Incremental Value of the En Face View of the Tricuspid Valve by Two-Dimensional and Three-Dimensional Echocardiography for Accurate Identification of Tricuspid Valve Leaflets

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Background: In this study, advanced postprocessing of three-dimensional echocardiographic (3DE) data sets was used to identify tricuspid valve (TV) leaflets in two-dimensional echocardiographic (2DE) views, and the feasibility of the subcostal view to obtain 2DE en face views of the TV, as an alternative imaging option to image reconstruction from 3DE imaging, was also tested.

Methods: In 155 consecutive patients, attempts were made to obtain the en face view of the TV by 2DE imaging (from the subcostal window) and by reconstruction from 3DE imaging. Using both in-house-developed and commercially available software for postprocessing of 3DE data, image planes from the standard 2DE views were reconstructed and TV leaflets identified in each view.

Results: With 2DE imaging, all TV leaflets could be visualized in 58% of patients, compared with 56% using 3DE imaging. In 30 patients (19%), en face views of the TV could be obtained only by 3DE imaging. The anterior leaflet was the largest one in 90% of patients, and the smallest leaflet was either the posterior (49%) or septal (41%) leaflet. In 12% of patients, the TV was either bicuspid or quadricuspid. In patients with pacemakers, the position of the right ventricular lead relative to the TV leaflets was readily determined using both imaging techniques. Visible TV leaflets varied in all standard 2DE views because of variability in image planes and leaflet morphology.

Conclusions: High variability in TV leaflet anatomy and the dependence on transducer position do not allow schematic leaflet identification. All existing TV leaflet identification schemes are therefore only partially correct, and if correct leaflet identification is needed, the use of an en face view is recommended. (J Am Soc Echocardiogr 2014;■:■-■.)

Keywords: Tricuspid valve, Leaflet identification, Three-dimensional echocardiography

Increased mortality among patients with moderate and severe tricuspid regurgitation (TR), regardless of pulmonary pressure and left ventricular ejection fraction, has revived interest in better visualization of the tricuspid valve (TV).[1] Two-dimensional (2D) echocardiographic (2DE) assessment of the TV is a challenging task because of complex anatomy and the unfavorable retrosternal position of the valve. Only two TV leaflets are routinely visualized in standard 2DE views, and cumbersome mental three-dimensional (3D) reconstruction of the TV is needed for individual leaflet identification. Unfortunately, currently available schemes for the identification of TV leaflets in existing guidelines, the most influential textbooks, and previous studies are conflicting.[2-7]

Simultaneous visualization of all TV leaflets in one 2DE cross-sectional view would allow immediate leaflet identification, but achieving an en face view of the TV on 2DE imaging is widely believed to be impossible.[2-8] A subcostal approach to obtain an en face view of the TV has been suggested,[9] but the feasibility and usefulness of this approach are unknown. Three-dimensional echocardiographic (3DE) imaging permits the en face visualization and comprehensive evaluation of the TV leaflets, annulus, subvalvular apparatus, and surrounding structures, but the need for expensive equipment still delays the integration of this technique in routine clinical practice.[8]

The primary objectives of this study, therefore, were to clarify TV leaflet identification in standard 2DE views by advanced postprocessing of 3DE data sets and to test the feasibility of obtaining an en face view of the TV from a modified subcostal short-axis view.

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Abbreviations

A4C = Apical four-chamber

PSAX = Parasternal short-axis

RV = Right ventricular

RVI = Right ventricular inflow

Speqle_3D = Software Package for Echocardiographic Quantification Leuven 3D

3D = Three-dimensional

3DE = Three-dimensional echocardiographic

TR = Tricuspid regurgitation

TV = Tricuspid valve

2D = Two-dimensional

2DE = Two-dimensional echocardiographic

METHODS

Two-dimensional and 3D transthoracic echocardiography was performed in 155 consecutive patients (mean age, 59 ± 15 years; range, 19–94 years; 76% men) referred for standard 2DE studies. All patients were examined using the commercially available Vivid E9 scanner (GE Vingmed Ultrasound AS, Horten, Norway) equipped with a 3V or 4V matrix-array transducer. The same echocardiographer (I.S., A.M.D., or R.J.) acquired both 2D and 3D data sets. A four-point scale (0 = not visualized, 1 = poor, 2 = sufficient, 3 = good) was used to assess the image quality of 2DE and 3DE en face views of the TV. Only data sets with sufficiently good image quality were further analyzed. The relative sizes of the leaflets were assessed semiquantitatively, ranking the leaflets from largest to smallest.

