Prognostic value of computed tomography derived measurements of pulmonary artery diameter for long-term outcomes after transcatheter aortic valve replacement

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ABSTRACT

Background: An increase in pulmonary artery diameter (PAD) on multi-detector computed tomography (MDCT) may indicate pulmonary hypertension. We assessed the prognostic value of MDCT-derived measurements of PAD on outcomes after successful transcatheter aortic valve replacement (TAVR).

Methods: Consecutive patients treated with TAVR from February 2013 to October 2017, with a 68.8% rate of new generation valves, underwent pre-interventional MDCT with measurements of PAD (in the widest short-axis within 3 cm of the bifurcation) and ascending aortic diameter (AoD; at the level of the PAD). The PAD/AoD ratio was calculated. Patients with high-density lipoprotein cholesterol levels ≤46 mg/dl and C-reactive protein levels ≥0.20 mg/dl at baseline were identified as the frail group. One-year mortality was established for all subjects.

Results: Among studied 266 patients (median age, 82.0 years; 63.5% women) those who died at 1 year (n = 34; 12.8%) had larger PAD and PAD/AoD (28.9 [5.0] vs. 26.5 [4.6] mm and 0.81 [0.13] vs. 0.76 [0.13] mm vs. the rest of the studied subjects; $P = 0.005$ and $P = 0.02$, respectively) but similar AoD. The cutoff value for the PAD to predict 1-year mortality was 29.3 mm (sensitivity, 50%; specificity, 77%; area under the curve, 0.65). Patients with PAD >29.3 mm (n = 72; 27%) had higher 1-year mortality (23.6% vs. 8.8%, log-rank $P = 0.001$). Baseline characteristics associated with PAD >29.3 mm were a bigger body mass index, more frequent diabetes mellitus, more prior stroke/transient ischemic attacks and atrial fibrillation, and lower baseline maximal aortic valve gradient with higher pulmonary artery systolic pressure (PASP). PAD >29.3 mm and frailty, but not baseline PASP, remained predictive of 1-year mortality in the multivariable model (hazard ratio [HR], 2.221; 95% CI, 1.038–4.753; $P = 0.04$ and HR, 2.801; 95% CI, 1.328–5.910; $P = 0.007$, respectively).

Conclusion: PAD >29.3 mm on baseline MDCT is associated with higher 1-year mortality after TAVR, independently of echocardiographic measures of PH and frailty.

Key words: TAVR, pulmonary hypertension, pulmonary artery diameter

WHAT'S NEW?

Pulmonary hypertension (PH) is common (75%) among patients undergoing transcatheter aortic valve replacement (TAVR) and is routinely diagnosed using echocardiography through pulmonary artery systolic pressure measurement (PASP). An increase in pulmonary artery diameter (PAD) on multi-detector computed tomography (MDCT) may indicate PH. We found that systolic PAD >29.3 mm measured at baseline angio-MDCT was associated with increased 1-year mortality after successful TAVR, whereas baseline PASP was not.

INTRODUCTION

In patients undergoing transcatheter aortic valve replacement (TAVR) for severe aortic stenosis (AS), pulmonary hypertension (PH) has a prevalence of up to 75% [1]. Transthoracic echocardiography (TTE) is recommended for measuring pulmonary artery systolic pressure (PASP) [2].

Multi-detector computed tomography (MDCT) provides very accurate structural images of the heart and enables repeatable measurements. Therefore, MDCT is the imaging method of choice used for planning TAVR procedures. An increase in pulmonary artery diameter (PAD) noticeable on MDCT is one of the characteristic features of PH [3]. However, the translation of MDCT data into clinical consequences through long-term prognosis after successful TAVR remains not entirely clear and documented, particularly whether this is an additive/independent prognostic marker to the measure of frailty and baseline aortic valve (AV) calcification [4, 5].

This study aimed to evaluate the value of PAD measurements obtained from MDCT in predicting outcomes after successful TAVR.

