 0.045). Elderly patients with ATAAD surgery were more likely to decrease their walking ability at discharge because they were significantly less likely to discharge by walking without any aids ($P = 0.021$) and more likely to discharge with a wheelchair compared with patients in the control group ($P = 0.052$). Postoperative walking difficulty was significantly more advanced in the elderly group ($P = 0.013$); therefore, the Barthel index for the elderly group on discharge was significantly lower than the control group ($P = 0.032$).

Rehabilitation outcomes

The rehabilitation outcomes were compared between the groups to assess their physical activities among the patients regaining ambulatory autonomy at discharge (30 patients in the elderly group, and 37 patients in the control group). Preoperative characteristics and operative details in patients are presented in Supplemental Table 1 and Supplemental Table 2. Rehabilitation outcomes in patients regaining ambulatory autonomy at discharge are presented in Table 3. During rehabilitation, it was likely that elderly patients took longer to walk 100 or 200 m postoperatively ($P = 0.024$ and $P = 0.025$, respectively); although, there was no difference in postoperative walking difficulty between the groups. Elderly patients required significantly more speaking and swallowing therapy after surgery ($P = 0.043$). However, the length of ICU stay and the total hospitalization were not significantly different between the groups. There was no difference in communicating dissection between the groups postoperatively. Pre-rehabilitation sBP and dBP levels were 112.5 mmHg (104.3–120) and 68 mmHg (61.5–74), respectively, in the elderly group compared with 121.5 mmHg (110–130) and 72 mmHg (60–75), respectively, in the control group. Post-rehabilitation sBP and dBP levels were 123 mmHg (112.3–133.3) and 75 mmHg (65.5–81.3), respectively, in the elderly group compared with 121 mmHg (110–134.3) and 70 mmHg (59–80), respectively, in the control group. There were no statistical differences in pre-rehabilitation and post-rehabilitation blood pressure levels between the groups. During the rehabilitation program, antihypertensive drugs, including calcium blockers, ARB or ACE inhibitors, and beta blockers, were prescribed to control blood pressure. The ARB and ACE inhibitors were needed less significantly in patients in the elderly group to control the blood pressure ($P = 0.003$), although the use of calcium blockers and beta blockers was not significantly different between the groups. The combination of the aforementioned three drugs was needed less significantly in patients in the elderly group to control blood pressure ($P = 0.004$).

The prognostic value of patients' ability to walk 200 m postoperatively was evaluated using ROC analysis; the results showed that AUC as a prognostic indicator for late mortality was 0.878 (95% confidence interval [CI]: 0.722–1; $P = 0.002$), with the highest accuracy at 30 days (sensitivity = 83.3%, specificity = 91.8%; Figure 2A). Evaluation of patient's ability to walk 100 m postoperatively using the ROC analysis as well, the AUC as a prognostic indicator for late mortality was 0.878 (95% CI: 0.753–1; $P = 0.002$), with a the highest accuracy at 20 days (sensitivity = 83.3%, specificity = 82%; Figure 2B).

Long-term outcomes

There were eight remote deaths in the elderly group and three in the control group during follow up (Table

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4). Median follow-up time was 49 months (19.5–90.5) for all patients; 42.5 months (18.8–75.8) for patients in the elderly group and 53 months (22.5–99) for patients in the control group. Survival rate at 1, 3, and 5 years from initial surgical repair, excluding hospital deaths within 30 days, was 92% (95% CI: 0.801–0.969), 84.7% (95% CI: 0.703–0.924); and 84.7% (95% CI: 0.703-0.924), respectively, in the elderly group compared with 97.8% (95% CI: 0.853–0.997), 97.8% (95% CI: 0.853–0.997), and 94.2% (95% CI: 0.778–0.986), respectively, in the control group. A log-rank test comparing the two survival curves did not indicate the significant difference between the groups ($P = 0.117$) (Figure 3).

Causes of remote deaths included heart failure (1), stroke (2), rupture of the downstream aorta (1), and pneumonia (4) in the elderly patients. There were eleven late reinterventions including repair for aortic root (1), aortic arch (1), descending aorta (6), and abdominal aorta (3). There were no significant differences in late reinterventions between the groups.

