Psoas Muscle Area as a Predictor of Outcomes in Transcatheter Aortic Valve Implantation.

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Published In/Presented At

Garg, L., Agrawal, S., Pew, T., Hanzel, G. S., Abbas, A. E., Gallagher, M. J., & ... Hanson, I. D. (2016). Psoas Muscle Area as a Predictor of Outcomes in Transcatheter Aortic Valve Implantation. *The American Journal Of Cardiology*, doi:10.1016/j.amjcard.2016.10.019

Psoas Muscle Area as a Predictor of Outcomes in Transcatheter Aortic Valve Implantation

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Frailty is a powerful predictor of outcomes after transcatheter aortic valve implantation (TAVI). Sarcopenia as assessed by psoas muscle area (PMA) is a validated tool to assess frailty before surgical procedures. We evaluated PMA as a predictor of outcomes after TAVI in 152 consecutive patients who underwent this procedure at our institution from 2011 to 2014. Preoperative computed tomography scans were used to measure PMA, which then was indexed to body surface area. Outcomes evaluated included (1) early poor outcome (30 days mortality, stroke, dialysis, and prolonged ventilation), (2) 1-year mortality, and (3) high-resource utilization (length of stay >7 days, discharge to rehabilitation, or readmission within 30 days). Indexed PMA (odds ratio [OR] 3.19, confidence interval [CI] 1.30 to 7.83; p = 0.012) and age (OR 1.92, CI 1.87 to 1.98; p = 0.012) predicted early poor outcome. Society of Thoracic Surgeons score predicted 1-year mortality (hazard ratio 3.07, CI 1.93 to 6.23; p = 0.011). High-resource utilization was observed more frequently in patients with PMA less than the median (73% vs 51%, OR 2.65, CI 1.32 to 5.36; p = 0.006). In conclusion, indexed PMA predicts early poor outcome and high-resource utilization after TAVI. **(Am J Cardiol 2017;119:457−460)**

Frailty, defined as a syndrome of impaired physiological reserve and decreased resistance to stressors,[1] is characterized by wasting and malnutrition, weakness, slowness, and inactivity,[2] all resulting in subsequent disability.[3] An important predictor of poor outcomes and slow recovery in older subjects after general[4] and cardiac surgery,[5,6] frailty plays a central role in clinical decision making in these patients. There is increasing interest in frailty as a predictor of outcomes after transcatheter aortic valve implantation (TAVI) with frail patients noted to face a twofold to threefold increased risk of mortality and decreased functionality at 6 to 12 months.[7−9] However, frailty is difficult to measure objectively, and it is often estimated on the basis of clinical judgment, subjective measures, and questionnaires of patient functionality[10,11] in combination with the Society of Thoracic Surgeons (STS) score.[12] Muscle mass has garnered interest as an objective quantitative measure of frailty that is independent of immobility, disability, or illness acuity. In particular, the psoas muscle area (PMA) obtained from axial cuts on computed tomography (CT), which has been validated as a surrogate for global muscle mass,[13,14] is a strong predictor of outcomes in patients who underwent noncardiac surgery.[15,16] In patients who underwent TAVI, PMA has previously been shown to predict mortality, especially in women.[17,18] The present analysis examines the effect of PMA on 30-day clinical outcomes, 1-year mortality, and high-resource utilization after TAVI.

Methods

Consecutive adult patients who underwent TAVI from January 2011 to December 2015 and had a clinically indicated pre-procedure CT scan at our institution were included. Baseline clinical characteristics included age, sex, height, weight, body mass index, body surface area, serum albumin, and estimated glomerular filtration rate and STS predicted operative mortality. Outcomes included: (1) early poor outcome (defined as 30 days mortality, stroke, dialysis, and/or prolonged ventilation >24 hours), (2) 1-year mortality, and (3) high-resource utilization (defined as length of stay >7 days, discharge to rehabilitation, and/or hospital readmission within 30 days). PMA was measured on the pre-procedural abdominopelvic CT scan images using *Aquarius* (version 4.4.11; TeraRecon, Foster City, California). Axial and sagittal images were co-registered to identify bilateral psoas muscles at the level of the L3 vertebra. This level has been shown to correlate most closely with frailty. PMA was measured using the "polygon" tracing tool. PMA was calculated as the mean of left and right psoas areas, and mean of 2 PMA measurements made by independent observers was used. Sarcopenia was defined as PMA indexed to body surface area less than the median. Continuous variables were described as means ± SDs and categorical variables as frequencies. Between-group differences were examined using the Student's *t* test for continuous variables and either the chi-square test or Fisher's exact test for categorical variables as appropriate. Cox and logistic regression models were used to determine association of PMA with outcomes. A value of $p < 0.05$ was considered statistically significant. Analysis was performed

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See page 459 for disclosure information.