METHODS

From the hospital database at the National Institute of Cardiology in Warsaw, Poland, we identified 294 patients who underwent successful TAVR (according to Valve Academic Research Consortium: VARC-2 criteria) for severe AS from February 2013 to October 2017. All patients were Heart-Team qualified, the study complied with the Declaration of Helsinki; all signed informed consent, and the study was approved by the local ethics committee. Indications for the TAVR procedure were determined on the basis of the consensus of the multidisciplinary cardiac team. Data regarding baseline clinical characteristics and baseline and post-procedural echocardiographic measurements were prospectively gathered within the confines of the Polish Registry of Transcatheter Aortic Valve Implantation (POL-TAVI). Notably, dyslipidemia was defined as its previous history or current statin/fibrate treatment, whereas chronic renal disease was its previous diagnosis. At baseline, the measurements obtained using 2-dimensional TTE (Vivid S5/E95, General Electric, Boston, MA, US) included left ventricular ejection fraction (LVEF), maximal and mean aortic valve (AV) gradient, AV area, and PASP (using the maximal tricuspid regurgitation velocity and the estimated right atrial pressure). Patients with baseline PASP >36 mm Hg [6, 7] were considered to have PH. Post-procedural TTE evaluation included maximal AV gradient and grade of paravalvular leak (PVL) [8].

All patients underwent ECG-gated angio-MDCT (384-row SOMATOM® Definition Flash, Dual Source, SIEMENS, Forchheim, Germany) before TAVR for evaluation of (1) AV anatomy (tricuspid vs. bicuspid valve category and no/mild vs. moderate/heavy valve leaflet Rosenhek score calcification) [9]; (2) annulus dimension and calcification [5] (no/mild vs. moderate/severe); and (3) vascular access.

Twenty-eight patients (9.5%) were excluded from the current study because: (1) their MDCT images could not be found or were of poor quality (e.g. obtained without ECG gating, or with technical errors in acquisition); or (2) had missing information regarding baseline characteristics or follow-up.

In an off-line fashion using systolic image reconstructions with syngo.via (Siemens Healthcare GmbH, Erlangen Germany), a single experienced observer (blinded to the clinical data) measured PAD in the widest short-axis within 3 cm of the bifurcation and ascending aortic diameter (AoD) measured at the level of the PAD; the ratio of PAD/AoD was calculated. To assess interobserver variability, another experienced observer examined 25 randomly selected datasets that were also measured again by the first observer for the intraobserver variability >6 months after initial evaluation.

We chose baseline high-density lipoprotein cholesterol (HDL-C) and C-reactive protein (CRP) levels as valid measures of patient frailty; both were measured with the Cobas C 311 automated chemistry analyzer (Roche Diagnostics, Indianapolis, IN, US) and categorized accordingly for low HDL-C (≤46 mg/dl) and high CRP (≥0.20 mg/dl) [4].

The primary endpoint was all-cause death at 1-year after TAVR. Secondary endpoints were in-hospital outcomes collected in accordance with VARC-2. Survival status and date of death were obtained from both the National Registry of Population and the Valve Polyclinic.

The TAVR procedure was performed [10] with either a self-expandable supra-annular device — early generation CoreValve or newer generation Evolut-R/-Pro (CoreValve ReValving Technology, Medtronic, Inc., Minneapolis, MN, US); Acurate neo (Boston Scientific Corporation, Maple Grove, MN, US); or Engager (Medtronic, Inc., Minneapolis, MN, US); a balloon expandable early generation Edwards SAPIEN or newer generation SAPIEN XT/3 (Edwards Lifesciences, Irvine, CA, US); or new generation self-deployed

intra-annular Lotus Edge Aortic Valve System (Boston Scientific Corporation) [11]. TAVR procedural characteristics were prospectively collected.