2DE

All patients underwent the standard 2DE imaging of the TV, comprising the parasternal right ventricular (RV) inflow (RVI) view, the parasternal short-axis (PSAX) view at the aortic valve level, and the apical four-chamber (A4C) view. The acquisition of the en face view of the TV was attempted from the subcostal window in all patients. Given the nearly vertical position of the TV (approximately 45° to the sagittal plane), the en face view of the TV can be obtained by directing the transducer to a slightly modified subcostal short-axis imaging plane. Patients were placed in the supine position and scanned during a breath hold after deep inspiration. Relative to the subcostal four-chamber view, the transducer was rotated counterclockwise and tilted inferiorly and slightly to the patient's right (Figure 1, Video 1; available at www.onlinejase.com). Depending on the patient's constitution, inspiration depth and the degree of probe rotation and angulation were adjusted to optimize viewing of the TV. Image loops of three consecutive heart cycles were digitally stored for further offline analysis (EchoPAC version BT12; GE Healthcare, Milwaukee, WI). Assessment of the subcostal en face view of the TV comprised (1) identification of individual leaflets, (2) anatomy (the number, relative sizes, and mobility of the leaflets), (3) the anatomic relationship between the RV leads and leaflets (in patients with pacemakers), and (4) the origin and size of the regurgitant orifice by color Doppler (in patients with TR).

3DE

During a breath hold, full-volume 3D data sets were acquired from the apical and parasternal windows by stitching partial volumes from six cardiac cycles. From the apex, full-volume 3D data sets were acquired using a modified A4C view as a scout image (for this, the imaging plane was slightly inclined to cover the entire the right heart chamber and to obtain a good view of the TV). For acquisitions from the parasternal window, the transducer was placed in a modified RVI or PSAX position and adjusted to center the TV in the 3D volume. Because we aimed to determine the spatial relationships of individual TV leaflets and surrounding cardiac structures in all standard 2DE views, a gated full 3D volume was acquired that included the whole heart, with the largest acquisition sector possible, at the expense of a loss of spatiotemporal resolution (frame rates typically of 20–25 Hz). Data sets were digitally stored for further offline analysis.

Postprocessing of 3DE Data Sets

Postprocessing of 3DE data sets was performed using both a commercially available EchoPAC workstation (version BT12; GE Healthcare) and customized research software (Software Package for Echocardiographic Quantification Leuven 3D [Speqle_3D]; P. Claus, Leuven, Belgium), based on different approaches for leaflet identification in the reconstructed 2DE views.

EchoPAC. Flexislice and Laser Lines are part of the commercially available 3D toolbox in EchoPAC. The Flexislice tool allows the user to slice in any direction, and full-volume 3DE data sets were sliced along the 2D tomographic planes for standard apical (A4C) and parasternal (PSAX and RVI) views. These 2D tomographic planes remained visible on the 3D volume rendered image as "laser lines": transparent colored lines showing the origin of reconstructed 2D slices. Simultaneous display of reconstructed standard 2DE and volume-rendered en face view of the TV using the Laser Lines tools allowed immediate identification of the TV leaflets in each view (Figure 2, Videos 2 and 3; available at www.onlinejase.com).

Speqle_3D. Volumetric echocardiographic data sets were postprocessed using dedicated, in-house-developed research software (Speqle_3D). This software allows colorization of a partial volume of the 3DE data set semitransparently in such a way that the coloring remains visible when the 3D data set is resliced. At first, all three TV leaflets were visualized in a ventricular en face view and then manually delineated and colored, using different color for each leaflet. Second, image planes from the standard A4C, PSAX, and RVI views were reconstructed from the colorized 3DE data set (Figure 3). Colors allowed the reliable identification of TV leaflets in any 2DE view, and the frequency of occurrence of individual leaflets was counted. The agreement of results obtained by EchoPAC and Speqle_3D was assessed for all reconstructed 2DE views, in all patients.

Statistical Analysis

Continuous data are expressed as mean ± SD. Interobserver and intraobserver agreement on categorical variables (2DE and 3DE image quality and the relative sizes of the TV leaflets) was estimated using the κ statistic in a randomly selected group of 30 patients. The feasibility of obtaining the en face view by 2DE and 3DE imaging (yes or no) was compared using the χ^2 test.

RESULTS

Baseline patient characteristics and indications for standard 2DE imaging are shown in Table 1. En face views of the TV, demonstrating all three leaflets, could be obtained in 119 of the 155 patients (77%)

