ORIGINAL

Assessment of postoperative nutritional status and physical function between open surgical aortic valve replacement and transcatheter aortic valve implantation in elderly patients

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Abstract : Background and aims : Severe aortic stenosis (AS) has been normally treated with surgical aortic valve replacement (AVR) whereas recently, transcatheter aortic valve implantation (TAVI) has been introduced as a minimally invasive operation for patients with high surgical risk and frailty. In this study, we have evaluated postoperative physical function and nutrition intake in the patients following AVR and TAVI. Methods : This prospective observational study involved 9 patients with surgical aortic valve replacement (AVR) and 7 patients with transcatheter aortic valve implantation (TAVI). Body composition was measured one day prior surgery, postoperative day (POD) 1, POD 3, POD 5 and POD 7. Hand grip strength, calf circumference and gait speed were measured one day before surgery and on the day of discharge. Results : Skeletal muscle was significantly decreased in AVR patients at postoperative day 3 and 7, while there was no change in TAVI patients. Patients with TAVI showed higher dietary intake after surgery compared to patients with AVR, and they maintained hand grip strength and calf circumference at discharge. Conclusions : In elderly patients with AS, TAVI can improve post-operative recovery maintaining nutritional status and physical function even. J. Med. Invest. 67 : 139-144, February, 2020

Keywords : *Aortic stenosis, Surgical aortic valve replacement, Transcatheter aortic valve implant, Nutrition intake, Physical function*

INTRODUCTION

Aortic stenosis (AS) is the end result of an inflammatory process caused by endothelial damage due to mechanical stress, lipid penetration leading to fibrosis, leaflet thickening, and finally calcification (1). AS is increased with age, affecting up to 10% of the populations by the eighth decade (2, 3). Due to the prolonged life expectancy, the number of patients with AS has been increasing in industrialized countries (4) .

There is no effective pharmacologic treatment. Surgical aortic valve replacement (AVR) has been the gold standard treatment for decades. The first successful surgical AVR was performed in 1960 (5). Over the past half century, the mortality associated with AVR has decreased dramatically because of marked progress in operative techniques and valve design (6, 7). However, open surgery often leaves people immobile during recovery and in particular sternal healing, requiring a significant period of rehabilitation. In addition, it is also associated with higher risk of complications and mortality in elderly patients (8).

Recently, transcatheter aortic valve implantation (TAVI) has emerged as an attractive, less-invasive option for appropriately selected patients. As a result, it is therefore usually preferred in elderly or frail patients (8, 9). Frailty in the elderly is a significant predictor of morbidity in patients undergoing TAVI (10, 11). It is well known that several key factors such as chronic under-nutrition, decreased physical function and muscle mass could induce disability or worse prognosis. Decreased food intake is a risk factor for mortality and morbidity in hospitalized patients (12), however, there is still a lack of data on the nutritional status and physical functions of Japanese elderly patients after AS procedure. We investigated postoperative physical function and nutrition status in the patients with AVR and TAVI in the elderly population.

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MATERIALS AND METHODS

Subjects

This study was conducted following the Declaration of Helsinki with approval from the Committee for Medical Ethics of Tokushima University Hospital in Tokushima, Japan (approval number : 2326) and registered UMIN CTR (UMIN number : 000022913). Written informed consent was obtained from each patient prior to enrollment. Patients with surgical aortic valve replacement (AVR) and transcatheter aortic valve implantation (TAVI) were prospectively enrolled from August 2018 to March 2019. All of patients were enrolled but excluded patients with a pacemaker.

Body composition analysis

Body composition was assessed using a portable bioelectrical impedance analysis (BIA) device for InBodyS10 (InBody, Tokyo, Japan). Skeletal muscle mass (SMM), body cell mass (BCM), body fat, and water values including total body water (TBW), intracellular waster (ICW), extracellular water (ECW), ECW/

TBW were analyzed. Skeletal muscle mass index (SMI) was calculated as the appendicular skeletal mass divided by the square of patient height. All patients were assessed preoperative, postoperative day 1, 3, 5, 7, regardless of whether they were fasting, edematous, or still on anesthesia. Actual body weight was measured by scale in the inpatients' ward on their exam date.

