ORIGINAL ARTICLE

Initial clinical evaluation of preoperative frailty in surgical patients with Stanford type A acute aortic dissection

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Abstract

Background We retrospectively assessed the initial clinical role of preoperative frailty in surgical patients with Stanford type A acute aortic dissection (AAAD).

Methods One hundred and fourteen consecutive patients who underwent emergent or urgent surgical interventions for AAAD in our institute between April 2000 and March 2016 participated in this retrospective study. Patients with more than three of the following six modalities were defined as being frail: age older than 75 years, preoperative requirement of assistance in daily living, body mass index less than 18.5 kg/m^2, female, history of major stroke, and chronic kidney disease greater than class 3b. Twenty-three patients (20.2%) were diagnosed with frailty (group F), while 91 patients (79.8%) were not (group N). Early clinical outcomes, major postoperative complications, postoperative recovery of activity, and early or mid-term survival were evaluated.

Results Although early clinical outcomes and the prevalence of major postoperative complications were similar in both groups, postoperative activity of daily living (ADL), such as the rate of being ambulatory on discharge ($p < 0.05$) and home discharge ($p < 0.01$), was significantly lower in group F than in group N. A Kaplan–Meier analysis revealed that 1- and 5-year survival rates were similar in groups F (85.9 and 76.4%, respectively) and N (86.0 and 76.9%, respectively).

Conclusions Preoperative frailty in AAAD surgical patients has potential as a prognostic factor that affects delays in ADL recovery, but does not influence the early or mid-term clinical outcomes of prompt surgical strategies for life rescue in AAAD patients with frailty.

Keywords Frailty · Stanford type A acute aortic dissection · Activity of daily living · Elderly patients · Cardiac rehabilitation

Introduction

Frailty is a geriatric syndrome that is characterized by deficits in multiple physiological systems and has the potential to affect the prognosis of patients in clinical settings [1, 2]. With the increasing global prevalence of patients with an advanced age who require surgical interventions for cardiovascular diseases, the concept of frailty has been attracting

attention as a novel preoperative prognostic tool in surgical risk assessments. This unique surgical risk predictor has become an important modality for preoperatively identifying high-risk patients in great vascular surgery [3] as well as cardiothoracic surgery [4–7].

Due to advanced aging of the population and medical care improvements, cardiovascular surgeons are now encountering an increasing number of elderly patients with significant and complex vascular diseases. However, there is no preoperative risk assessment for vascular surgery. Stanford type A acute aortic dissection (AAAD) is a challenging clinical emergency associated with high morbidity and mortality, particularly in those undergoing emergent surgical interventions for life rescue. The surgical strategy for AAAD in patients with an advanced age is still being debated [8–12] because the surgical and clinical outcomes of AAAD remain poor due to preoperative hemodynamic compromise with

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malperfusion, cardiac tamponade, subsequent and significant invasive surgical interventions for primary central repair, and unexpected postoperative complications. Several factors are associated with an increased risk of AAAD; however, to the best of our knowledge, the clinical relationship between preoperative frailty indicated by the activities of daily living (ADL) or physical status and the clinical outcomes of AAAD surgical patients remains unclear. Therefore, we herein retrospectively evaluated the initial clinical role of preoperative frailty in emergent or urgent surgical patients with AAAD in our institute, and reported our initial clinical retrospective assessment.

Definition of frailty

Frailty is a well-characterized concept as a comprehensive geriatric syndrome that is evaluated by multidisciplinary factors and is clinically relevant for the prognosis of patients. According to previous novel studies on the clinical validity of frailty for proximal aortic surgery [3, 7], we described the clinical role of preoperative frailty in AAAD patients who underwent surgical interventions. Although our previous report presented the multifactorial components of frailty [4], preoperative anemia and hypoalbuminemia which sometimes accepted as the component of frailty were excluded because they are common phenomenon in AAAD surgery patients preoperatively.