To assess how postoperative physical activities after the surgery impacted late mortality, patients with postoperative walking difficulty, excluding hospital deaths within 30 days, were compared with patients without postoperative walking difficulty. The patients with postoperative walking difficulty were found to have significantly worse late mortality compared with the patients without it (Figure 4A) ($P < 0.001$).

Survival rate at 1, 3, and 5 years from initial surgical repair was 89.7% (95% CI: 0.749–0.960), 80.6% (95% CI: 0.635–0.903), and 76.4% (95% CI: 0.576–0.877), respectively, for patients with postoperative walking difficulty vs 98.2% (95% CI: 0.878–0.997), 98.2% (95% CI: 0.878–0.997), and 98.2% (95% CI: 0.878–0.997), respectively, for patients without postoperative walking difficulty. Cox proportional hazard analysis showed that postoperative walking difficulty was a significant risk factor for late mortality according to multivariable analysis, whereas age[?]70 and postoperative stroke were not (Table 5) (HR 12.65; $P = 0.017$).

We also assessed the risk factors for late mortality in the patients who regained ambulatory autonomy at discharge. Patients with postoperative walking difficulty were found to have significantly worse late mortality compared with the patients without it difficulty (Figure 4B) ($P < 0.001$). It was also found in Cox proportional hazard analysis that postoperative walking difficulty was a significant risk factor for late mortality according to multivariable analysis, whereas age[?]70, re-exploration for bleeding, and long-term intubation (>3 weeks) were not (Table 6) (HR 15.54; P = 0.026).

DISCUSSION

Life expectancy is increasing steadily in many countries and consequently presents a higher incidence of cardiovascular diseases, including ATAAD,[13, 14] which remains a potentially lethal clinical presentation as emergency surgery is still a challenging procedure for elderly patients. It has been reported that surgical risks are increased in the elderly and old age is a negative prognostic factor of early mortality after emergency surgery for ATAAD.[2, 3, 15, 16] However, surgical outcomes for ATAAD have been improving in Japan [17] as well as in the rest of the world[18], with several studies reporting good results from the surgical repair of ATAAD in elderly patients.[4, 13] Surgical outcomes in elderly patients with ATAAD may improve in this decade. Postoperative physical activities may be strongly associated with quality of life, mental health, and functional capacity in elderly patients with ATAAD.[8]It is reported that walking difficulty is an important risk factor for mortality and morbidity in patients after elective cardiac surgery.[6, 19] However, there are few studies that assess physical activities or rehabilitation outcomes in elderly patients after surgery for ATAAD.

This study demonstrated that: 1) there were no significant differences in short-term and long-term mortality and major postoperative complications between patients undergoing surgical repair for ATAAD in the elderly group and in the control group; 2) during rehabilitation, it took significantly longer for elderly patients to walk 100 or 200 m and to require speech and swallowing therapy postoperatively for dysphagia; 3) the AUC of the 200-m walk after surgery as a prognostic indicator for late mortality was 0.878, with a highest accuracy at 30 days (sensitivity = 83.3%, specificity = 91.8%); 4) intriguingly, postoperative walking difficulty was an independent risk factor for late mortality in patients regaining ambulatory autonomy at discharge as well as in all cohorts.

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It is still unclear what specific types and intensities of rehabilitation may be postoperatively safe and beneficial for patients with ATAAD. In this study, cardiopulmonary exercise testing or invasive walking tests were not performed to assess physical activities because the safety and efficacy of these tests have not yet been fully established in patients with postoperative residual aortic dissection for ATAAD.[7, 20] However, we assessed the duration for the patients to walk 100 or 200 m postoperatively, which is less invasive and helps to assess postoperative physical activity resumption with ease compared with cardiopulmonary exercise testing or other walk tests.

Corone et al reported 33 French patients with type I DeBakey aortic dissection (mean age, 55.1 years) who underwent cardiac rehabilitation soon after surgical repair.[21] They reported that noncontact aerobic activity with moderate intensity is likely safe and effective for patients with surgical repair for ATAAD. In this study, our rehabilitation program was based on walking exercise. During rehabilitation, acute elevations in BP may transiently increase the risk of recurrent aortic dissection or rupture after surgical repair for ATAAD,[22, 23] because a postdissection aorta is almost invariably dilated and may have increased associated wall stress compared with a nondilated aorta.[24] During rehabilitation in our study, sBP was strictly controlled between 100–130 mmHg with antihypertensive drugs without any aortic event, which may support the safety profile of our rehabilitation program. Elderly patients required fewer antihypertensive drugs to control blood pressure during the rehabilitation. Because BMI in the elderly group was significantly lower than the control group, small body size and older age in the elderly group may affect pharmacological metabolism.