Statistical analysis

Categorical data were compared with the χ^2 or Fisher exact tests. Normally distributed variables were compared using Student t-test and presented as the mean (standard deviation [SD]). The Mann-Whitney test was used for comparisons of variables with non-normal distributions, presented as the median and interquartile range (IQR). Interand intraobserver variability in PAD and AoD measurements were assessed with calculated respective intraclass correlation coefficients. Simple relationships between the relevant parameters were analyzed with bivariate correlation computing Spearman rho (*r*). The 1-year mortality predictive performance of PAD and PAD/AoD were analyzed separately using receiver operating characteristic curve (ROC) analysis. The maximum value of the Youden Index was used for cutoff point selection with the highest predictive performance, and respective areas under the ROC curve (AUC) were measured. Survival rates were assessed using Kaplan-Meier analysis and compared with the log-rank test. The 1-year all cause-mortality predictors were identified using Cox regression (100% of studied subjects accomplished 1-year follow-up). All baseline clinical variables with *P*-value <0.1 in the univariate analysis were entered in the multivariable model. *P*-value <0.05 was considered significant. Statistical analysis was performed using the PASW Statistics 18 (IBM Corporation, Armonk, NY, US).

RESULTS

The study included 266 patients treated with successful TAVR for *de novo* AS from February 2013 to October 2017. Median (IQR) patient age was 82.0 (78.0–85.3) years, the majority were female (n = 164; 61.7%), and most had surgical high-risk (n = 169; 63.5%) according to EuroSCORE I/II. The VARC-2 combined safety endpoint was recognized in 64 (24.1%) patients, with 30-day and 1-year mortality rates of 3.4% (n = 9) and 12.8% (n = 34), respectively.

Overall, mean PAD and mean AoD were 26.8 (4.7) mm and 35.1 (4.3) mm, respectively, with a mean PAD/AoD ratio of 0.76 (0.13). High interobserver and intraobserver agreement in PAD and AoD measurements was documented (Supplementary material, *Table S1*). Patients who died at 1 year had larger mean PAD and mean PAD/AoD compared with the survivors (28.9 [5.0] mm vs. 26.5 [4.6] mm and 0.81 [0.13] vs. 0.76 [0.13]; *P* = 0.005 and *P* = 0.02 respectively), but similar mean AoD (35.7 [4.3] vs. 35.2 [4.3] mm; *P* = 0.60). The optimal cutoff values for PAD and the PAD/AoD ratio to predict 1-year mortality were 29.3 mm (sensitivity, 50%; specificity, 77%; AUC, 0.65; 95% confidence interval [CI], 0.58–0.70) and 0.74 (sensitivity, 79.4%; specificity, 46.1%; AUC, 0.62; 95% CI, 0.56–0.68).

Patients with PAD >29.3 mm had higher body mass index (BMI), tended to have diabetes mellitus (DM) more frequently, and had substantially more prior stroke/transient ischemic attacks (TIA) (Table 1). Overall, at baseline there were 18.0% (n = 48) of subjects with low HDL-C and concomitant high CRP, indicating a frail patient population with similar distribution between the studied groups of patients with PAD >29.3 mm vs. PAD ≤29.3 mm (Table 1). Overall, median PASP was 40.5 (30.0–51.0) mm Hg and weakly correlated with a larger PAD (r = 0.290 and *P* <0.001). Patients with PAD >29.3 mm had higher PASP and had a more frequent tendency for PH (PASP >36 mm Hg; Table 1).

Landing zone calcification in the annulus region and AV leaflets was similar between patients with PAD ≤29.3 mm vs. PAD >29.3 mm (Table 2). Subjects with PAD >29.3 mm were treated with valves with larger nominal diameters (Table 3). On the other hand, intra-annular (balloon or mechanically expanded) valves were deployed more often among patients with severe annular calcification/heavily calcified AV leaflets (54.7% vs. 43.1% in other subjects, *P* = 0.04, respectively). These were used with similar frequency between patients with PAD ≤29.3 mm vs. PAD >29.3 mm (50.0% vs. 47.2%, respectively; *P* = 0.78).

