Usefulness of the Right Parasternal Echocardiographic View to Improve the Hemodynamic Assessment After Valve Replacement for Aortic Stenosis

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Right-parasternal-view (RPV) often provides the best hemodynamic assessment of the aortic-valve-stenosis by echocardiography. However, no detailed study on patients with aortic prosthesis is available. Thus, RPV usefulness is left as an anecdotical notion in this context. We aimed to define feasibility and clinical-impact of RPV before and soon-after percutaneous implantation (TAVI) or surgical (SAVR) aortic-valve-replacement (AVR) for AS. Patients with severe-AS electively referred for AVR between September-2019 and February-2020 were prospectively evaluated. Echocardiographic examinations inclusive of apical and RPV to measure aortic-peak-velocity , gradients and area (AVA) were performed the day before AVR and at hospital discharge and compared by matched-pair-analysis. Forty-seven patients (mean age 79 ± 8 years, 63% female, ejection-fraction 61 ± 6%) referred for SAVR (24 [51%]) or TAVI (23 [49%]) were enrolled. RPV was feasible in 45 patients (96%) before-AVR but in only 32 after-AVR (68%), particularly after SAVR (50%) than TAVI (87% p = 0.005). RPV remained the best acoustic window after TAVI in 75% of cases. Hemodynamic assessment of TAVI, but not SAVR, invariably benefit from RPV versus apical evaluation (aortic-peak-velocity: 2.57 ± 0.39 vs 2.23 ± 0.47 m/sec, p = 0.002; mean gradient: 15 ± 5 vs 12 ± 5 mm Hg, p = 0.01). Five (11%) patients presented severe patient-prosthesis-mismatch, 4 of which were detectable only by RPV. This pilot-experience demonstrates that RPV feasibility is slightly reduced after AVR. RPV can improve the hemodynamic assessment of the prosthetic valve versus apical view, including the detection of patient-prosthesis-mismatch. Furthermore, when RPV is the best acoustic windows in patients with severe AS, it generally remains so after-TAVI. **(Am J Cardiol 2021;142:103−108)**

It has long been mentioned that multiple, nonapical windows, particularly right parasternal view (RPV), are useful to accurately assess aortic valve hemodynamics for native aortic valve stenosis (AS) as well for aortic valve prothesis.[1,2] The incremental value of RPV in the assessment of native aortic valves has been demonstrated in the last years.[3−5] Despite being highly feasible and little time consuming, RPV is routinely adopted by only half of cardiologist in routine practice for the assessment of native aortic valve.[6] In addition, no study specifically addressed feasibility and relevance of RPV after aortic valve replacement (AVR),[2] leaving RPV usefulness and its effectiveness unsupported by evidence in this context. Thus, we aimed at prospectively studying the feasibility of RPV before and soon after (in hospital) both surgical (SAVR) and percutaneous (TAVI) valve implantation, exploring whether best acoustic windows before-AVR remains the same after-AVR. Moreover, we sought to examine whether the incremental hemodynamic information provided by RPV at baseline persists after AVR.

Methods

We prospectively enrolled consecutive patients referred for isolated AVR (surgical or percutaneous) at the University of Verona, Cardiovascular department, Italy between September 2019 and February 2020. Exclusion criteria were the need for concomitant coronary revascularization, severe combined valvular disease, urgent procedures, previous cardiac surgery. All patients underwent a complete echocardiogram the day before and 3 to 6 days after AVR, before the hospital discharge. The study was approved by the institutional review board and all patients signed the written informed consent. Complete clinical information was collected, including referral echocardiogram details. Echocardiographic examinations were performed by a single board-certified echo-cardiologist with more than 5 years of experience, with commercially available ultrasound systems. Left ventricular volumes and ejection fraction were measured using bi-plane Simpson's method. Left ventricular outflow-tract (LVOT) stroke volume was calculated as

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Funding: none.

See page 108 for disclosure information.