The most obvious limitations of this study were its retrospective nature, small number of participants, and single-center design, which are potential sources of bias. In addition, although the majority of patients showed preoperative independence in activities of daily living in this study, patients with impaired physical activity may not have been transferred to our hospital because the family or patients did not want surgical treatment or because they were assessed as inoperable by former doctors. Furthermore, the mean follow-up period in the elderly group was comparatively short (median 42.5 [18.8–75.8] months; range 1–125 months), although we did not find significant differences in long-term follow up between the elderly group and the control group. Further studies with a larger number of patients, longer observation time, and greater emphasis on hemodynamic and biomechanical parameters should be performed to evaluate physical activities and surgical outcomes in elderly patients with ATAAD.

CONCLUSIONS

Elderly patients who underwent surgical repair for ATAAD showed acceptable short- and long-term survival. However, they were more likely to experience a decrease in walking ability and to experience postoperative dysphagia compared with younger patients. Moreover, postoperative walking difficulty was an independent risk factor for late mortality in patients regaining ambulatory autonomy at discharge as well as in all cohorts.

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CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interests.

AUTHOR CONTRIBUTIONS

Conception and design: Yasushi T, Yurie T

Analysis and interpretation: Yasushi T, Yurie T

Data collection: Yasushi T, Yurie T, NN

Writing the article: Yasushi T, Yurie T

Critical revision of the article: Yasushi T, Yurie T, KC, NN, KA, AY

Final approval of the article: Yasushi T, Yurie T, KC, NN, KA, AY

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TABLE 1 Preoperative charactaristics

Characteristics	Total (n=103)	Age<70 (n=51)	A
Age	70 (61.5-78)	61 (52.5-65.5)	7
Male	46 (44.7%)	35 (68.6%)	1
BMI	24.1 (21-27.7)	25.6 (22.5-29.8)	2
Hypertention	69 (67.0%)	35 (65.8%)	3
Diabetes mellitus	5 (4.9%)	2 (3.9%)	3
Choronic kidney disease	34 (33.0%)	17 (33.3%)	1
Hyperlipidemia	15 (14.6%)	9 (17.6%)	6
DeBakey Ior IIIb retrograde	79 (76.7%)	44 (86.3%)	3
DeBakey II	24 (23.3%)	7 (13.7%)	1
Communicating dissection	57 (55.3%)	37 (72.5%)	2

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Preoperative shock (sBP < 80mmHg)	19 (18.4%)	8 (15.9%)	1
Cardiac tamponade	59 (57.3%)	25 (49.0%)	3
Cardiopulmonary resuscitation	3 (2.9%)	2 (3.9%)	1
Neruologic deficit	6 (5.8%)	3 (5.9%)	3
Malperfusion	19 (18.4%)	12 (23.5%)	7
Paraplegia	1 (1.0%)	1 (2.0%)	0
Limb	6 (5.8%)	4 (7.8%)	2
Renal	6 (5.8%)	4 (7.8%)	2
Brain	11 (10.7%)	5 (9.8%)	6
Coronary	1 (1.0%)	1 (2.0%)	0
Mesenteric	7 (6.8%)	6 (11.8%)	1
Preoperative physical activities			
Barthel index	96.6 ± 13.9	99.8 ± 1.4	9
Walking without any aids	94 (91.3%)	48 (94.1%)	4
Walking with assistive device	8 (7.8%)	3 (5.9%)	5
Wheelchair	0 (0%)	0 (0%)	0
Bedridden	1 (1.0%)	0 (0%)	1
Abbreviations: BMI, body mass index	Abbreviations: BMI, body mass index	Abbreviations: BMI, body mass index	A