In-hospital outcomes were alike in patients with PAD ≤29.3 mm vs. PAD >29.3 mm (Table 4). The PAD >29.3 mm group (n = 72; 27%) had higher 1-year mortality than other patients (23.6% vs. 8.8%, log-rank *P* = 0.001; Figure 1). Patients who died within 1-year were older and frailer; they suffered from more prior stroke/TIA, chronic obstructive pulmonary disease, and atrial fibrillation (AF). They had lower baseline maximal AV gradient and higher PASP and PAD/AoD but similar frequency of severe annular calcification or heavily calcified AV leaflets (Supplementary material, *Table S2*).

After adjustment for baseline clinical, echocardiographic, and angio-MDCT parameters, baseline PAD >29.3 mm was associated with increased mortality after first year (HR, 2.221; 95% CI, 1.038–4.753; *P* = 0.04) independently of other risk factors (presence of low HDL-C and high CRP) (Table 5).

DISCUSSION

The main findings of our study are as follows: (1) Apart from the detailed insight into the aortic root anatomy crucial for sizing and valve type selection, baseline angio-MDCT done before the procedure provided additional information about the long-term prognosis after successful TAVR derived from a simple and quick measure of the maximal absolute systolic PAD; (2) The optimal cutoff value of maximal PAD to predict 1-year mortality found in our study (29.3 mm) is consistent with the current guidelines on diagnosis and treatment of PH, indicating that MDCT may raise a suspicion of PH by showing an increased PA diameter of ≥29 mm [2]; (3) However, almost 45% of our patients with PAD >29.3 mm had corresponding PASP that was within normal limits (≤36 mm Hg), with MDCT-derived PAD and Doppler-measured PASP having only a weak correlation, and increased baseline PASP not providing independent

Table 1. Comparison of baseline demographic clinical characteristics and echocardiographic parameters (preand post-TAVR) between the studied groups

	All patients (n = 266, 100%)	Patients with PAD ≤29.3 mm (n = 194, 72.9%)	Patients with PAD >29.3 mm (n = 72, 27.1%)	*P*-value
Baseline demographic and clinical characteristics				
Surgical high-risk[a], n (%)	169 (63.5)	119 (61.3)	50 (69.4)	0.25
Age, years, median (IQR)	82.0 (23.9–85.3)	82.0 (78.0–85.3)	82.0 (78.3–85.6)	0.95
Female, n (%)	164 (61.7)	117 (60.3)	47 (65.3)	0.48
BMI, kg/m^2, median (IQR)	26.9 (23.9–30.0)	26.1 (23.4–29.4)	27.9 (25.9–32.0)	0.001
Diabetes mellitus, n (%)	99 (37.2)	66 (34.0)	33 (45.8)	0.09
Hypertension, n (%)	207 (77.8)	153 (78.9)	54 (75.0)	0.51
Dyslipidemia, n (%)	228 (85.7)	169 (87.1)	59 (81.9)	0.32
Chronic renal disease, n (%)	98 (36.8)	68 (35.1)	30 (41.7)	0.32
Previous stroke/TIA, n (%)	36 (13.5)	20 (10.3)	16 (22.2)	0.02
Peripheral vascular disease, n (%)	39 (14.7)	24 (12.4)	15 (20.8)	0.12
Chronic obstructive lung disease, n (%)	28 (10.5)	17 (8.8)	11 (15.3)	0.18
Previous cardiac surgery, n (%)	53 (19.9)	40 (20.6)	13 (18.1)	0.73
Previous percutaneous coronary intervention, n (%)	82 (30.8)	62 (32.0)	20 (27.8)	0.55
Previous myocardial infarction, n (%)	62 (23.3)	47 (24.2)	15 (20.8)	0.63
Atrial fibrillation, n (%)	73 (27.4)	48 (18.0)	25 (34.7)	0.12
Pacemaker implanted, n (%)	40 (15.0)	28 (14.4)	12 (16.7)	0.70
HDL-C, mg/dl, mean (SD)	52.9 (21.6)	53.1 (22.3)	52.5 (19.8)	0.84
CRP, mg/dl, median (IQR)	0.20 (0.10–0.46)	0.18 (0.09–0.45)	0.28 (0.10–0.54)	0.18
Low HDL-C and high CRP[b], mean (SD)	52 (19.5)	35 (18.2)	17 (23.1)	0.47
Echocardiographic parameters (baseline and post-TAVR)				
Baseline LVEF, %, median (IQR)	57.0 (41.0–73.0)	59.0 (41.0–75.0)	53.0 (38.8–67.8)	0.048
Baseline LVEF <50%, n (%)	53 (19.9)	36 (18.6)	17 (23.6)	0.39
Baseline maximal AV gradient, mm Hg, median (IQR)	80.0 (65.4–92.9)	82.0 (68.0–95.0)	75.5 (59.8–89.2)	0.06
Baseline mean AV gradient, mm Hg, median (IQR)	49.0 (40.0–60.0)	49.4 (40.4–60.0)	48.0 (38.1–61.0)	0.46
Bicuspid aortic valve, n (%)	37 (13.0)	30 (15.5)	7 (9.7)	0.32
Baseline AV area, cm^2, median (IQR)	0.70 (0.50–0.80)	0.70 (0.50–0.82)	0.60 (0.50–0.79)	0.11
PASP, mm Hg, median (IQR)	40.5 (30.0–51.0)	39.0 (30.0–50.0)	45.5 (30.3–59.8)	0.02
PASP >36 mm Hg, n (%)	148 (55.6)	101 (52.1)	47 (65.3)	0.07
Post-TAVR maximal AV gradient, mm Hg, median (IQR)	15.0 (11.0–20.0)	15.0 (11.0–20.0)	16.0 (10.6–19.8)	0.89
Mild paravalvular leak, n (%)	63 (23.7)	43 (22.2)	21 (29.2)	0.26