In the present study, we adopted six components to define preoperative frailty; (1) age older than 75 years, (2) requirement of assistance in daily living, (3) BMI less than 18.5 kg/m^2, (4) female, (5) history of major stroke, and (6) chronic kidney disease (CKD) greater than grade 3b (Table 1) based on multidisciplinary viewpoints, including several components such as age, gender, preoperative ADL, nutritional status, and preoperative co-morbidities. Generally, women are more vulnerable than men, and gender-related difference in AAAD patients was indicated in IRAD report that surgical outcome was worse in women than men [13]. Weight loss which revealed by lower body mass index (BMI) sometimes affected the poor prognosis in cardiac surgery, especially in frail transcatheter aortic valve replacement patients [14].

Table 1 Modality of frailty definition in the present study

1	Age older than 75 years
2	Preoperative requirement of assistance in daily living
3	Body mass index less than 18.5 kg/m^2
4	Female
5	History of major stroke
6	Chronic kidney disease greater than class 3b

Patients with more than three categories were defined as being frail

Moreover, in patients with significant CKD, lower levels of physical functioning and activity were well recognized [15]. In patients with the medical history of major stroke, some poor physical activity was recognized with or without hemiplegia which needed to require the assistance in daily life. Then, in the current retrospective analysis, patients with more than three of these components were diagnosed with frailty.

Statistical analysis

This study was a retrospective review of medical records from patients who underwent emergent or urgent surgery for AAAD in Kawasaki Medical School Hospital. Continuous variables were expressed as the mean ± standard deviation and compared using the t test. Categorical variables are presented as frequencies and were analyzed using the chi-squared test. Normally distributed variables were analyzed using the Mann–Whitney non-parametric test, and p values less than 0.05 ($p < 0.05$) were considered to be significant. Early and mid-term survival was analyzed using the Kaplan–Meier method, and comparisons between groups were made using the log-rank test. Excel (Microsoft Corp, Redmond, WA) was used for statistical and survival analyses.

Patients and methods

One hundred and fourteen consecutive patients (female:male 46:68) who underwent open surgical interventions for AAAD between April 2000 and March 2016 in our institute were enrolled in this retrospective study. The mean age at surgery was 65 ± 15 years and ranged between 16 and 90 years. Emergent or surgical interventions were considered for AAAD patients with no neurological deficits, such as coma, or no refusal by the family for surgery, and were indicated for patients with a patent false lumen at the ascending aorta or an early thrombosed false lumen at the ascending aorta if the diameter of the thrombosed false lumen was greater than 11 mm or the diameter of the ascending aorta was more than 50 mm with or without cardiac tamponade according to generally accepted clinical guidance [16, 17].

Based on the definition of frailty described previously, 23 patients (20.2%) were defined as being frail (group F), whereas 91 (79.8%) were not frail (group N). There was no excluded case in this period. The preoperative characteristics of patients in both groups, including preoperative co-morbidities, frailty-related profiles and aortic dissection-related profiles, are summarized in Table 2. Patients were significantly older in group F than in group N ($p < 0.01$), and there were more females in group F than in group N ($p < 0.01$). In terms of frailty-related preoperative co-morbidities, a

Table 2 Preoperative characteristics of patients, frailty-related profile and aortic dissection-related profile

	Group F ($N=23$)	Group N ($N=91$)	p value
Mean age (years)	80 ± 6	62 ± 14	<0.01
Gender (female)	21 (91.3%)	25 (27.5%)	<0.01
Preoperative co-morbidities			
HT	16	62	0.9
DM	0	6	0.21
DL	1	8	0.48
Frailty-related profile			
BMI less than 18.5 kg/m^2	7	6	<0.01
Preoperative requirement of assistance in daily living	18	4	<0.01
History of major stroke	2	9	0.86
CKD ($\geq$ class 3b)	10	8	<0.01
Aortic dissection-related profile			
Patent false lumen	16	75	0.17
Malperfusion	2	18	0.34
Cardiac tamponade	6	28	0.66
AR more than moderate	5	24	0.65
Shock vitals on admission	0	3	0.38