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http://dx.doi.org/10.1016/j.amjcard.2016.10.019

Table 1
Characteristics of the study cohort

Variable*	BSA indexed PMA	
	<50th percentile (n=76)	≥50th percentile (n=76)
Age (years)	83.6 ± 5.8	83.0 ± 7.2
STS mortality score	6.6 ± 2.7	7.1 ± 4.0
Serum albumin (gm/dL)	3.7 ± 0.7	3.9 ± 0.8
TAVI approach:		
Transfemoral	56 (73.7%)	62 (81.6%)
Transapical	11 (14.5%)	8 (10.5%)
Transaortic	9 (11.8%)	6 (7.9%)
Female	32 (42.1%)	32 (42.1%)
GFR (mL/min)	60 ± 25	63 ± 24
BMI (kg/m^2)	29.0 ± 5.0	27.6 ± 5.9

BMI = body mass index; BSA = body surface area; GFR = glomerular filtration rate; PMA = psoas muscle area; STS = Society of Thoracic Surgery; TAVI = transcutaneous aortic valve replacement.
* p Values for all comparisons were not significant.

Table 2
Outcomes based on BSA indexed PMA

Outcomes	BSA indexed PMA			P- value
	Overall (n=152)	<50th percentile (n=76)	≥50th percentile (n=76)	
30 day death	9 (5.9 %)	4 (5.3%)	5 (6.6%)	0.731
Stroke	11(7.2%)	7 (9.2%)	4 (5.3%)	0.348
New onset dialysis	7 (4.6%)	6 (7.9%)	1 (1.3%)	0.053
Prolonged ventilation	6 (3.9%)	5 (6.6%)	1 (1.3%)	0.096
Early poor outcome	31 (20.0%)	21 (27.6%)	10 (13.1%)	**0.027**
1 year mortality	23 (15.1%)	12 (16.6%)	11 (14.4%)	0.821
Discharge to home	80 (52.6%)	36 (47.4%)	44 (57.9%)	0.134
30 day readmission	20 (13.2%)	11 (14.5%)	9 (11.8%)	0.654
Length of stay >= 7 days	68 (44.7%)	35 (46.1%)	33 (43.4%)	0.744
High resource utilization	95 (62.5%)	56 (73.6%)	39 (51.3%)	**0.004**

Bold values denotes statistically significant p < 0.05.
BSA = body surface area; PMA = psoas muscle area.

using SPSS, version 22.0, and R statistical packages (IBM, Armonk, New York). The Institutional Human Investigation Committee at Beaumont, Royal Oak, approved the study.

Results

Descriptive characteristics of the study cohort (n = 152) are listed in Table 1. The mean age at the time of TAVI was 83.3 ± 6.5 years and 64 (42%) were women. Mean STS-predicted operative mortality was 6.9 ± 3.4%. Indexed PMA was not normally distributed, so median values were analyzed: median indexed PMA for men: 4.15 cm^2/m^2 and for women: 3.47 cm^2/m^2. Interobserver coefficient of variability was 3.7% (95% confidence interval [CI] 3.5 to 4.1) and was in acceptable range.

Table 2 represents early and late outcomes based on indexed PMA. Twenty- three patients (15%) died during the predefined follow-up period of 1 year. Sarcopenia was not associated with 1-year mortality (16.6% for patients with sarcopenia compared with 13.1% for those without sarcopenia; p = 0.205, log-rank test) (Figure 1). By Cox regression analysis, the only predictor of higher 1-year mortality was STS score. There was 4.9% increase in 1-year mortality for every 1-point increase in STS score >6.9 (hazard ratio 3.06; CI 1.93 to 6.22; p = 0.011) (Supplementary Table 1). The composite measure of poor early outcomes occurred in 31 patients (20%) and was independently predicted by older age (odds ratio [OR] 1.92; CI 1.86 to 1.98; p = 0.012) and sarcopenia (OR 3.18; CI 1.29 to 7.83; p = 0.012) (Supplementary Table 2).