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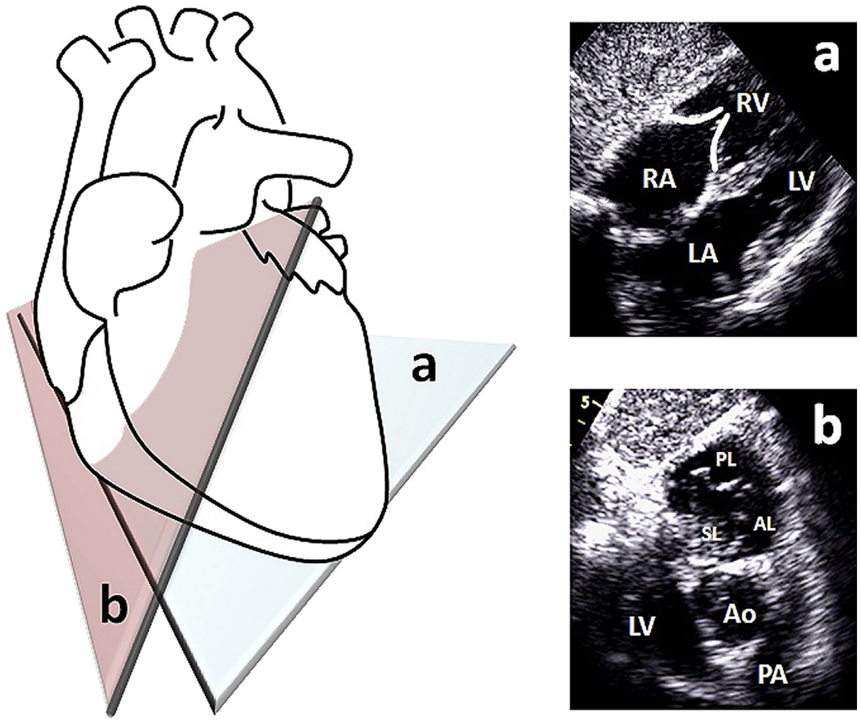

Figure 1 Imaging planes for the subcostal four-chamber view (a) and a modified subcostal short-axis view at the TV level (b). Starting from the subcostal four-chamber imaging plane (a), the en face view of the TV (b) (Video 1; available at www.onlinejase.com) can be obtained by rotating the transducer counterclockwise, tilting inferiorly and slightly to the patient's right. *AL*, Anterior TV leaflet; *Ao*, aortic valve; *LA*, left atrium; *LV*, left ventricle; *PA*, pulmonary artery; *PL*, posterior TV leaflet; *RA*, right atrium; *RV*, right ventricle; *SL*, septal TV leaflet.

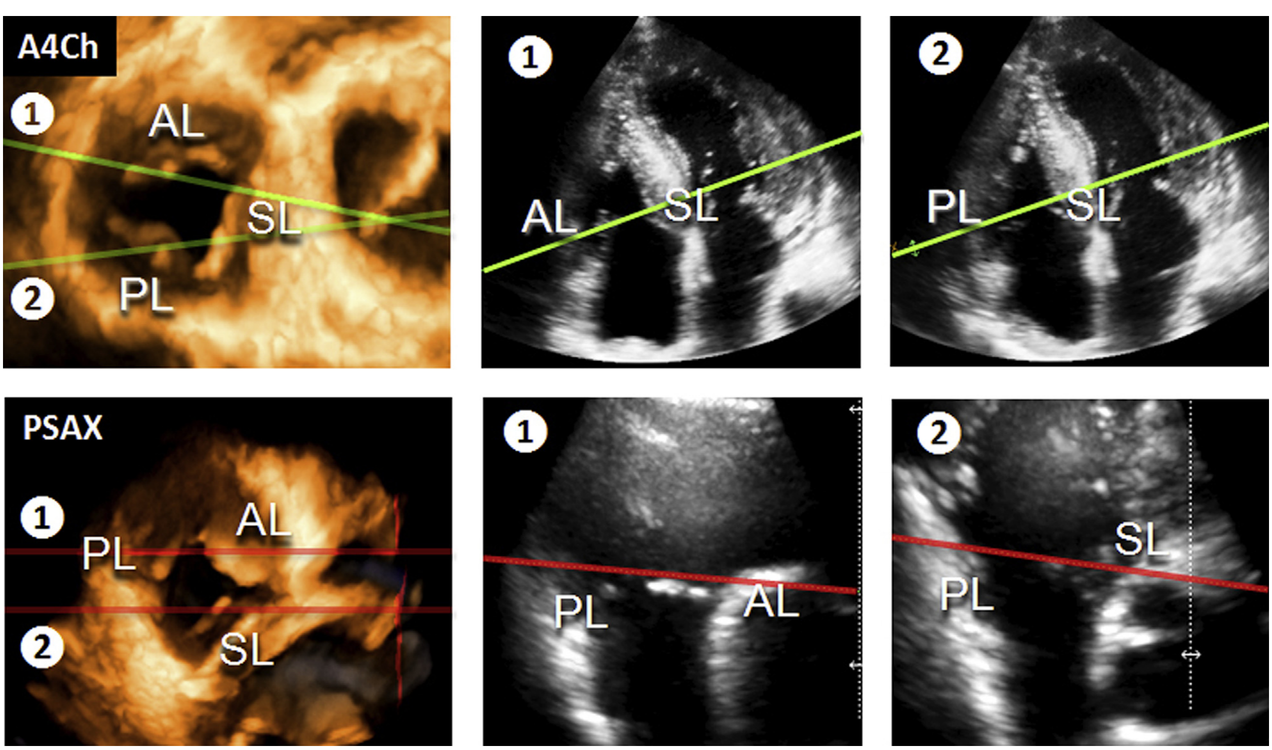

Figure 2 TV leaflet identification using commercially available software (EchoPAC version BT12). Using the Flexislice tool, the en face view of the TV and standard 2DE views were reconstructed from full-volume 3DE data sets, while the Laser Lines tool indicated the relationship between the surface-rendered 3D image and the reconstructed 2DE views. In the A4C view (A4Ch), both the anterior and posterior leaflets could be seen adjacent to the RV wall (Video 2; available at www.onlinejase.com); in the PSAX view, the leaflet adjacent to the aortic valve was either the anterior or septal leaflet (Video 3; available at www.onlinejase.com). *AL*, Anterior TV leaflet; *PL*, posterior TV leaflet; *SL*, septal TV leaflet.