TABLE 2 Operative details and complications

Operative details	Total (n=
Ascending aorta replacement	79 (76.7%
Aortic arch replacement	21 (20.4%
Aortic root replacement	3 (2.9%)
Concomitant AVR	7 (6.8%)
Concomitant CABG	3 (2.9%)
Pump run time, minutes	141 (126
Aortic cross-clamp Time, minutes	92 (75-10
Operation time, minutes	290 (245-
Complications	
Stroke	6 (5.8%)
Pneumonia	15 (14.6%
Mediastinitis	3 (2.9%)
Intestinal ischemia	1 (1.0%)
Postoperative hemodialysis	12(11.7%
Re-exploration for bleeding	5 (4.9%)
Long-term intubation (more than 3 weeks)	14 (13.6%
Dysphagia	45 (43.7%
ICU stay, days	7 (6-13.5
Hospital stay, days	24 (17-45
Barthel index at discharge	79.4 ± 3
Discharged by walking without any aids	52 (50.5%
by walking with assistive device	15 (14.6%
by a wheelchair	11 (10.7%
Postoperative walking difficulty	38 (36.9%
Hospital death within 30 days	8 (7.8%)
Abbreviations: AVR, aortic valve replacement; CABG, coronary artery bypass grafting; ICU, intensive care unit	Abbrevia

TABLE 3 Rehabilitation-outcomes in the patients regaining ambulatory autonomy at discharge

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Rehabilitation-outcomes
Duration for walking 100m, days
Duration for walking 200m, days
Postoperative walking difficulty
Speech and swallowing therapy
Communicating dissection after surgery
Pre-rehabilitation sBP, mmHg
Pre-rehabilitation dBP, mmHg
Post-rehabilitation sBP, mmHg
Post-rehabilitation dBP, mmHg
Antihypertensive drugs during rehabilitation
Calcium blocker
ARB or ACE inhibitor
Beta blocker
Dual-drugs combination
Triple-drugs combination
Barthel index at discharge
ICU stay, days
Hospital stay, days
Abbreviations: ACE, angiotensin-converting-enzyme; ARB, angiotensin II receptor blocker; dBP, diastolic blood pressure; I

TABLE 4 Long-term outcome

Long-term outcome	Total (n=103)	Age<70 (n=51)	Age[?]70 (n=52)	P value
Remote death	11	3	8	0.201
Aortic event	2 (18.2%)	0 (0%)	2 (25%)	0.495
Stroke	1 (9.1%)	0 (0%)	1 (12.5%)	> 0.99
Pneumonia	6 (54.5%)	2 (66.7%)	4 (50%)	0.678
Cardiac failure	1 (9.1%)	0 (0%)	1 (12.5%)	> 0.99
Unknown	1 (9.1%)	1 (33.3%)	0 (0%)	0.495
Aortic reintervention	11	5	6	> 0.99
Aortic root	1 (9.1%)	1 (20%)	0 (0%)	0.495
Aortic arch	1 (9.1%)	1 (20%)	0 (0%)	0.495
Descending aorta	6 (54.5%)	2 (40%)	4 (66.7%)	0.678
Abdominal aorta	3 (27.3%)	1 (20%)	2 (33.3%)	> 0.99

TABLE 5 Univariable and Multivariable Analysis of Late Mortality, Excluding Hospital Deaths within 30days

Variables	**Univariable HR (95% CI)**
Preoperative characteristics	
Age[?]70	2.78 (0.73-10.52)
Male	1.59 (0.48-5.23)
Obesity, BMI >28 kg/m^2	0.685 (0.15-3.18)
Choronic kidney disease	1.29 (0.38-4.42)
DeBakey Ior IIIb retrograde	1.34 (0.35-5.08)
Communicating dissection	0.98 (0.3-3.23)
Preoperative shock (sBP < 80mmHg)	0.53 (0.07-4.19)

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Cardiac tamponade	0.89 (0.27-2.91)
Malperfusion	0.55 (0.07-4.27)
Barthel index	-
Operative details and complications	
Aortic arch replacement	0.97 (0.21-4.51)
Pump run time >4hr	2.04 (0.43-9.59)
Complications	
Stroke	6.58 (1.35-31.9)
Pneumonia	2.56 (0.65-10.13)
Postoperative hemodialysis	0.75 (0.1-5.87)
Reexploration for bleeding	1.72 (0.22-13.43)
Long-term intubation (more than 3 weeks)	2.49 (0.66-9.45)
Dysphagia	1.44 (0.44-4.72)
Postoperative physical activities	
Barthel index	1.00 (0.98-1.02)
Walking difficulty	16.45 (2.1-128.7)
Abbreviations: BMI, body mass index; sBP, systolic blood pressure	Abbreviations: BMI, body mass index; sBP, systolic b