Assessment of postoperative conditions

Blood chemistry results, length of ICU and hospital stay were collected from medical records. Hand grip strength, calf circumference and gait speed were measured at the time of rehabilitation. Nutrition intake was calculated from medical records. Energy intake per body weight was calculated using actual measured body weight.

Statistical analysis

Data were expressed as means ± standard deviation (SD), categorical data are expressed as percentages. The two groups (AVR, TAVI) were compared using a Mann-Whitney-U test and χ^2 test. Paired t-test was used for before and after comparison in each group. P-values of 0.05 were considered statistically significant. All of the statistical analysis was performed using JMP version 13 (SAS Institute Inc., Tokyo, Japan). Graphs were created using PRISM 7 software (GraphPad Software Inc, San Diego, CA).

RESULTS

Characteristics of patients with severe aortic stenosis (AS)

A total of 16 patients with severe AS were included in this study. Nine patients received surgical aortic valve replacement (AVR) and 7 patients received transcatheter aortic valve implantation (TAVI). Baseline characteristics are shown in Table 1. The average age was 72.8 ± 7.5 years old in patients with AVR and 78.7 ± 10.4 years old in patients with TAVI. The proportion of female was 44.4% in patients with AVR and 85.7% in patients with TAVI ($p = 0.09$). There were no significant differences between groups in echocardiographic variables and biochemical parameters. The average BMI was 25.8 ± 2.7 kg/m^2 in patients with AVR and 27.2 ± 6.9 kg/m^2 in patients with TAVI. The average body fat percentage was 31.2 ± 8.6% in patients with AVR and 38.9 ± 10.9% in patients with TAVI. The average extracellular water (ECW) / total body water (TBW), which indicate hydration level, was 0.40 ± 0.01 in AVR and 0.40 ± 0.02 in TAVI, were categorized in the edema range. There was no significant difference in hypertension and dyslipidemia. Patients with AVR included 4 diabetes patients whereas there were no diabetes in patients with TAVI ($p = 0.0417$). In addition, there was no difference in medications among these groups. Prior to surgery, sarcopenia was identified in 48.3% of TAVI patients and 0% of AVR patients (data not shown).

Table 1. Characteristics of patients with severe aortic stenosis (AS) before surgery.

Variable	All patients (n =16)	AVR (n = 9)	TAVI (n = 7)	p value (AVR vs TAVI)
Age, years	75.4 ± 9.1	72.8 ± 7.5	78.7 ± 10.4	0.2038
Female, n (%)	10 (62.5)	4 (44.4)	6 (85.7)	0.0907
Echocardiographic variables				
Aortic valve area, cm^2	0.72 ± 0.14	0.77 ± 0.12	0.67 ± 0.15	0.2428
Left ventricular ejection fraction, %	65.5 [61.5, 67]	66.0 [63, 67.5]	64 [47, 67]	0.3121
Biochemical parameters				
Albumin, g/dL	3.88 ± 0.53	3.82 ± 0.57	3.98 ± 0.49	0.6151
CRP, mg/dL	0.12 [0.06, 0.38]	0.12 [0.04, 0.33]	0.12 [0.1, 2.58]	0.5526
BNP, pg/mL	57.4 [39.8, 374]	58.4 [36, 644.5]	56.3 [42, 413.8]	0.7913
Anthropometric and body composition characteristics				
BMI, kg/m^2	26.4 ± 4.9	25.8 ± 2.7	27.2 ± 6.9	0.5919
Skeletal muscle mass, kg	20.5 ± 3.9	22.0 ± 2.4	18.5 ± 4.9	0.0834
Skeletal muscle index (SMI), kg/m^2	6.5 ± 1.1	6.8 ± 0.7	6.1 ± 1.4	0.1889
Body fat percentage, %	34.6 ± 10.1	31.2 ± 8.6	38.9 ± 10.9	0.1341
ECW/TBW	0.39 ± 0.02	0.40 ± 0.01	0.40 ± 0.02	0.7382
Comorbid diseases				
Hypertension, n (%)	13 (81.3)	8 (88.9)	5 (71.4)	0.3748
Diabetes, n (%)	4 (25.0)	4 (44.4)	0 (0)	0.0417*
Dyslipidemia, n (%)	6 (37.5)	4 (44.4)	2 (28.6)	0.5153
Medications				
Cardioprotective agent use, n (%)	11 (68.6)	5 (55.6)	6 (85.7)	0.1967
Statin use, n (%)	7 (43.8)	5 (55.6)	2 (28.6)	0.2804
Diuretic agent, n (%)	7 (43.8)	3 (33.3)	4 (57.1)	0.3409