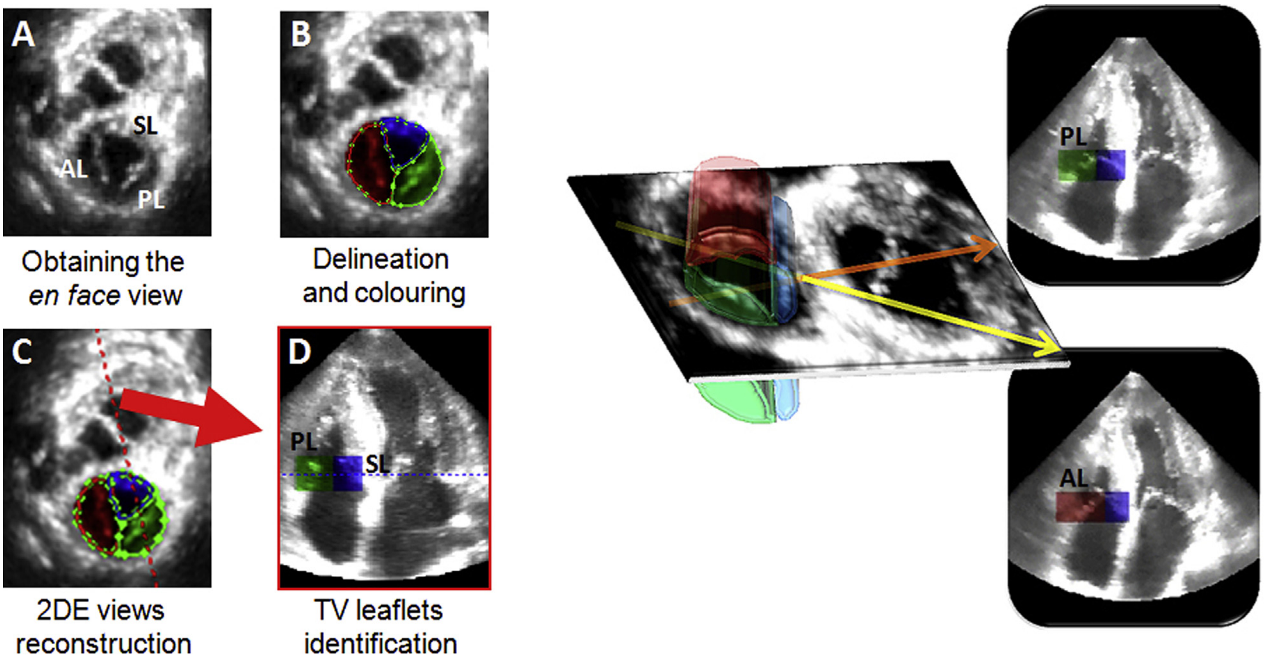

Figure 3 TV leaflets identification using customized research software (Speqle_3D). (*Left*) After obtaining the en face view of the TV **(A)**, leaflets were manually delineated and colored (*blue* = septal leaflet, *red* = anterior leaflet, *green* = posterior leaflet) **(B)**. Standard 2DE views were then reconstructed from the colorized 3DE data set, allowing immediate identification of the TV leaflets in any reconstructed view **(C,D)**. (*Right*) In the A4C view, either the anterior or posterior leaflet can be seen adjacent to the RV free wall, which can be easily recognized by the different coloring. *AL*, Anterior TV leaflet; *PL*, posterior TV leaflet; *SL*, septal TV leaflet.

Table 1 Baseline patient characteristics and indications for standard echocardiography

Characteristic	Value
Age (y)	59 ± 15
Men/women	118 (76%)/37 (24%)
Body mass index (kg/m^2)	26 ± 4
Body surface area (m^2)*	1.9 ± 0.2
RV dilation (yes/no)†	24 (15%)/131 (85%)
Indication for 2D TTE	
Heart failure	24 (16%)
Coronary artery disease‡	89 (57%)
Chemotherapy follow-up	9 (6%)
Evaluation of suspected heart disease	33 (21%)

TTE, Transthoracic echocardiography.
*Calculated using the Mosteller formula.
†Defined as RV basal diameter in the A4C view > 42 mm.
‡Previous coronary artery bypass grafting, percutaneous intervention, or myocardial infarction.

by means of echocardiographic imaging. Using 2DE imaging from a subcostal view, a technically adequate en face view of the TV leaflets could be obtained in 90 patients (58%), compared with 87 (56%) using 3DE imaging. En face views of the TV were feasible using both methods in 57 patients (37%), while in 30 patients (19%), en face views of the TV were possible only using 3DE imaging. In 36 patients (23%), technically adequate en face views of the TV could not be obtained using either technique because of poor acoustic windows related to body size, chronic obstructive pulmonary disease, previous thoracotomy, or chest radiotherapy.