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0002-9149/
https://doi.org/10.1016/j.amjcard.2020.11.028

the product of LVOT cross-sectional area and LVOT time-velocity-integral, measured by pulsed wave Doppler. At baseline, pulsed-wave Doppler sample volume was located just apical (≤5 mm) to the aortic annulus and the LVOT diameter was measured close (≤5 mm) to the aortic annulus. After-AVR, the LVOT velocity and diameter were obtained just apical to prosthetic valve stent or ring; the LVOT diameter was measured outer-to-outer border. Transvalvular velocities were interrogated, using a standard 2D and/or Doppler probe, by continuous-wave Doppler from apical and RPV. Maximal instantaneous gradient across the aortic valve was calculated using a modified Bernoulli equation; mean transaortic gradient (MG) was measured by tracing of the velocity curve. Aortic valve area (AVA) was calculated by the continuity equation and subsequently indexed for body surface area (AVA-i). Doppler velocity index (DVI) was calculated as the ratio of LVOT-VTI to aortic-VTI. Severe prosthesis-patient mismatch (PPM) was defined as the indexed AVA-i <0.65 cm2/m2.[1,7–9]

Comparison between apical and RPV measurements was performed by matched paired t-test or Wilcoxon signed-rank test as appropriate. Interobserver variability was blindly tested on 10 consecutive patients between Cardiologist and Echocardiography Fellow before and after an adequate training (20 severe AS cases). Reliability was tested using intraclass correlation coefficient (ICC). We computed an a-priori sample sizing for a matched pair analysis for peak transaortic velocity (Vmax) based on our previously published large experience,[5] and the minimum number of patients needed to achieve 80% power was 19.

Results

A total of 47 consecutive patients were enrolled. Patients' clinical and echocardiographic characteristics are presented in Table 1. The majority of patients (87%, n = 41) had class I indication for surgery whereas 6 symptomatic patients had class IIa (referred as low-flow low-gradient with preserved ejection fraction). RPV was feasible in 45 of 47 (96%) patients before AVR. The 2 nonfeasible patients were a man referred for TAVI and a woman referred for SAVR. In total 29 of 45 (64%) patients had higher Vmax from RPV versus apical view. Hemodynamic parameters from RPV versus apical acoustic windows are presented in Table 2. Vmax and mean gradient were significantly higher and valve area (AVA) lower from RPV versus apical view (4.54 ± 0.73 vs 4.31 ± 0.67 m/sec, p = 0.0003; 53 ± 20 vs 48 ± 17 mm Hg p = 0.0004; 0.63 ± 0.18 vs 0.68 ± 0.18 cm^2, p = 0.03); paradigmatic examples are presented in Figure 1. Noteworthy, the number of patients with very-severe AS (Vmax>5 m/sec) significantly increased (from 5 to 9 patients p = 0.0009) when RPV was performed on top of apical view. Interestingly, of the above-mentioned patients referred to AVR with diagnosis of discordance between AVA and MG, only 2 of 6 presented a paradoxical low-flow low-gradient AS after RPV assessment, the other four had concordance between AVA (<1 cm^2) and MG (>40 mm Hg). AVR with biological valves was uneventfully performed in all patients: 24 (51%) underwent SAVR and 23 (49%) underwent TAVI. Only biological valves were chosen for SAVR. The average prosthetic valve size was 24 ± 3 mm (22 ± 2 mm in SAVR and 26 ± 3 mm in TAVI). Postoperative echocardiogram was performed 4 ± 2 days after the procedures. After AVR, RPV was feasible in 32 patients (68%), being higher in TAVI than in SAVR (20 of 23 [87%] vs 12 of 24 [50%] p = 0.005). Among feasible cases, Vmax was higher from RPV versus apical view in 24 of 32 (75%) patients (16 after-TAVI, 8 after-SAVR).

As shown in Table 2, peak trans-prosthetic velocity and mean gradient were overall slightly higher from RPV versus apical view, with comparable DVI and AVA-i. Evaluations in the TAVI subgroup gained particular benefit from RPV assessment versus apical (Vmax: 2.57 ± 0.39 vs 2.23±0.47 m/sec, p = 0.002; mean gradient: 15 ± 5 vs 12 ± 5 mm Hg, p = 0.01, DVI: 0.54 ± 0.06 vs 0.60 ± 0.07, p = 0.005, AVA-i 0.95 ± 0.24 vs 1.07 ± 0.33, p = 0.007). In addition, RPV had provided the best hemodynamic assessment in 16 of 20 patients before TAVI and yet remained the best acoustic window after TAVI in 75% (12 of 16) of those