Data is presented as mean ± standard deviation for normally distributed, median and interquartile range for non-normally distributed continuous variables and proportions (%) for categorical variables.
AVR, aortic value replacement ; TAVI, transcatheter aortic valve implantation ; CRP, C-reactive protein ; BNP, brain natriuretic peptide ; BMI, body mass index ; SMI, skeletal mass index ; ECW, extracellular water ; TBW, total body water.
Statistically significant ; $^*p < 0.05$.

Changes in body composition of AVR and TAVI patients during a week after surgery

We evaluated the body composition of patients with AVR or TAVI at preoperation, postoperative day (POD) 1, POD 3, POD 5 and POD 7. As shown in Figure 1A, BMI significantly decreased at POD 7 compared to preoperation whereas BMI was increased at POD 1 because of an increase of ECW. On the other hand, there was no significant change of BMI in patients with TAVI during observation period. Both group of patients had no significant change in body fat mass (Fig 1B). Patients with AVR showed a significant decrease of SMM (skeletal muscle mass) and body cell mass (BCM) at POD 3 and POD 7 compared to preoperation (Fig 1C and D) whereas there was no change in patients with TAVI. As shown in Figure 1E, ECW/TBW was increased at POD 1 and not changed in patients with TAVI.

The comparison of postoperative nutritional take and physical conditions in patients with AVR and TAVI

We assessed the postoperative conditions in patients with AVR and TAVI as shown in Table 2. Compared to patients with AVR, patients with TAVI have significantly reduced length of ICU and hospital stay ($p < 0.05$). In addition, 71.4% of patients with TAVI were discharge to home, all of patients with AVR were transferred to other hospital. Patients with TAVI also resumed walking and oral intake earlier for rehabilitation than in patients with AVR groups ($p < 0.05$). As shown in Figure 2, patients with TAVI patients significantly showed higher energy intake at POD 1 and POD 3 than in patients with AVR (POD 1 : 11.0 ± 2.4 vs 4.1 ± 2.1 kcal/kg/day, POD 3 : 22.0 ± 3.6 vs 8.0 ± 3.1 kcal/kg/day). The energy intake between the two groups was comparable to the time of discharge. It has also showed that resumption of oral