HT hypertension, *DM* diabetes mellitus, *DL* dyslipidemia, *CKD* chronic kidney disease, *CVD* cerebrovascular disease, *AR* aortic valve regurgitation

significant rate of BMI less than 18.5 hg/m^2, preoperative requirement of assistance in daily life, and CKD greater than class 3b were observed in group F ($p<0.01$), whereas the prevalence of old stroke was similar in both groups ($p=0.86$). Aortic dissection-related profiles were similar in both groups, as shown in Table 2. Early clinical outcomes were evaluated using 30-day mortality, hospital mortality, duration of the intensive care unit (ICU) stay, and length of the postoperative hospital stay. Major postoperative complications were defined as the need for early reoperation for any reason, lethal arrhythmia, such as cardiac arrest and ventricular tachycardia, respiratory failure requiring tracheotomy, septic issues, mediastinitis, and the new onset of cerebrovascular disease. The ambulatory rate on discharge and prevalence of home discharge were presented for the postoperative recovery of daily living. Early and mid-term survival was assessed by the Kaplan–Meier method.

Surgery

Standard emergent or urgent surgical interventions were performed on all patients in our institute, and consisted of central repair followed by primary entry resection and necessary minimum graft replacement for the dissecting aorta. In the initiation of extracorporeal circulation, an arterial cannula was placed in the femoral artery with or without the axillary artery to supply blood to the body according to patient preoperative conditions or aortic dissection findings on preoperative enhanced computed tomography. Regarding blood removal, a two-stage venous cannula with a side hole was inserted into the right arterial appendage to drain blood from the body or two venous cannulas were each inserted into the superior or inferior vena cava. Antegrade selective cold cardioplegia following aortic cross-clamp and incision of the proximal ascending aorta was intermittently conducted during myocardial ischemia. All patients underwent primary entry resection and graft replacement under systemic moderate hypothermia of approximately 25° with bilateral selective cerebral perfusion (SCP). By accounting for the preoperative patients' frailty, surgical management was performed as compact and minimum invasive as possible, subsequently, ascending and hemiarch replacement was the leading surgical procedure in both groups, especially in group F from the point of preoperative frailty consideration.

Results

The profiles of surgical procedures and surgical outcomes are summarized in Table 3. The surgical procedure of ascending and hemiarch replacement following primary entry resection was more prevalent in group F than in group N ($p<0.05$); therefore, the procedural time, cardiopulmonary bypass time, and aortic cross-clamp time were significantly shorter in group F than in group N ($p<0.01$, respectively). Although emergent or urgent surgical repair was performed in a standard manner, postoperative complications were favorable and

Table 3 Surgical procedure and outcomes

	Group F ($N = 23$)	Group N ($N = 91$)	p value
Emergency	19	73	0.8
Urgent	4	18	0.8
Surgical procedure			
AAR + HAR	22	68	< 0.05
TAR	1	19	0.06
Bentall	0	9[a]	0.12
AV suspension	13	58	0.53
Surgical outcomes			
Operative time (min)	381 ± 78	468 ± 152	< 0.01
CPB time (min)	188 ± 40	236 ± 76	< 0.01
ACC time (min)	124 ± 35	159 ± 56	< 0.01
SCP time (min)	50 ± 21	60 ± 28	0.17
Lower body CA (min)	50 ± 13	58 ± 20	0.09
Minimum core temperature (°)	25.5 ± 2.6	25.1 ± 2.1	0.42
Intra-procedural bleeding (ml)	1187 ± 725	2139 ± 2324	0.056
Intra-procedural transfusion (units)	9.9 ± 3.9	9.0 ± 8.0	0.58

AAR ascending aortic replacement, *HAR* Hemiarch replacement, *TAR* total arch replacement, *AV* aortic valve, *CPB* cardiopulmonary bypass, *ACC* aortic cross clamp, *SCP* selective cerebral perfusion, *CA* circulatory arrest

[a]The Bentall procedure was included for isolated or concomitant

acceptable, but more significant than with standard aortic surgery. Postoperative early clinical outcomes and complications are summarized in Table 4. Although early clinical outcomes and the prevalence of major postoperative complications in both groups were similar (group F 30.4% vs group N 34.1%, $p = 0.74$), postoperative ADL, such as the rate of being ambulatory on discharge (group F 65.0% vs group N 87.3%, $p < 0.05$) and home discharge (group F 35.0% vs group N 74.9%, $p < 0.01$), was significantly lower in group F than in group N. However, a Kaplan–Meier analysis revealed that 1- and 5-year survival rates were similar at 85.9 and 76.4% in group F and 86.0 and 76.9% in group N, respectively, except in the early phase (Fig. 1) with a mean follow-up period of 29.6 ± 35.1 months in group F and 49.9 ± 55.1 months in group N ($p = 0.096$).