Finally, 95 patients (62.5%) in our cohort required higher resource utilization. In a multivariate model, sarcopenia was an independent predictor of higher resource utilization, 73.6% of sarcopenic patients had high-resource utilization compared with 51.6% of nonsarcopenic patients (OR 2.648, CI 1.322 to 5.307; p = 0.006) (Supplementary Table 3).

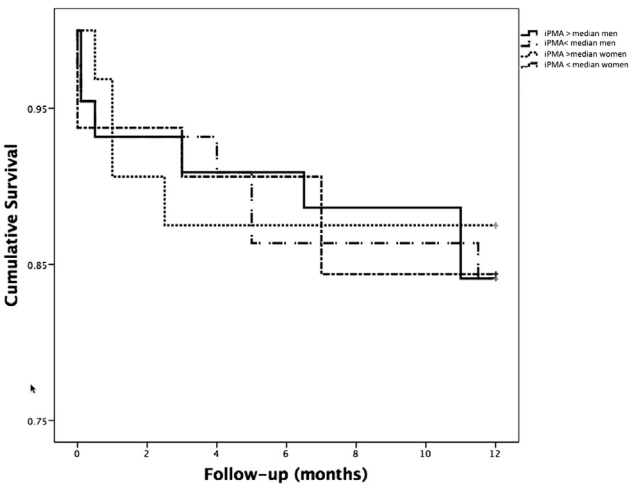

Figure 1. Kaplan-Meier curve comparing patients with sarcopenia (indexed PMA < median) versus those with no sarcopenia (indexed PMA > median).

Discussion

These results demonstrate that sarcopenia, as defined as PMA less than the median, is predictive of 30-day poor outcome and high-resource utilization but not 1-year mortality. Frailty in patients who underwent TAVI has emerged as a potent predictor of outcomes following the procedure, but assessment of frailty can be challenging. Traditional performance-based frailty assessment tools, such as gait speed and grip strength, have been used, but these could be affected by co-morbidities that are unrelated to operative risk. For example, a patient with fluctuating arthritis-related pain affecting the knees may be unable to complete a gait speed test and may, therefore, be labeled as frail but on a certain day, whereas on a day when arthritis pain is well controlled, performance could be better and the same patient not be considered frail.

PMA is a good surrogate for sarcopenia and an established marker of frailty and poor outcomes after proximal aortic surgery, abdominal aortic surgery, endometrial cancer surgery, colorectal cancer surgery, liver cancer surgery, and liver transplantation.[15,16,19–21] Frail patients with low

muscle mass are at higher risk for deconditioning after an invasive procedure. Measuring PMA from CT was technically easy and reproducible, and considering the routine preoperative use of CT did not add to the cost of workup. Assessing frailty with PMA has a major advantage over performance-based assessments of frailty in that it is objective, quantitative, and independent of day-to-day changes in functional status that may be unrelated to operative risk factors. We observed that a low indexed PMA was associated with poor outcomes in the early postoperative period after TAVI, findings that are consistent with earlier studies that have examined the value of PMA in noncardiac surgery.[16,19−21] Furthermore, we observed that patients with indexed PMA less than the median have higher resource utilization, are less likely to be discharged to home, and have higher 30-day readmission rates. These findings have not previously been reported in the TAVI population and may have tremendous public health implications. In our cohort, low PMA was not associated with higher 1-year mortality, in contrast to the studies by Mamane et al[18] and Saji et al.[22] Interestingly, Mamane et al reported that PMA predicted survival among female but not male patients. Also of note, the 1-year mortality rate of 15% in our cohort was lower than the 6-month mortality rate of 21% in Saji et al. However, there was a higher rate of transfemoral access utilization in our patients compared with Saji et al (76% vs 61%). Lastly, inclusion of different variables for regression analysis could also potentially explain differences in our results compared with those of Mamane and Saji.

The results of this study should be interpreted with caution because data were retrospectively collected from a single center, and a relatively small number of patients were enrolled. However, the sample size was consistent with previous studies. We measured PMA at the level of L3 vertebrae, a technique that had been validated in previous studies; however, more recent studies have used L4 vertebrae level to calculate PMA.[22] Future studies are required to test whether the median, or a different "cut point" PMA value, is most predictive of outcomes after TAVI. Perhaps a "global frailty index," combining PMA and already established functional indexes, will be most predictive.

Disclosures

The authors have no conflicts of interest to disclose.

Supplementary Data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.amjcard.2016.10.019.

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