[a]Logistic EuroSCORE I ≥10% or EuroSCORE II ≥4. [b]HDL-C ≤46 mg/dl and CRP ≥0.20 mg/dl

Abbreviations: AV, aortic valve; BMI, body mass index; CRP, C-reactive protein; HDL-C, high-density lipoprotein cholesterol; IQR, interquartile range; LVEF, left ventricular ejection fraction; PAD, pulmonary artery diameter; PASP, pulmonary artery systolic pressure; TAVR, transcatheter aortic valve replacement; TIA, transient ischemic attack

Table 2. Comparison of relevant baseline angio-MDCT measurements between the studied groups

Procedural characteristics	All patients (n = 266, 100%)	Patients with PAD ≤29.3 mm (n = 194, 72.9%)	Patients with PAD >29.3 mm (n = 76, 27.1%)	*P*-value
PAD, mm, mean (SD)	26.8 (4.7)	24.6 (3.0)	32.7 (3.2)	<0.001
AoD, mm, mean (SD)	35.3 (4.3)	34.6 (4.3)	37.2 (3.6)	<0.001
PAD/AoD index, mean (SD)	0.76 (0.13)	0.72 (0.11)	0.89 (0.11)	<0.001
Moderate/severe annular calcification, n (%)	60 (22.9)	45 (23.7)	15 (20.8)	0.74

[a]Rosenhek score = 3 or 4

Abbreviations: AoD, ascending aortic diameter; SD, standard deviation; other — see Table 1

prognostic information; (5) At the same time, baseline PAD >29.3 mm accompanied by a joint presence of more frequent AF, more AF-related cerebrovascular events, and lower maximal AV gradient and LVEF at baseline, appeared to be novel and clinically useful markers of a more advanced stage of LV deterioration (5). PAD >29.3 mm proved to offer prognostic information that was independent of that obtainable with frailty assessment.