Table 1
Clinical and echocardiographic characteristics of the study cohort

Variable	Patients(n = 47)
Age (years)	79 ± 8
Women	30 (63%)
BSA (m^2)	1.78 ± 0.15
Systolic arterial pressure (mm Hg)	138 ± 10
Diastolic arterial pressure (mm Hg)	75 ± 7
Heart rate (beats per minute)	70 ± 9
Hypertension	41 (87%)
Smokers	8 (17%)
Dyslipidemia	18 (38%)
Family history of coronary artery disease	6 (13%)
Diabetes	11 (23%)
Previous ischemic heart disease, n (%)	5 (11%)
Baseline echocardiography	
End Diastolic Volume-index (ml/m^2)	59 ± 12
End Systolic Volume- index (ml/m^2)	25 ± 7
Ejection Fraction (%)	61 ± 6
Left atrial volume-index (ml/m^2)	41 ± 12
Mild Aortic regurgitation	28
Moderate Aortic regurgitation	8
Mild Mitral regurgitation	40
Moderate Mitral regurgitation	3
Mild Tricuspid regurgitation	38
Moderate Tricuspid regurgitation	1
E/A	0.98 ± 0.46
DTE (msec)	226 ± 73
E/e' ratio	15 ± 5
TAPSE (mm)	23 ± 4
Systolic pulmonary artery pressure (mm Hg)	38 ± 10
LVOT diam (mm)	1.98 ± 0.21
LVOT SV (ml)	67 ± 17
Peak transaortic gradient (mm Hg)	87 ± 28
Mean transaortic gradient (mm Hg)	55 ± 18
Peak transaortic velocity (m/sec)	4.62 ± 0.68
Aortic valve area (cm^2)	0.60 ± 0.19
Aortic Hemodynamic after AVR	
Peak transaortic gradient (mm Hg)	25 ± 9
Peak transaortic velocity (m/sec)	2.46 ± 0.45
Mean transaortic gradient (mm Hg)	14 ± 6
Doppler velocity index	0.56 ± 0.08
Aortic valve area (cm^2)	1.93 ± 0.53
Aortic valve area-index (cm^2/ m^2)	0.96 ± 0.23

Table 2
Feasibility and aortic hemodynamic parameters from apical versus right parasternal view before and after aortic valve replacement

Feasibility RPV baseline = 45 of 47	Mean from Apical(n = 45)	Mean from RPV(n = 45)	Mean difference (95%CI)	p value matched pairs
Peak transaortic gradient, mm Hg	76.1 ± 23.9	84.7 ± 29.3	+8.7 (3.1-14.2)	0.003
Mean transaortic gradient, mm Hg	48.1 ± 16.9	53.2 ± 19.7	+5.06 (1.7-8.4)	0.004
Peak transaortic velocity, m/sec	4.31 ± 0.67	4.54 ± 0.73	+0.24 (0.07-0.39)	0.003
Aortic valve area, cm^2	0.68 ± 0.18	0.63 ± 0.18	-0.04 (0.01-0.08)	0.03
Feasibility RPV after AVR (surgical or TAVI) =32/47	**Mean from Apical (n = 32)**	**Mean from RPV (n = 32)**	**Mean difference (95%CI)**	**p value matched pairs**
Peak transaortic gradient, mm Hg	22.2 ± 8.9	25.8 ± 8.4	+3.6 (1.61-6.93)	0.03
Mean transaortic gradient, mm Hg	12.7 ± 5.7	14.7 ± 5.3	+1.94 (0.92-3.82)	0.04
Peak transaortic velocity, m/sec	2.29 ± 0.47	2.51 ± 0.41	+0.21 (0.08-0.37)	0.01
Doppler velocity index	0.58 ± 0.11	0.60 ± 0.09	-0.02 (-0.07-+0.02)	0.1
Aortic valve area, cm^2	1.86 ± 0.51	1.78 ± 0.50	-0.07 (-0.22-+0.07)	0.3
Aortic valve area-index, cm^2/m^2	1.04 ± 0.30	0.99 ± 0.26	-0.04 (-0.13-+0.05)	0.2
TAVI subgroup Feasibility 20/23	**Mean from apical (n = 20)**	**Mean from RPV (n = 20)**	**Mean difference (95%CI)**	**p value matched pairs**
Peak transaortic gradient, mm Hg	20.8 ± 8.4	27.1 ± 8.3	+6.2 (1.9-10.2)	0.004
Mean transaortic gradient, mm Hg	11.7 ± 5.1	14.6 ± 5.2	+2.9 (1.0-5.1)	0.01
Peak transaortic velocity, m/sec	2.23 ± 0.47	2.57 ± 0.39	+0.34 (0.13-0.55)	0.002
Doppler velocity index	0.54 ± 0.060	0.60 ± 0.07	-0.05 (0.01-0.09)	0.005
Aortic valve area, cm^2	1.84 ± 0.54	1.66 ± 0.44	-0.20 (-0.05-0.35)	0.01
Aortic valve area-index, cm^2/m^2	1.07 ± 0.33	0.95 ± 0.24	-0.011 (-0.04-0.19)	0.007

AVR = Aortic Valve Replacement; RPV = Right parasternal view; TAVI = Transcatheter aortic valve implantation.

patients. This pattern was detectable in only 50% of SAVR cases. Treatment option (SAVR vs TAVI) resulted a predictor of RPV feasibility (p = 0.01 at logistic regression). Figure 2 summarizes the incremental value of RPV before and after AVR in the hemodynamic assessment.