Usefulness of the En Face View of the TV

The en face view of the TV, obtained by either 2DE or 3DE imaging, allowed the assessment of leaflet anatomy (number, relative size, and mobility) and the simultaneous visualization of all leaflets. The anterior leaflet was the largest leaflet in 90% of patients, while in the remaining 10%, all three leaflets were of similar size. The smallest leaflet was either posterior (49%) or septal (41%). In 8% of patients, it was not possible to clearly distinguish between the anterior and posterior leaflets, while in 4% of patients, deep indentations between the scallops gave the valve an appearance of being quadricuspid. Of note, the appearance of the TV in standard 2DE views was never indicative of unusual valve anatomy. The variability in TV leaflet number and morphology, as seen by 2DE (subcostal approach) and 3DE imaging, is shown in Figure 4.

Clinical Context

Similar to the parasternal en face view of the mitral valve, it would have been theoretically possible to estimate the TV orifice area from the subcostal en face view of the TV. In addition, color Doppler could identify size and position of the regurgitant orifice in patients with TR. In one patient with annular dilation and TR that appeared to be functional at the initial standard 2DE evaluation, the en face view of the TV obtained by both 3DE and subcostal 2DE imaging revealed the organic origin of TR, due to a prolapsed anterior leaflet (Figure 5, Videos 4–7; available at www.onlinejase.com).

In all patients with pacemaker leads ($n = 9$), the position of the RV lead relative to the TV leaflets was readily determined by the en face view obtained by both 2DE and 3DE imaging; in seven patients, the RV lead was positioned between the posterior and septal leaflets, whereas in two patients, the leads traversed and obstructed the septal

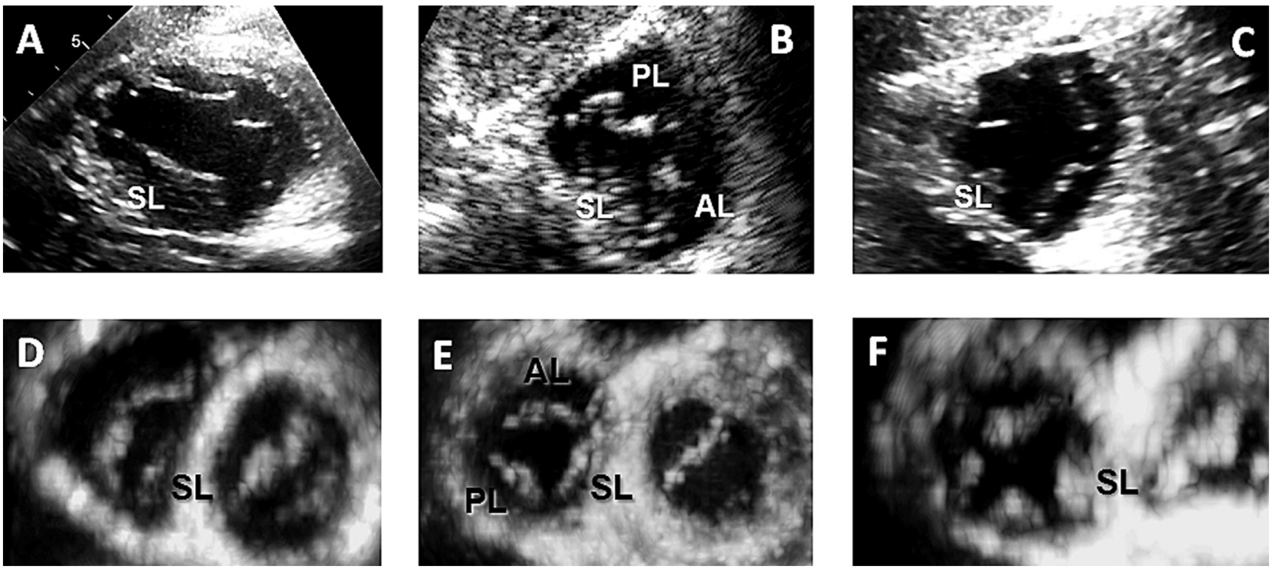

Figure 4 En face views of the TV acquired by 2DE imaging from the subcostal view **(A–C)** and reconstructed from 3DE data sets **(D–F)**. Note the variability in TV anatomy. **(A,D)** No clear commissure between anterior and posterior leaflets (“bicuspid” valve). **(B,E)** Normal valve. **(C,F)** Additional scallops (“quadricuspid” valve). *AL*, Anterior TV leaflet; *PL*, posterior TV leaflet; *SL*, septal TV leaflet.

leaflet (Figure 6, Videos 8 and 9; available at www.onlinejase.com). The relationship between the RV leads and the TV leaflets could be appreciated by standard 2DE evaluation only in one patient, in whom the lead obstructing the septal leaflet could be seen in the A4C view.