Discussion

Although the concept of frailty as a preoperative risk assessment tool has recently been attracting attention, few studies have examined the clinical role of frailty in aortic surgery. The number of surgical procedures performed on elderly patients with aortic vascular diseases has markedly increased

Table 4 Postoperative early clinical outcomes and complications

	Group F ($N = 23$)	Group N ($N = 91$)	p value
30-day mortality	2 (8.7%)	7 (7.7%)	0.87
Hospital mortality	3 (13.0%)	12 (13.2%)	0.99
Prolonged ventilator assist (> 72 h)	10 (43.5%)	41 (45.1%)	0.97
ICU stay (days)	7.8 ± 8.5	5.4 ± 4.3	0.09
Hospital stay (days)	35.5 ± 26.5	40.2 ± 34.8	0.57
Postoperative major complications[a]	7	30	0.74
Postoperative ADL at discharge			
Ambulatory on discharge	13/20	69/79	< 0.05
Home discharge	2/20	59/79	< 0.01

ICU intensive care unit, *ADL* activity of daily living

[a]Major postoperative complications were defined as the need for early reoperation for any reason, lethal arrhythmia, such as cardiac arrest and ventricular tachycardia, respiratory failure requiring tracheotomy, septic issues, mediastinitis, and the new onset of cerebrovascular disease
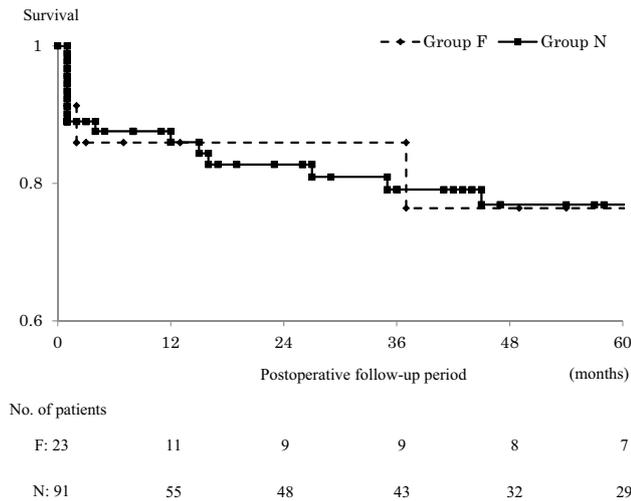
Fig. 1 Early and mid-term survival by a Kaplan–Meier analysis

in the last decade, and the incidence of the postoperative deterioration of ADL also appears to be higher in elderly patients unless preventive strategies are intended. Surgical repair for great vascular diseases, such as aortic dissection and aortic aneurysm, appears to be a significantly more invasive approach than cardiac surgery, particularly for patients with AAAD who require emergent management as a life-saving strategy. However, there is currently no consensus on preoperative surgical risk evaluations in AAAD surgical patients. Nevertheless, more invasive technical issues and complex surgical interventions are required in AAAD surgery, even in the current endovascular era.