Overall, severe PPM was detected in 5 of 47 patients (11%), in one case PPM was detectable by both apical and RPV, in the remaining 4 cases it was only detectable from RPV.

Before training, RPV feasibility was significantly lower for the Fellow versus the Cardiologist (4 of 10 vs 8 of 10). Furthermore, when RPV was feasible by both, the detected Vmax showed lower values for the Fellow versus the Cardiologist (mean difference -0.4 [+0.3 to 1.1] m/sec, p = 0.1) with low agreement (ICC 0.46 [0.30 to 0.94], p = 0.1). After the 20 cases of training, test-retest was performed in additional 10 cases. This time feasibility was comparable (9 of 10 vs 9 of 10) and test-retest variability was remarkably

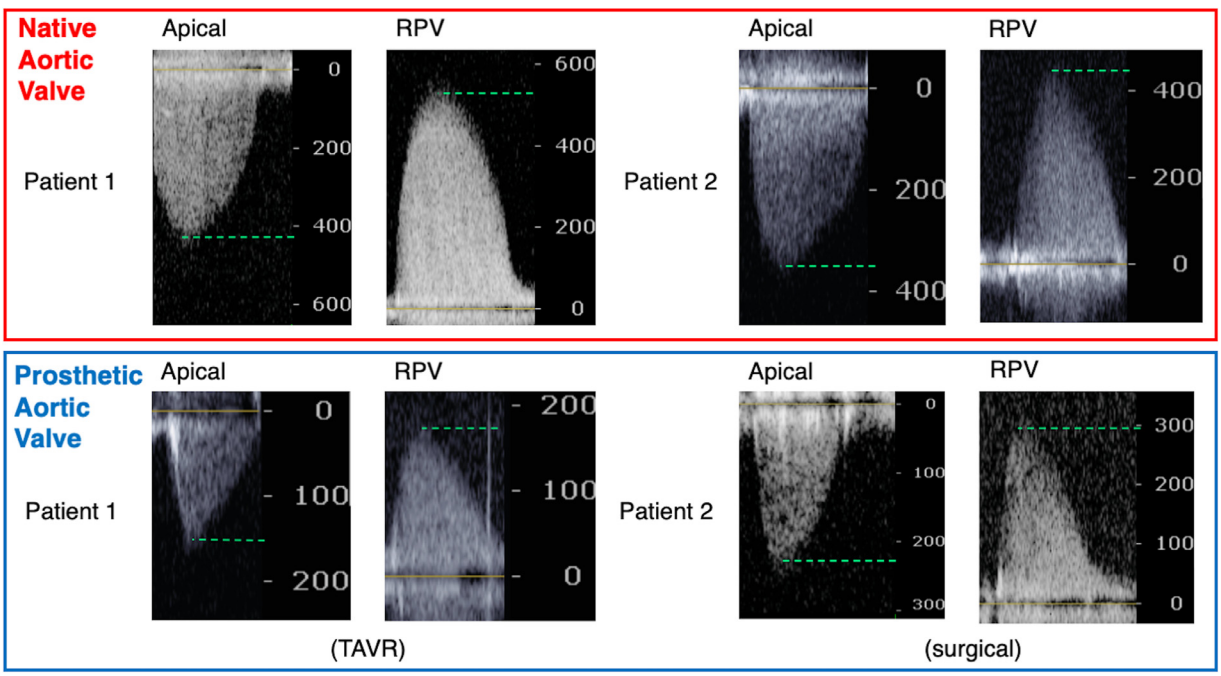

Figure 1. Paradigmatic examples of hemodynamic assessment in apical versus right parasternal view in native aortic valve stenosis (red box) and after surgical or percutaneous aortic valve replacement (blue box). Green dashes indicate the reached peak velocity (in cm/sec).