Mean PAD measured in TTE among patients with PH (diagnosed upon invasive measure of mean pulmonary artery pressure [mPAP]), with measured in TTE mean PASP of 52 mm Hg, was 28.0 mm. This is in line with the current PAD cutoff point of 29.3 mm and corresponding PASP of 45 mm Hg [12]. The cutoff value of MDCT-measured PAD to identify PH (diagnosed with right heart catheterization) reported in previous studies ranges from 25 to 33.2 mm

Table 3. Comparison of procedural characteristics between the studied groups

Procedural characteristics	All patients (n = 266, 100%)	Patients with PAD ≤29.3 mm (n = 194, 72.9%)	Patients with PAD >29.3 mm (n = 76, 27.1%)	*P*-value
Transfemoral access, n (%)	218 (82.0)	156 (80.4)	62 (86.1)	0.53
Subclavian access, n (%)	16 (6.0)	13 (6.7)	3 (4.2)	0.53
Nominal valve diameter, mm, median (IQR)	26.0 (26.0–29.0)	26.0 (26.0–29.0)	29.0 (26.0–29.0)	0.005
Self-expanded supra-annular valve, n (%)	137 (51.5)	97 (50.0)	40 (52.8)	0.78
Newer valve generations, n (%)	183 (68.8)	134 (69.1)	49 (68.1)	0.88
Post-dilatation, n (%)	67 (25.2)	48 (24.7)	19 (26.4)	0.87
Contrast agent volume (ml), median (IQR)	200 (150–200)	200 (150–200)	200 (150–200)	0.24
Fluoroscopy time, min, median (IQR)	28.3 (21.1–38.0)	28.2 (21.0–37.1)	28.7 (21.9–40.4)	0.23
Radiation, mGy, median (IQR)	1269 (783–2181)	1229 (709–2118)	1537 (936–2476)	0.04

Abbreviations: see Table 1

Table 4. Comparison of in-hospital events between the studied groups

VARC-2 endpoints	All patients (n = 266, 100%)	Patients with PAD ≤29.3 mm (n = 194, 72.9%)	Patients with PAD >29.3 mm (n = 76, 27.1%)	*P*-value
Life-threatening/disabling bleeding, n (%)	16 (6.0)	12 (6.2)	4 (5.6)	1.0
Major bleeding, n (%)	43 (16.2)	32 (16.6)	11 (15.3)	1.0
Any red blood cell transfusion, n (%)	88 (33.1)	67 (34.5)	21 (29.2)	0.46
Major vascular complications, n (%)	44 (16.5)	32 (16.5)	12 (16.7)	1.0
Myocardial infarction but without coronary artery obstruction requiring intervention, n (%)	1 (0.4)	1 (0.5)	0 (0)	1.0
Stroke, n (%)	5 (1.9)	3 (1.5)	2 (2.8)	0.61
New permanent pacemaker, n (%)	33 (12.4)	22 (11.3)	11 (15.3)	0.41
In-hospital mortality, n (%)	9 (3.4)	5 (2.6)	4 (5.6)	0.26
VARC-2 combined endpoint, n (%)	54 (20.3)	45 (23.2)	19 (26.4)	0.63
1-year all-cause mortality, n (%)	34 (12.8)	17 (8.8)	17 (23.6)	0.003

Abbreviations: VARC, Valve Academic Research Consortium; other — see Table 1

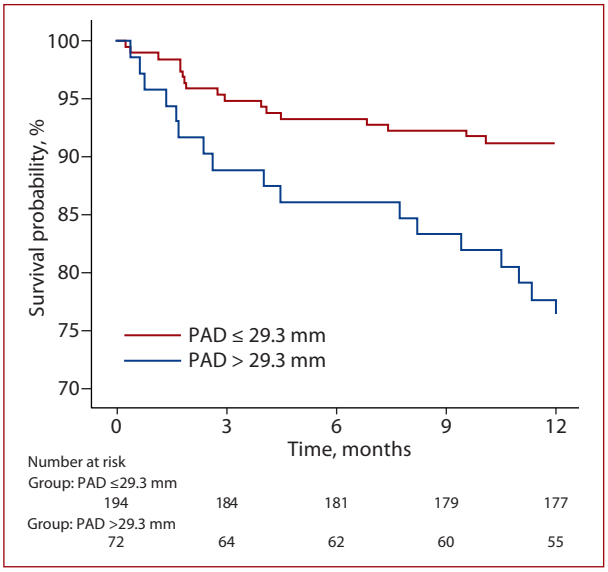

Figure 1. Subsequent mortality rates within 1-year after successful transcatheter aortic valve replacement were higher among subjects with pulmonary artery diameter ≥29.3 mm (log-rank *P* = 0.001), with median (interquartile range) 2.8 (1.7–7.8) months follow-up of those who died