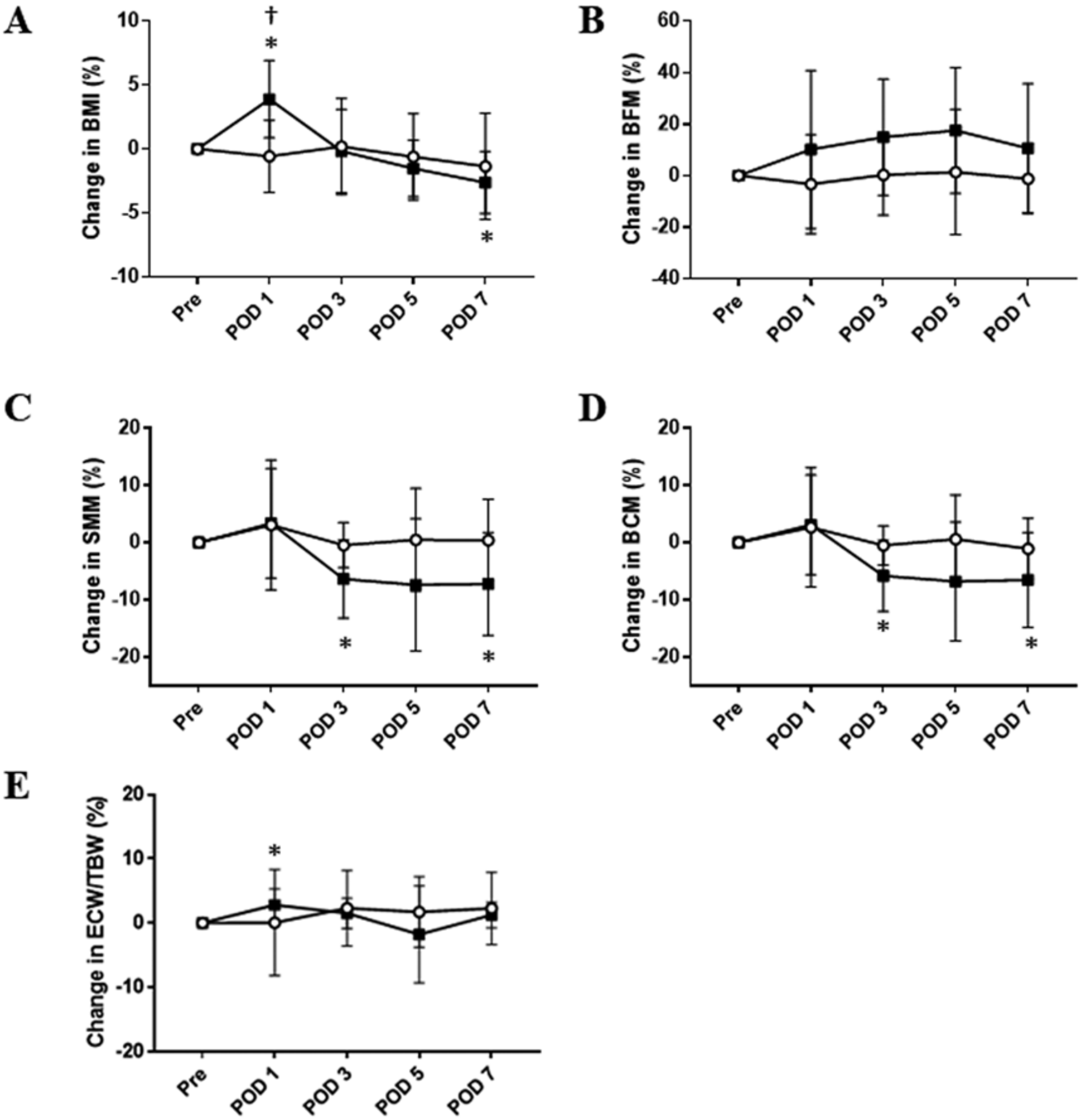

Figure 1. Changes in body composition of AVR and TAVI patients during a week after surgery.
Body composition was measured using bioelectrical impedance analysis (BIA) at preoperation, POD 1, POD 3, POD 5 and POD 7. The changes in (A) BMI ; body mass index, (B) BFM ; body fat mass, (C) SMM ; skeletal muscle mass, (D) BCM ; body cell mass, and (E) ECW/TBW are shown as means ± SD. + $p < 0.05$, AVR versus TAVI group. *$p < 0.05$, versus preoperation. Closed squares : AVR group (n = 9) ; open circles : TAVI group (n = 7). Pre, preoperation ; POD, postoperative day.

Table 2. The comparison of postoperative conditions in AVR and TAVI patients.

Variable	AVR (n = 9)	TAVI (n = 7)	p value
TAVI approach route			
TF approach, n (%)		9 (100)	
Non-TF approach, n (%)		0 (0)	
Postoperative course			
Length of ICU stay, days	3.8 ± 1.4	1.0 ± 0.0	0.0001**
Length of hospital stay, days	11.3 ± 0.7	9.1 ± 0.8	0.0161*
Discharge to home, n (%)	0 (0)	5 (71.4)	0.0022**
Resumption of walking, days	4.0 ± 1.2	2.3 ± 1.3	0.0157*
Resumption of oral intake, days	2.0 ± 1.2	1.0 ± 0.0	0.0235*
Anthropometric characteristics at discharge			
BMI, kg/m^2	25.1 ± 2.7	26.9 ± 6.8	0.4774
Biochemical parameters at discharge			
Albumin, g/dL	3.24 ± 0.30	3.34 ± 0.53	0.6444
CRP, mg/dL	2.04 [1.34, 4.82]	1.41 [0.63, 4.05]	0.4273

Data is presented as mean ± standard deviation for normally distributed, median and interquartile range for non-normally distributed continuous variables and proportions (%) for categorical variables.
AVR, aortic value replacement ; TAVI, transcatheter aortic valve implantation ; TF, transfemoral ; ICU, intensive care unit ; BMI, body mass index ; CRP, C-reactive protein.
Statistically significant ; *p < 0.05, **p < 0.01.