Of note, even though the en face view of the TV using the subcostal approach was superior to standard transthoracic 2DE imaging, its range of information remains limited compared with 3DE imaging, which allows visualization of the valve from any perspective and which is not affected by out-of-plane motion of the investigated structures. The ability of the different methods assessed in this study to visualize TV anatomy adequately and completely is summarized in Table 2.

Identification of the TV Leaflets in Standard 2DE Views

Only patients with three clearly separated leaflets were included in the leaflet identification analysis. There was complete agreement in the leaflet identification between the two methods (Speqle_3D and EchoPAC) in all reconstructed 2DE views.

In the A4C view, the leaflet visible as adjacent to the septum was the septal leaflet in all patients, whereas the leaflet visible as adjacent to the RV free wall was either the anterior (81%) or posterior (19%) leaflet, depending on the transducer angulation and rotation (Figure 2 and Figure 3, *top*).

In the PSAX view, the leaflet adjacent to the RV free wall was always the posterior leaflet, while the leaflet visible as adjacent to the aortic valve was either the anterior (62%) or the septal one (38%) (Figure 3, *bottom*). Of note, in 20% of patients, all three leaflets could be seen in this view: the septal leaflet adjacent to the aortic valve, the posterior leaflet adjacent to the RV free wall, and the anterior leaflet in between (Figure 7, Video 10; available at www.onlinejase.com).

In the RVI views, the degree of transducer angulation and rotation determined which leaflets were seen (Figure 8). A slight rightward angulation and rotation from the left ventricular long-axis plane will result in an atypical RVI view, with the part of the left ventricle preserved within the view. The leaflets seen in this RVI view were always septal and anterior. With further rightward rotation and angulation, the left ventricle would disappear from the view, and the true RVI view would be obtained. In this view, the anteriorly placed leaflet was always anterior, while the other leaflet was either posterior (77%) or septal (23%). A summary of the appearance of the different leaflets in the different views is shown in (Figure 9).

Intraobserver and Interobserver Variability

Intraobserver agreement was good for image quality scoring ($\kappa = 0.86$ and 0.81 for 2DE and 3DE imaging, respectively) and for the assessment of relative size of TV leaflets ($\kappa = 0.86$ and 0.88 for 2DE and 3DE imaging, respectively).

Interobserver agreement was good for both image quality scoring ($\kappa = 0.84$ and 0.82 for 2DE and 3DE imaging, respectively) and the assessment of relative size of TV leaflets ($\kappa = 0.82$ and 0.79 for 2DE and 3DE imaging, respectively).

Agreement between 2DE and 3DE imaging for the assessment of the relative sizes of TV leaflets was good ($\kappa = 0.66$).

DISCUSSION

In contrast to previous publications,[2-6] we demonstrated that high variability in the TV leaflet anatomy and the dependence on transducer position did not allow simple schematic leaflet identification in standard 2DE views.

We also showed that the simultaneous visualization of all three TV leaflets is feasible by both 2DE and 3DE imaging and has an incremental value for the accurate identification of leaflets.

The same results for leaflet identification obtained using vendor software on the basis of tomographic lines and using customized software suggest that the principle of partial 3DE volume coloring may also be useful in future software development for tracking and identifying multiple moving cardiac structures in reconstructed 2DE views.