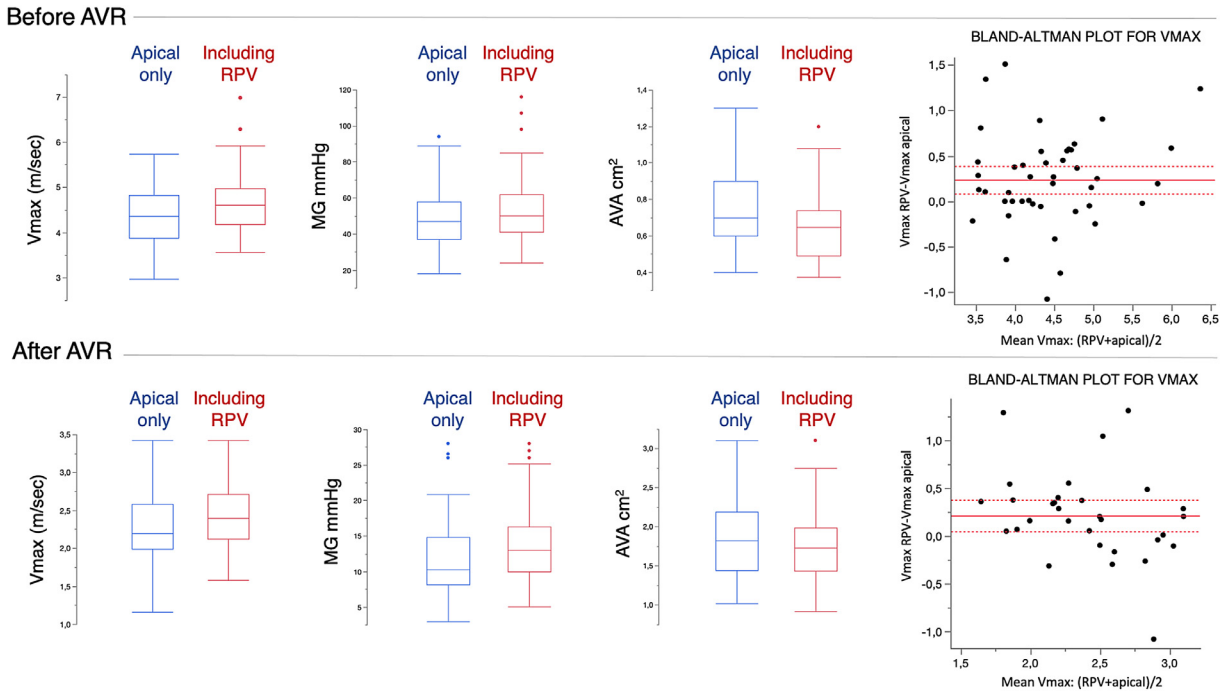

Figure 2. The left box plot shows the average peak velocity, mean gradient, and aortic valve area when RPV is implemented to the echocardiographic evaluation (vs apical only). On the right, Bland-Altman plots comparing Vmax from apical versus right parasternal view. All comparisons are presented before (top) and after-AVR (bottom). AVR = aortic valve replacement; RPV= right parasternal view; Vmax = aortic-peak-velocity.

lower (ICC 0.96 [0.79 to 0.99], p <0.0001) between the 2 physicians with mean difference in Vmax of just -0.1 [0.01 to 0.21] mm Hg, p = 0.05.

Discussion

This pilot study on RPV in patients undergoing AVR provides for the first-time supporting evidence to this often-forgotten approach. The main results are: (1) RPV feasibility is reduced soon after AVR, particularly after SAVR; (2) RPV significantly improves the accuracy of echocardiographic evaluation after AVR, with important clinical implications such as the improvement of severe PPM detection; (3) When RPV provides the best assessment before AVR, it often results in the best view also after AVR.

The recommendations for the assessment of valvular disease mention the importance of right parasternal window,[2,9] but the supporting evidence are anecdotical.[10,11] Moreover, to our knowledge, no data are provided in the TAVI era. It is worrisome that, even for the assessing of native AS, the RPV approach is not always performed; indeed, a systematic adoption of RPV is reported by only 52% of the practitioners who participated to a recent European survey.[6] Similarly, the recommendation on the assessment of prosthetic aortic valves state the needs for multi-windows echocardiographic assessment. However, there is scarce data from clinical practice on utilization or usefulness of RPV after AVR, and this enhances the importance of the present study.