Abbreviations: see Table 1

[13], and its corresponding correlation with mPAP ranged from r = 0.301 to r = 0.83 and it did not increase with larger PAD dimensions. Consistently, in our study, PAD correlated only weakly with PASP (r = 0.290). At least a 17% misdiagnosis rate (false positive) was also reported in the above studies. In our analysis, almost 45% of patients with PAD >29.3 mm had PASP ≤36 mm Hg (normal limit). Thus, an invasive measure of mPAP >25 mg was found in 75% of patients undergoing TAVR, with 82% of these having LV end-diastolic pressure (LVEDP) of >15 mm Hg [14], indicating postcapillary PH (a result of an increase in pulmonary venous pressure). On the other hand, a precapillary component of PH due to pulmonary vascular remodeling (identified with LVEDP ≤15 mm Hg or calculated diastolic PAP minus LVEDP of ≥7 mm Hg) was found in 32.3% of patients, which corresponds to the current 27.1% frequency of PAD >29.3 mm. Successful TAVR procedures lead immediately to a substantial decrease in mPAP. When compared with no PH, higher 1-year mortality rates were observed only among those with the precapillary element of PH. Hazard ratios of the precapillary and combined PH (joint presence of pre and postcapillary components) associated with increased subsequent mortality are similar to those

Table 5. Predictors of all-cause 1-year mortality

	Univariate		Multivariable	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Age, years	1.061 (1.000–1.126)	0.05	1.049 (0.983–1.119)	0.15
Previous stroke/TIA history	2.463 (1.149–5.277)	0.02	2.130 (0.922–4.921)	0.08
Chronic obstructive lung disease	2.188 (0.953–5.026)	0.06	2.397 (0.879–6.536)	0.09
Atrial fibrillation	2.838 (1.449–5.561)	0.002	1.706 (0.793–3.670)	0.17
Baseline maximal AV gradient	0.976 (0.952–1.000)	0.046	0.991 (0.977–1.004)	0.17
PASP >36 mm Hg	2.007 (0.960–4.198)	0.06	1.704 (0.729–3.981)	0.21
PAD >29.3 mm	2.879 (1.470–5.641)	0.002	2.221 (1.038–4.753)	0.04
Low HDL-C and high CRP[a]	3.183 (1.519–6.667)	0.002	2.801 (1.328–5.910)	0.007

The multivariable model included all baseline clinical variables with *P*-value <0.1 in the univariate analysis

[a]HDL-C ≤46 mg/dl and CRP ≥0.20 mg/dl

Abbreviations: CI, confidence interval; HR, hazard ratio; other — see Table 1

found by us for PAD >29.3 mm (2.3 in precapillary and 3.15 in combined PH vs. the current 2.8, respectively). Thus, if PAD >29.3 mm is to reflect PH, it appears to indicate the presence of its precapillary component.