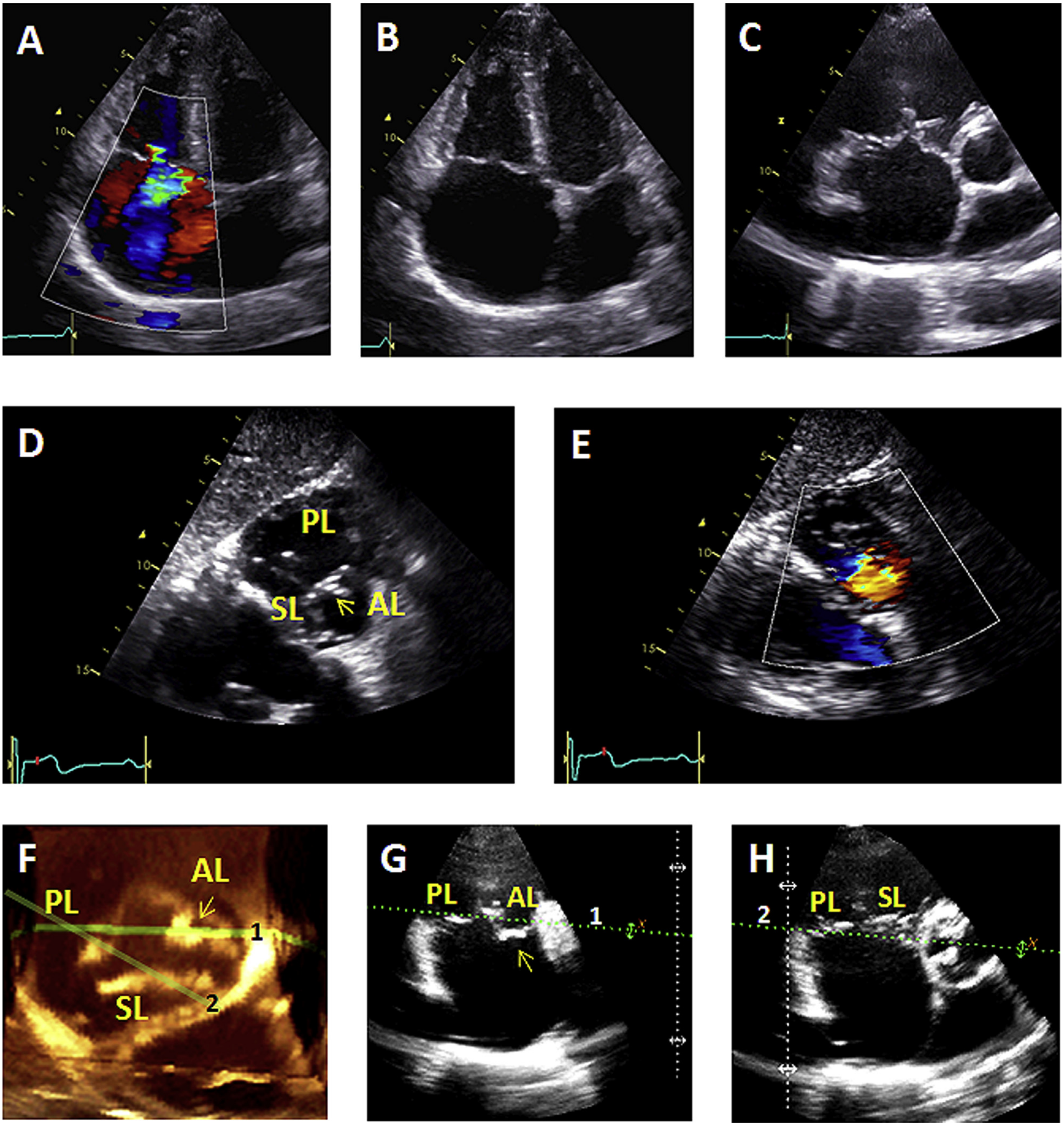

Figure 5 Unmasking pseudofunctional TR using the en face view of the TV. Enlarged right ventricle, tricuspid annular dilation, and a normal appearance of the tricuspid leaflets in the standard parasternal and apical views were suggestive of functional TR in this patient with moderate pulmonary hypertension **(A–C)**. The en face view of the TV by the subcostal approach allowed an immediate identification of the anterior leaflet prolapse (**D**, *arrow*) (Video 4; available at www.onlinejase.com) and the origin of the consequent TR jet **(E)** (Video 5; available at www.onlinejase.com). The en face view obtained by 3D echocardiography confirms the anterior leaflet prolapse (**F**, *arrow*), with green laser lines demonstrating the difference in scan-plane orientation between two PSAX views **(G,H)** (Videos 6 and 7; available at www.onlinejase.com). Reconstructed views show that, depending on transducer orientation, the prolapse may (**G**, *arrow*) or may not be clearly visible on the leaflet adjacent to the aortic valve when a PSAX view is obtained. *AL*, Anterior TV leaflet; *PL*, posterior TV leaflet; *SL*, septal TV leaflet.

The Importance of the En Face View of the TV

In this study, the en face view of the TV could be obtained by both 2DE (the subcostal approach) and 3DE imaging. With subcostal 2DE imaging, the en face view of TV provides only a ventricular perspective of the leaflets but offers similar possibilities for TV assessment as the PSAX view of the mitral valve. Although our study population was not investigated with the intention to address any TV pathology, we were able, using the subcostal en face view, to unmask pseudofunctional TR in a