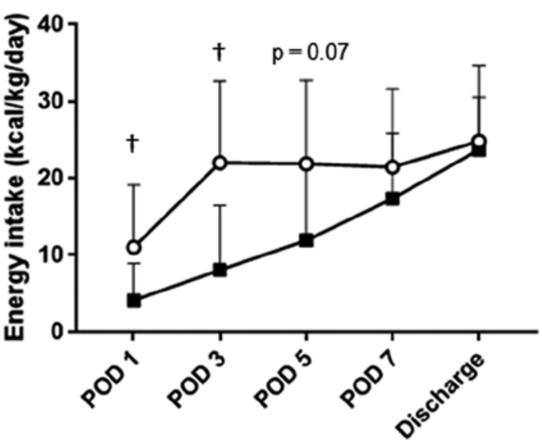

Figure 2. Postoperative energy intake in patients with AVR or TAVI.
Energy intake (kcal/kg/day) are shown as means ± SD. + p < 0.05, AVR versus TAVI group. Closed squares : AVR group (n = 9) ; open circles : TAVI group (n = 7). POD, postoperative day.

intake after surgery took 2.0 ± 1.2 days in patients with AVR and 1.0 ± 0.0 day in patients with TAVI (Table2). There were no differences in BMI, serum albumin and CRP concentration at discharge among patients with AVR and TAVI.

Assessment of physical function of patients with AVR and TAVI at discharge

We assessed physical function preoperation and at discharge in patients with AVR and TAVI. As shown in Figure 3A-B, a paired t-test showed that patients with AVR had significantly reduced hand grip strength and calf circumference at discharge compared to preoperation (p < 0.01). The hand grip strength in patients with TAVI remained kept until discharge, and the calf circumference tended to decrease (p = 0.08). The gait speed remained unchanged until discharge in both patients with AVR and TAVI. As for blood chemistry parameters, serum CRP increased significantly at discharge in patients with AVR but not in patients with TAVI (Figure 3D). With increasing serum CRP, serum albumin concentration decreased in both groups (p < 0.05).

DISCUSSION

In this study, we have assessed post-operative physical condition and body composition in patients with AVR and TAVI. Patients with AVR showed a significant decrease in skeletal muscle at POD 3 and 7 whereas there was no change in patients with TAVI. Patients with TAVI also kept hand grip strength and calf circumference until discharge. In preoperative body composition assessment, sarcopenia was identified in 48.3% of TAVI patients and 0% of AVR patients. The TAVI group contained patients with higher surgical risks such as malnutrition and old age, however, they were able to maintain skeletal muscle mass and nutritional intake. Impaired glucose tolerance and protein catabolism due to invasion, pain, and gastrointestinal dysfunction suppressed postoperative recovery (13). Since TAVI is minimally invasive, it significantly reduced length of ICU stay and allowed for early oral intake recovery. By POD 3 patients in the TAVI group improved food intake up to 20 kcal /kg/day. This expedited recovery led to the maintenance of preoperative skeletal muscle and physical function.

In this study, patients with TAVI were discharged earlier than in patients with AVR. In addition, 71.4% of patients with TAVI were discharged directly to home whereas all of AVR patients were transferred to other hospitals for rehabilitation. Previous studies reported that TAVI improves quality of life (QOL) when compared with surgical AVR (14) . Murray *et al.* showed that the patients' perceived health status was satisfactory more than five years after TAVI, and the incidence of clinical events and