TABLE 6 Univariable and Multivariable Analysis of Late Mortality, in the patients regaining ambulatory autonomy at discharge

Variables	**Univariable HR (95% CI)**
Preoperative characteristics	
Age[?]70	2.76 (0.50-15.13)
Male	2.19 (0.40-12.01)
Obesity, BMI >28 kg/m^2	1.37 (0.25-7.53)
Choronic kidney disease	-
DeBakey Ior IIIb retrograde	1.61 (0.29-8.87)
Communicating dissection	0.25 (0.03-2.17)
Preoperative shock (sBP < 80mmHg)	-
Cardiac tamponade	0.37 (0.07-2.02)
Malperfusion	1.31 (0.15-11.24)
Barthel index	-
Operative details and complications	
Aortic arch replacement	0.75 (0.09-6.47)
Pump run time >4hr	1.3 (0.15-11.36)
Complications	
Stroke	-
Pneumonia	3.24 (0.54-19.43)
Postoperative hemodialysis	2.35 (0.27-20.25)
Reexploration for bleeding	18.08 (1.61-203.3)
Long-term intubation (more than 3 weeks)	7.57 (1.37-41.71)
Dysphagia	1.78 (0.36-8.88)
Postoperative physical activities	
Barthel index	0.99 (0.89-1.1)
Walking difficulty	28.24 (3.29-242.6)
Abbreviations: BMI, body mass index; sBP, systolic blood pressure	Abbreviations: BMI, body mass index; sBP, systolic b