Baseline MDCT systolic PAD evaluation before TAVR is a noninvasive and simple measure with currently shown high inter and intraobserver accuracy, whereas invasive diagnosis is subjected to temporal changes in the relevant parameters (e.g. falsely normal LVEDP measure due to diuretics) that are crucial to specify a particular PH category to get the accurate prognostic information. Whereas mean AoD was similar, overall mean PAD in our study was substantially smaller than that measured among 707 consecutive patients treated with TAVR in Bonn (35.3 mm vs. 3.49 cm and 26.8 mm vs. 3.10 cm, respectively) [3]. However, the German authors did not perform inter- and intraobserver variability analyses. Importantly, our results of MDCT measurements of AoD and PAD, as well as the increased long-term mortality hazard ratios, are all in line with the recent large-scale study (n = 895) [15], which documented that patients with PAD ≥29.0 mm (41.2%) had 2.21 higher risk of 2-year mortality (95% CI, 1.44–3.39; *P* <0.001). Interestingly, in the above study absolute difference in average PASP between patients with PAD <29.0 vs. ≥29.0 mm was only 5 mm Hg (32 mm Hg vs. 37 mm Hg; *P* <0.001, respectively). Also, patients with PAD reduction on serial computed tomography (CT) studies compared to the no-reduction group had much better long-term survival (1.7% vs. 30.7%; *P* = 0.002 respectively).

The worse prognosis for patients with baseline PAD >29.3 mm observed currently after successful TAVR might be attributed to the natural course of the more frequent concomitant presence of DM with higher BMI and a trend toward twice more frequent chronic obstructive pulmonary disease, which is also in line with other observations among patients with dilated PAD or elevated pulmonary artery (PA) pressure [14, 15]. The above comorbidities are consistently associated with higher subsequent mortality despite successful TAVR and contribute also specifically to the progression of PH, thus their intensive treatment may also reduce severity of PH [16, 17]. At the same time, DM was shown to be associated with poor LV mass regression even after successful TAVR. Current results are in line with the prior observations linking dilatated PAD with features of more advanced and complex baseline LV dysfunction (abnormal myocardial structure with diastolic and systolic impairment) as signified by more frequent and longer AF history (more stroke/TIA complications) [18] and lower LVEF and baseline AV gradients. This further supports our hypothesis that the mechanism of worse prognosis of patients with PAD >29.3 mm is associated also with less LV recovery despite the successful AV replacement [19].

AoD indexed to body surface area (BSA; a measure of body size) appears a more patient-specific predictor of the risk of serious events than uncorrected AoD [19]. However, moderate or higher risk of subsequent events (≥8%/year) was seen with AoD <55.0 mm only among a few female subjects with height <150 cm. Further, there were a few male subjects with AoD >55.0 mm considered to be low-risk (~1%/year), with height ≥185 cm [20]. Indexing AoD for height was of similar predictive power compared to BSA [21].In our study, there was a weak correlation with BSA and PAD and with BSA and AoD ($r = 0.180$; $P = 0.003$ and $r = 0.224$; $P <0.001$, respectively), along with a weak correlation with PAD and AoD and none with BSA and PAD/AoD ($r = 0.316$ and $P <0.001$ and $r = 0.006$; $P = 0.927$, respectively). Similar results were obtained for BMI (estimate of total body fat). AoD in our study was significantly larger among patients with PAD >29.3 mm, but along with substantially bigger PAD/AoD index, indicating that the current increase in PAD is not just a simple measure of a larger dimension of the vessel parallel to bigger body size. Indexing PAD for height/BSA will not allow identification of patients with absolute PAD ≤29.3 mm but with increased risk of subsequent death. At the same time, it will not change the high-risk category of those with PAD >29.3 and bigger BSA/height.

Study limitations

This was a retrospective observational analysis subjected to the patient selection bias. The study is of a small scale with only a 1-year follow-up. PAD were measured on 2-dimensional axial images instead of 3-dimensional reconstructed images. We lacked data on the prior pulmonary embolism which might impact PAD and subsequent outcomes. Moreover, we did not have data on the right ventricular function and dimension, LV remodeling, or concomitant valvular insufficiencies, all of which are of potential prognostic importance [22].

CONCLUSIONS

Systolic PAD of >29.3 mm measured on baseline angio-MDCT is associated with increased subsequent 1-year mortality after successful TAVR regardless of the frailty measure. This measure is a suitable parameter for routine evaluation before TAVR and may be an important marker for patient prognosis to guide subsequent therapeutic actions.

Supplementary material

Supplementary material is available at https://journals.viamedica.pl/kardiologia_polska.

Article information

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