In our study, RPV feasibility is reduced early after AVR (68% vs 96%) as compared with native AS, remaining remarkable in the TAVI subgroup (87%). Reasons for lower feasibility in SAVR versus TAVI patients may be multiple. First, anatomical alteration may occur with the opening of the chest, and the pericardium. In this regard, we noticed that the probe generally needs to be positioned more laterally on the right side than usual to acquire RPV after SAVR. Second, the chest wound and wall edema are still present, and patients' mobility may still be limited a few days after surgery when the echocardiogram was performed in our study. Performing the echocardiography soon after AVR may have impaired the assessment of the right parasternal acoustic window more than the apical one. Of note, current recommendations suggest performing the baseline echocardiogram ideally 4 to 6 weeks after. However, it is specified that if the patient is being transferred to another hospital's care and may not return, it is better to perform the study before discharge.[9] This is the current practice in many institutions, and therefore the echocardiogram performed at discharge holds a key importance for comparison with the follow up echoes, in the next years.

The present study also highlights how RPV has greater impact on hemodynamic parameters before surgery compared with after-AVR. This effect may be related to the absolute amplitude of the parameters in the 2 groups (Vmax in the range of 4 to 5 m/sec vs 1 to 3 m/Sec). Nonetheless, the modest improvement of hemodynamic assessment provided by RPV significantly impacted the detection of PPM, which is an important prognosticator after AVR.[7] We previously showed the effect of RPV in patients with a wide range of AS severity (from mild to severe) as a Deming regression. Subsequently, considering that Vmax varies with the cosine of the angle of incidence, we calculated the angle of misalignment using the arccosine function of the ratio between the higher and the lower of the measured Vmax.[12] The systematic bias introduced by the angle

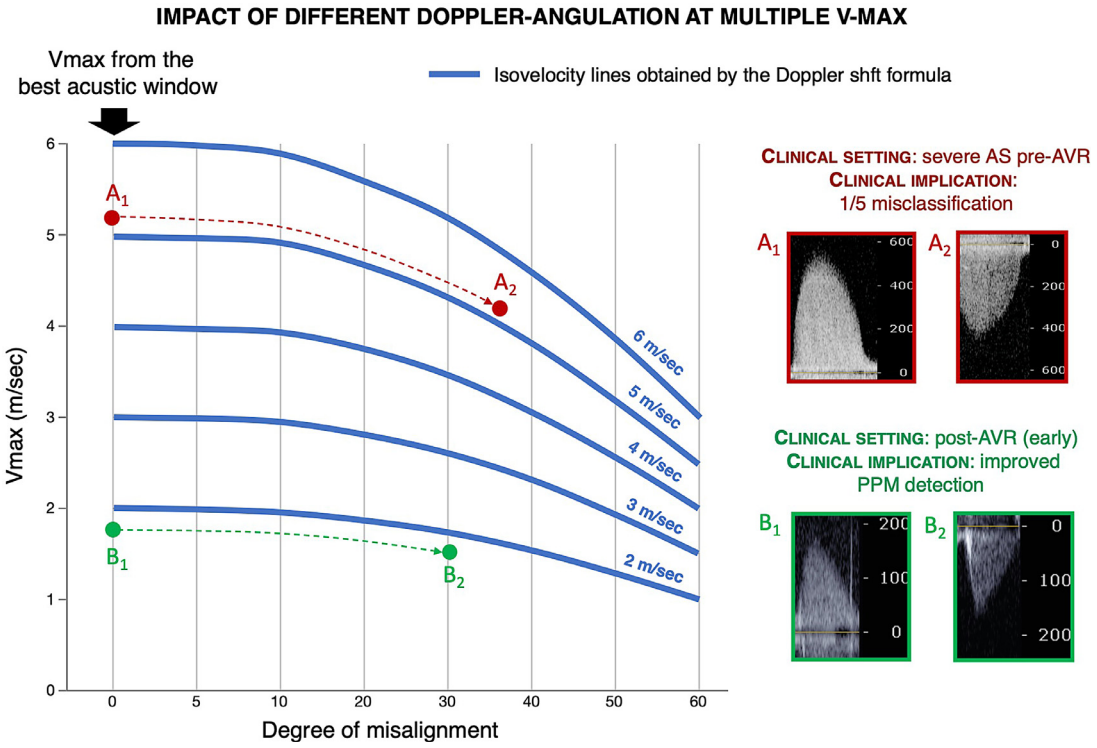

Figure 3. Summary of the effect of different Doppler angulation for the assessment of transaortic Peak Velocity. Each blue curvilinear line indicates an iso-velocity surface derived by the Doppler shift formula. The best acoustic window is assumed as aligned with the blood flow (angle = 0 degree). We illustrated the effect of a significant misalignment at high and low velocities. One patient is presented as paradigmatic example (A: before-AVR; B: after-AVR). Doppler measurements from RPV (A_1 and B_1) and from apical view (A_2 and B_2) are shown. In this case the RPV was the best acoustic window both before and after AVR. Clinical implications are summarized in the right part of the figure. PPM = patient-prosthesis mismatch; RPV= right parasternal view; Vmax = maximal transvalvular velocity.

difference between RPV and apical (mean 14 ± 16 degree)[12] results in a greater absolute Vmax difference in severe AS versus mild AS and/or newly implanted prosthetic valve as illustrated in Figure 3.