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FIGURE 1

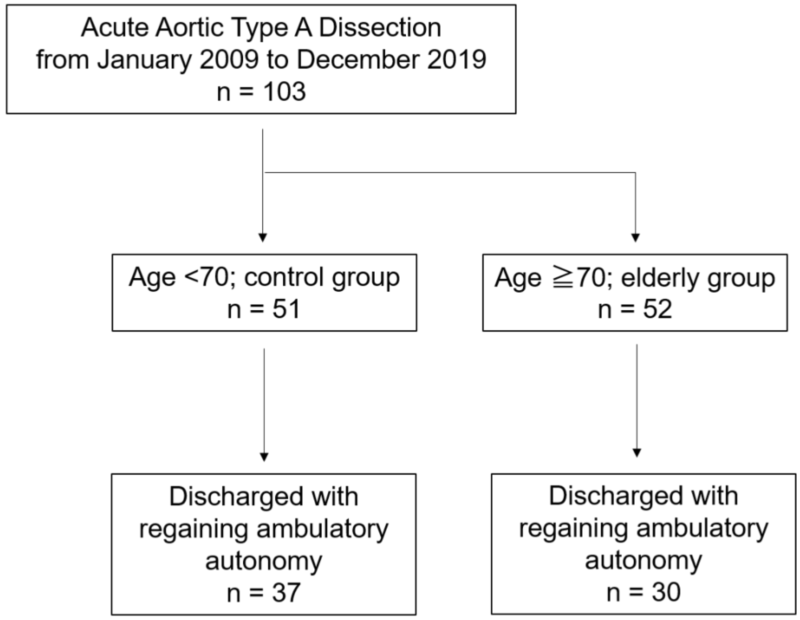

FIGURE 2

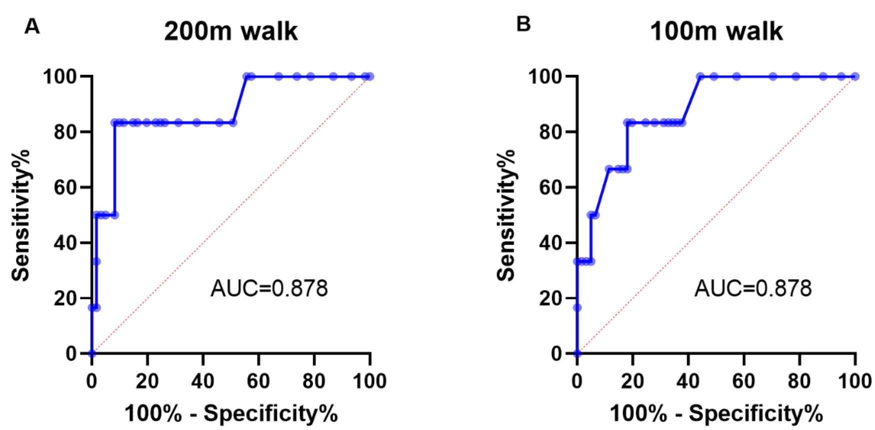

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FIGURE 3

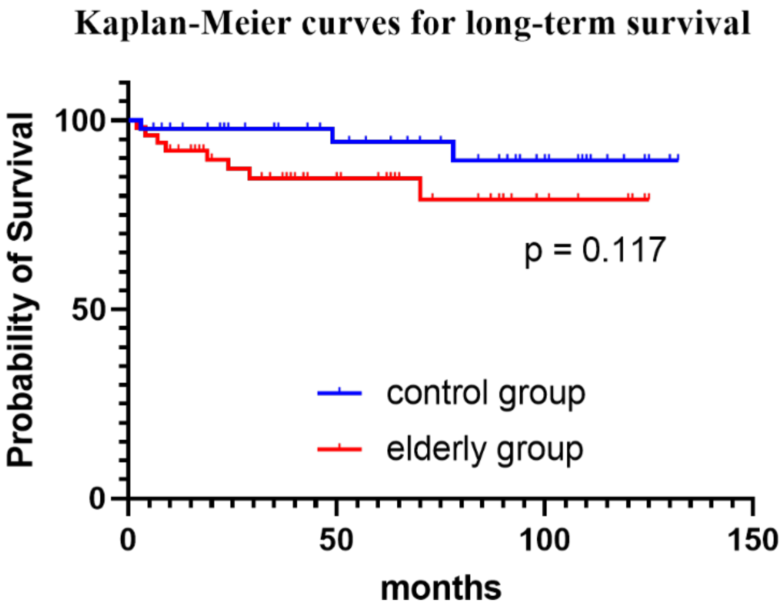

FIGURE 4

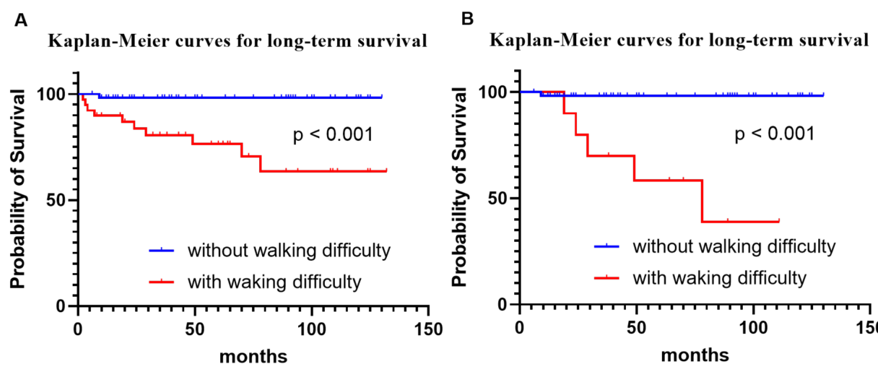

FIGURE LEGENDS

FIGURE 1 Patient selection flowchart

FIGURE 2 ROC curves showing the duration that patients could postoperatively walk (A) 200 m or (B) 100 m as a prognostic indicator for late mortality (200 m walk: AUC = 0.878; $P < 0.002$, the highest accuracy at 30 days, sensitivity = 83.3%, specificity = 91.8%; 100 m walk: AUC = 0.878; $P < 0.002$, the highest accuracy at 20 days, sensitivity = 83.3%, specificity = 82%)

FIGURE 3 Kaplan–Meier survival curves of patients undergoing surgery for acute type A aortic dissection, excluding hospital deaths within 30 days. The control and elderly groups are represented by blue and red line, respectively. P values are determined by analyzing log-rank test

FIGURE 4 Kaplan–Meier survival curves of patients with or without walking difficulty after surgery for acute type A aortic dissection, excluding hospital deaths within 30 days. A, Patients with and without postoperative walking difficulty are represented by red and blue lines, respectively. B, Among the patients regaining ambulatory autonomy at discharge, the patients with and without postoperative walking difficulty are represented by red and blue lines, respectively. P values are determined by analyzing log-rank test.

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