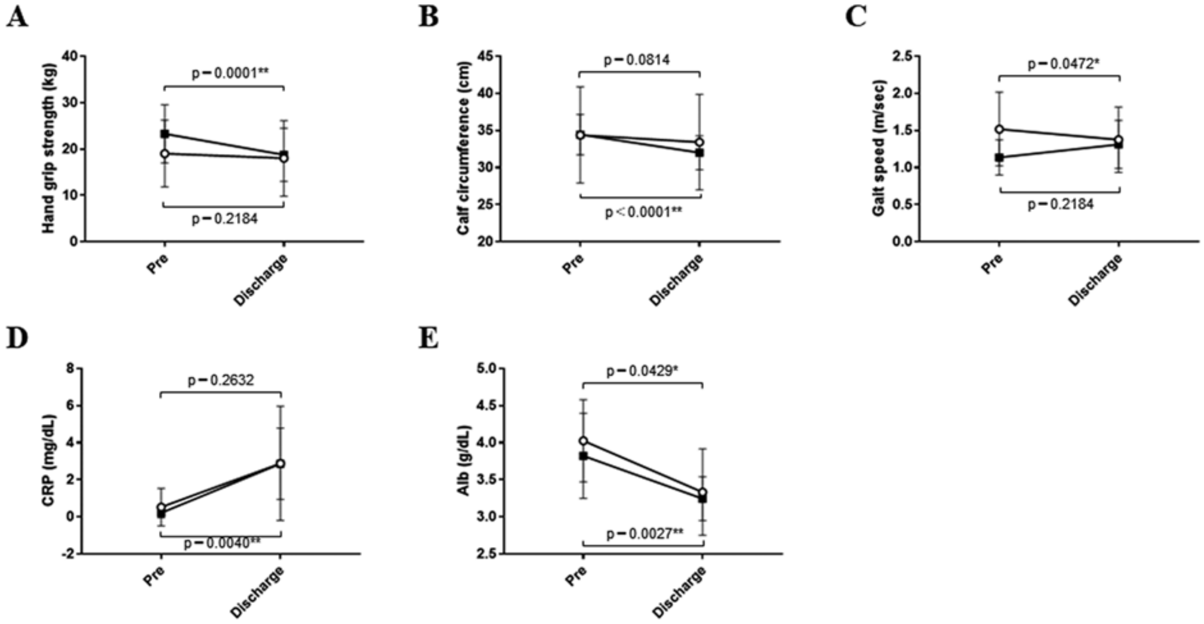

Figure 3. Physical function of AVR and TAVI patients at discharge.
(A) Hand grip strength, (B) calf circumference, (C) gait speed, (D) CRP and (E) Albumin at preoperation and discharge are shown as mean ± SD. A paired t-test, *$p < 0.05$, **$p < 0.01$, preoperation versus discharge. Closed squares : AVR group (n = 9) ; open circles : TAVI group (n = 7).

hospitalizations rarely occurred (15).

Previously, serum albumin has been shown to be a predictive indicator of 1-year mortality after TAVI (16) .Yamamoto *et al*. reported that patients with lower serum albumin level < 3.5 g/dL had a higher mortality rate than in patients with normal albumin level ≧ 3.5 g/dL (17). Bogdan *et al*. also reported that mortality after 2 years of TAVI was 35% in the patients with less than albumin 4.0 g/dL and 19% in the patients with albumin 4.0 g/dL or higher (18). These reports supported that perioperative nutritional interventions are important for patients, which could improve prognosis, morbitidy and mortality. In our study, serum albumin concentration at discharge in patients with TAVI was decreased to 3.34 ± 0.53 g/dL, but had CRP levels that were similar to pre-operative levels suggesting a decreased inflammatory response.

In general, early oral intake is possible in patients with cardiovascular surgery because they have no gastrointestinal problems. Our study have shown that resumption of oral intake after surgery took 2.0 ± 1.2 days in patients with AVR and 1.0 ± 0.0 day in patients with TAVI. The nutritional management of postoperative AS patients is mainly oral intake without parental nutrition or oral nutrition supplement (ONS). Since some patients had no appetite after surgery, the use of oral nutrition supplement should be better considered for patients who have insufficient oral intake after surgery. Previously, improved nutrition status has resulted in reduced readmission (19) .

This study has potential limitations. First, this was a nonrandomized, observational study and suffers from potential selection bias. The proportion of females and comorbidity of diseases were different between patients with AVR and TAVI. Due to the complexity of the surgery and patient population our sample size was limited. In addition, patients with diabetes were included only in AVR group. Diabetes might a confounding factor which affects on postoperative recovery. As a result, our study was underpowered to detect clinical meaning in change of body composition depending on the treatment of AS. Further investigation in larger studies with longer follow-up period is needed to reveal changes in body composition between AVR and TAVI.

In conclusion, our study suggested that TAVI allows for rapid recovery in the elderly patient resulting in early oral nutrition effectively maintaining nutritional status and physical function.

COMPETING INTERESTS

The authors have no conflicts of interest to declare.

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