Another important clinical aspect emphasized by the present study is the need to always specify in the final report the acoustic window from which the maximal transaortic velocity has been recorded. This information is important to compare consecutive examinations or to define the aortic valve progression rate, particularly when patients cannot be re-evaluated in the same center and/or same operator.[5,13] Also, the same window lead to the highest Vmax before and after AVR. Indeed, in the present study 16 of 20 TAVI patients had RPV as the best acoustic windows both before- and after-TAVI.

The main limitation of the present study is the sample size, which is adequate for the presented analysis, but limits the possibility of more detailed sensitivity consideration. In particular, the low feasibility in the SAVR group may have reduced the power to detect significant differences; this aspect needs to be evaluated with specifically designed studies, including echocardiogram performed longer after surgery. In addition, as only biological valves were surgically implanted, results are limited to this type of valves. We used conventional 2D and/or Doppler transducer, as the nonimaging Continuous-Wave-Doppler Probes are not available in our institution, and this may be another limit of the study. Indeed, we previously noticed that Vmax by the nonimaging dedicated continuous Doppler transducer resulted significantly higher ($p = 0.01$).[5] We acknowledge that RPV may be better performed with non-imaging Doppler probes, but having only 2D and/or Doppler shouldn't discourage from performing RPV, as it still resulted highly feasible and of incremental clinical value.[4,5] We did not measure the aorto-ventricular angulation, and this may be considered a further limitation of the present study. In the literature the aorto-ventricular angle is reported as a potential clue for the need of nonapical approach.[3,14] Indeed, when the angle between the ultrasound beam and the aortic valve jet direction from the apical window is wide, the aortic valve velocity measured by the apical window tends to be underestimated. This anatomical notion should trigger the operator since the beginning of the exam. However, aortic root angulation influences the location of maximal velocity modestly and that routine Doppler interrogation from all the acoustic windows must be performed to determine the true severity of the AS accurately.[14]

This experience demonstrates that RPV feasibility is slightly reduced after AVR but significantly improves the hemodynamic assessment of aortic bioprosthetic valves and the detection of PPM. Furthermore, when RPV is the best acoustic windows in patients with severe AS, it generally remains so after TAVI.

Author Contributions

Conceptualization: Giovanni Benfari, Stefano Nistri; Data curation: Giovanni Benfari, Luca F Cerrito, Luca Maritan, Enrico Tadiello; Formal analysis: Giovanni Benfari, Luca Maritan; Investigation: Luca F Cerrito, Luca Maritan, Davide de Manna, Enrico Tadiello; Methodology: Elvin Tafciu; Project administration: Andrea Rossi, Flavio L Ribichini; Supervision: Andrea Rossi, Flavio L Ribichini; Validation: Giovanni Benfari; Visualization: Giovanni Benfari, Martina Setti; Roles/Writing - original draft: Giovanni Benfari, Stefano Nistri; Writing - review & editing: Giovanni Benfari, Stefano Nistri, Martina Setti, Francesca Bursi, Elvin Tafciu.

Disclosures

The authors have no conflicts of interest to disclose.