The clinical role of frailty in the vascular surgery cohort was discussed previously. The novel and initial assessment by Ganapathi et al. clearly demonstrated the role of frailty in predicting postoperative morbidity and mortality in patients undergoing proximal aortic replacement surgery [2]. They defined preoperative frailty using a 6-component frailty index consisting of age older than 70 years, body mass index less than 18.5 kg.m^2, anemia, medical history of stroke, hypoalbuminemia, and total psoas volume in the bottom quartile of the population. They showed that these components of frailty were an independent predictor of discharge disposition and early and late mortality risks in patients undergoing proximal aortic surgery, and thus, the definition of frailty as a preoperative surgical risk tool was multifactorial. Lee et al. evaluated preoperative frailty in patients undergoing open abdominal aortic aneurysm (AAA) repair by core muscle size at the level of the L4 vertebra as an objective measure of frailty [18]. They found a strong correlation between core muscle size and mortality after elective AAA repair. Arya et al. also evaluated the effects of frailty on 30-day surgical mortality in AAA surgical patients [19]. Failure to rescue, which is

regarded as an evaluation for the quality of perioperative intensive management, after elective AAA abdominal aortic aneurysm repair was indicated to be independent of age and comorbidities in their study. Srinivasan et al. reported the Ruptured Aneurysm Frailty Score (RAFS) using pre-morbid function and preoperative co-morbidities [20]. The findings of their study indicated that frailty-specific predictors had the potential to result in poorer outcomes in patients presenting with ruptured AAA.

In the present study, preoperative frailty was considered to be a valid prognostic modality that affected the postoperative prolonged recovery of ADL and quality of life (QOL) but did not influence early or mid-term survival, the prevalence of major postoperative complications, or the perioperative clinical course. These findings were consistent with the clinical impact of frailty on functional survival after cardiac surgery, as reported by Lytwyn et al. [21]. They showed that preoperative frailty was associated with a higher risk of poor functional survival 1 year after cardiac surgery. Nevertheless, preoperative frailty did not influence mortality. In the clinical setting of AAAD surgical patients, postoperative recovery used to be protracted due to the invasiveness and manipulation of surgical interventions. Therefore, conservative primary central repair should be scheduled for these fragile and frail patients because of AAAD surgery for life rescue. Thus, surgical intervention should be minimized, and primary entry resection with ascending aortic replacement may be sufficient to rescue frail patients with AAAD. In the present study, mortality and morbidity after surgical interventions for AAAD were similar in both groups because of the precise and acceptable surgical interventions followed by our conservative surgical strategy. In contrast, appropriate emergent surgical interventions with minimal procedures for life rescue are needed, even in frail AAAD patients, while surgeons may appropriately operate on high-risk patients; however, the identification of these patients will be challenging.

Based on the results obtained, AAAD surgical patients with frailty had a poor prognosis for their postoperative functional status. To avoid the deterioration of postoperative ADL, aggressive postoperative patient management, such as cardiac rehabilitation, may need to be mandatory in order to improve the recovery of postoperative ADL and QOL. As reported in previous studies [22], pre- and postoperative rehabilitation after cardiac surgery is recommended to improve clinical outcomes and postoperative ADL, particularly in elderly patients, leading to better QOL. In AAAD surgical patients, preoperative cardiac rehabilitation was impossible because of emergent management; however, the early introduction of cardiac rehabilitation as soon as possible after surgery needs to be applied to frail AAAD patients who underwent emergent repair in order to avoid postoperative adverse effects and improve postoperative ADL.

In our current analysis, the selection bias about the frailty definition modality exists. As previously described, frailty should be defined by multifactorial components. The current selected factors were adopted by previous novel reports [3, 4], however, anemia and hypoalbuminemia were not good candidates in AAAD surgery patients. Previous clinical report insisted that female sex was associated with the poor prognosis in aortic dissection [13], however, some author revealed no differences about early and long-term mortality between women and men in AAAD surgery patients [23], it seems to be still debated.

There were several limitations that need to be addressed. This was a single-center, retrospective, non-randomized study. The sample size was not sufficiently large to confirm precise clinical efficacy. Since this was a retrospective study, we did not have the accurate documentation of patient medical records. However, the clinical role of frailty in postoperative ADL assessments for aortic surgery is cutting edge. Further studies are needed to assess the value of frailty in aortic surgery, and further evaluations of its clinical role are currently being performed.

Conclusion

Preoperative frailty in AAAD surgical patients has potential as a prognostic factor that affects the delay in ADL recovery but does not influence the early or mid-term clinical outcomes of precise surgical strategies for life rescue.

Compliance with ethical standards

Conflict of interest There is no conflict of interest to declare.

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