1. Baumgartner H, Falk V, Bax JJ, De Bonis M, Hamm C, Holm PJ, Iung B, Lancellotti P, Lansac E, Rodriguez Munoz D, Rosenhek R, Sjogren J, Tornos Mas P, Vahanian A, Walther T, Wendler O, Windecker S, Zamorano JL, Group ESCSD. 2017 ESC/EACTS Guidelines for the management of valvular heart disease. *Eur Heart J* 2017;38:2739–2791.
2. Lancellotti P, Pibarot P, Chambers J, Edvardsen T, Delgado V, Dulgheru R, Pepi M, Cosyns B, Dweck MR, Garbi M, Magne J, Nieman K, Rosenhek R, Bernard A, Lowenstein J, Vieira ML, Rabischoffsky A, Vyhmeister RH, Zhou X, Zhang Y, Zamorano JL, Habib G. Recommendations for the imaging assessment of prosthetic heart valves: a report from the European Association of Cardiovascular Imaging endorsed by the Chinese Society of Echocardiography, the Inter-American Society of Echocardiography, and the Brazilian Department of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging* 2016;17:589–590.
3. Cho EJ, Kim SM, Park SJ, Lee SC, Park SW. Identification of factors that predict whether the right parasternal view is required for accurate evaluation of aortic stenosis severity. *Echocardiography* 2016;33:830–837.
4. de Monchy CC, Lepage L, Boutron I, Leye M, Detaint D, Hyafil F, Brochet E, Iung B, Vahanian A, Messika-Zeitoun D. Usefulness of the right parasternal view and non-imaging continuous-wave Doppler transducer for the evaluation of the severity of aortic stenosis in the modern area. *Eur J Echocardiogr* 2009;10:420–424.
5. Benfari G, Gori AM, Rossi A, Papesso B, Vassanelli C, Zito GB, Nistri S. Feasibility and relevance of right parasternal view for assessing severity and rate of progression of aortic valve stenosis in primary care. *Int J Cardiol* 2017;240:446–451.
6. Michalski B, Dweck MR, Marsan NA, Cameli M, D'Andrea A, Carvalho RF, Holte E, Robert TP, Haugaa KH. The evaluation of aortic stenosis, how the new guidelines are implemented across Europe: a survey by EACVI. *Eur Heart J Cardiovasc Imaging* 2020;21:357–362.
7. Pibarot P, Magne J, Leipsic J, Cote N, Blanke P, Thourani VH, Hahn R. Imaging for predicting and assessing prosthesis-patient mismatch after aortic valve replacement. *JACC Cardiovasc Imaging* 2019;12:149–162.
8. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP 3rd, Guyton RA, O'Gara PT, Ruiz CE, Skubas NJ, Sorajja P, Sundt TM 3rd, Thomas JD. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association task force on practice guidelines. *Circulation* 2014;129:e521–e643.
9. Zoghbi WA, Chambers JB, Dumesnil JG, Foster E, Gottdiener JS, Grayburn PA, Khandheria BK, Levine RA, Marx GR, Miller FA Jr., Nakatani S, Quinones MA, Rakowski H, Rodriguez LL, Swaminathan M, Waggoner AD, Weissman NJ, Zabalgoitia M, American Society of Echocardiography's G, Standards C, Task Force on Prosthetic V, American College of Cardiology Cardiovascular Imaging C, Cardiac Imaging Committee of the American Heart A, European Association of E, European Society of C, Japanese Society of E, Canadian Society of E, American College of Cardiology F, American Heart A, European Association of E, European Society of C, Japanese Society of E, Canadian Society of E.. Recommendations for evaluation of prosthetic valves with echocardiography and doppler ultrasound: a report From the American Society of Echocardiography's Guidelines and Standards Committee and the Task Force on Prosthetic Valves, developed in conjunction with the American College of Cardiology Cardiovascular Imaging Committee, Cardiac Imaging Committee of the American Heart Association, the European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography and the Canadian Society of Echocardiography, endorsed by the American College of Cardiology Foundation, American Heart Association, European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography, and Canadian Society of Echocardiography. *J Am Soc Echocardiogr* 2009;22:975–1014. quiz 1082-1014.
10. Tavli T, Ammar A, Wong M. Doppler-derived aortic valve gradients: imaging versus non-imaging techniques. *J Heart Valve Dis* 1993;2:253–256.
11. Williams GA, Labovitz AJ, Nelson JG, Kennedy HL. Value of multiple echocardiographic views in the evaluation of aortic stenosis in adults by continuous-wave Doppler. *Am J Cardiol* 1985;55:445–449.
12. Benfari G, Mantovani F, Romero-Brufau S, Setti M, Rossi A, Ribichini FL, Nistri S, Clavel MA. The right parasternal window: when Doppler-beam alignment may be life-saving in patients with aortic valve stenosis. *J Cardiovasc Med* 2020;21:831–834.
13. Tafciu E, Mandoli GE, Santoro C, Setti M, d'Andrea A, Esposito R, Bandera F, Evola V, Malagoli A, Cameli M, Benfari G, Working Group of Echocardiography of the Italian Society of C. The progression rate of aortic stenosis: key to tailoring the management and potential target for treatment. *J Cardiovasc Med (Hagerstown)* 2020. https://doi.org/10.2459/JCM.0000000000001126. *in press*.
14. Thaden JJ, Nkomo VT, Lee KJ, Oh JK. Doppler imaging in aortic stenosis: the importance of the nonapical imaging windows to determine severity in a contemporary cohort. *J Am Soc Echocardiogr* 2015;28:780–785.