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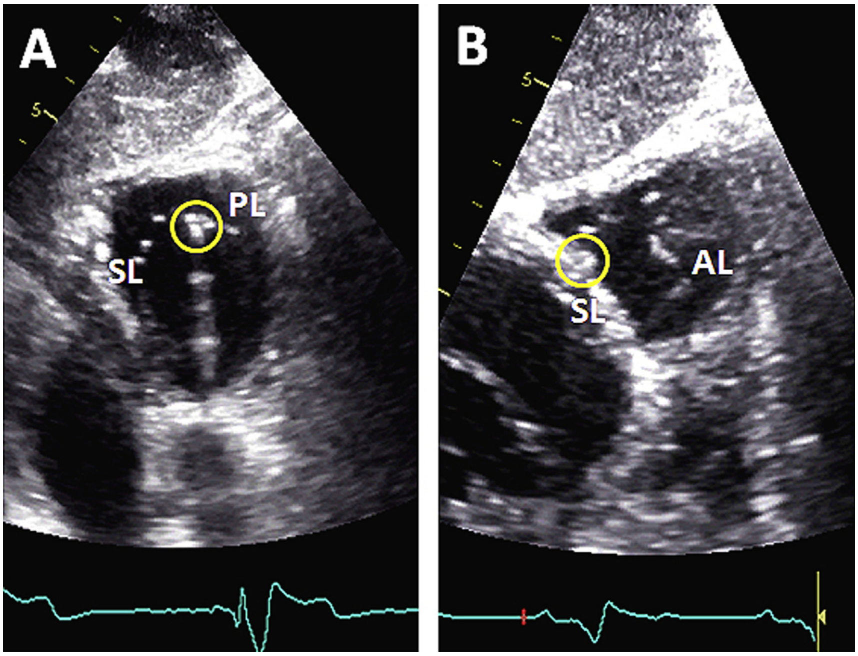

Figure 6 Assessment of anatomic relationship between RV device leads and TV leaflets using the modified subcostal cross-sectional view of the valve. **(A)** The device lead (*circled*) located in the posteroseptal commissure (Video 8; available at www.onlinejase.com). **(B)** The device lead (*circled*) traversing and blocking the septal leaflet (Video 9; available at www.onlinejase.com). *AL*, Anterior TV leaflet; *PL*, posterior TV leaflet; *SL*, septal TV leaflet.

Table 2 Comparison of different methods to visualize TV anatomy

Characteristic	Standard 2DE view	Subcostal 2DE en face view	Reconstructed 3DE en face view
Leaflet identification	Indirect, using identification schemes	Direct	Direct
Leaflet morphology assessment	Limited, possibly misleading	Direct visualization of leaflets (only from ventricular perspective)	Comprehensive assessment of TV complex (from atrial and ventricular perspective)
Relationship between device leads and TV	Limited	Only at the level of the leaflets	Comprehensive assessment (TV complex and right heart chambers)
Additional equipment or training	None	Minimal additional training	3D probe and software, additional training

patient with a prolapsed TV, to localize the origin of the TR (Figure 5) and to appreciate the spatial relationship between the device leads and leaflets in patients with pacemakers (Figure 6). This could be of clinical importance because it has been shown that in the majority of patients who undergo surgery for pacemaker-related TR, the damage to the TV caused by device leads could not be visualized by standard 2DE imaging.[10,11] It should be noted that although the subcostal en face view of the TV may provide better understanding of the underlying mechanisms of TR than standard 2DE imaging, only 3DE imaging allows comprehensive assessment of the TV apparatus and permits the observer to view the valve from either the ventricular or atrial (surgical) perspective.

Variability in Tricuspid Leaflet Anatomy

The TV has traditionally been described as having three leaflets and three commissures, while a number of anatomic studies have demonstrated frequent variation in the morphology of the TV leaflets and subvalvular apparatus.[12] In normal hearts of children and adults, the TV leaflets have been reported to number from two to six.[13-17] In line with this, using both 2DE and 3DE imaging to obtain the en face view of the TV, we observed as few as two and as many as four TV leaflets, whereas previous 3DE studies have not reported such variability.[7,18] Apart from the different sample sizes and compositions, the observed discrepancy may be related to different definitions of accessory leaflets. The tricuspid commissures frequently do not reach the annulus,[12] and the cusps between the two commissures may be considered as both separate leaflets and scallops. We conservatively considered the valve as being bicuspid only in the absence of anteroposterior commissure and quadricuspid in the presence of an additional deep indentation between the leaflets (Figure 4).

Leaflet Identification in Standard 2DE Views

We demonstrated that small changes in transducer position, angulation, or rotation can considerably change the appearance of the TV in standard 2DE views and, together with high variability in leaflet

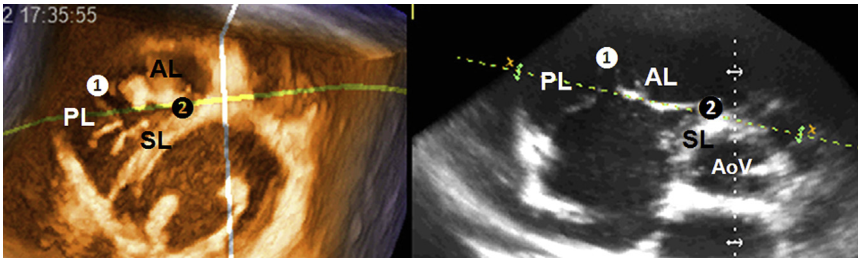

Figure 7 Simultaneous visualization of all three TV leaflets in the PSAX view (Video 10; available at www.onlinejase.com). *Solid lines* indicating cutting planes on the 3D volumetric image (*left*) correspond to dashed lines on the reconstructed 2D image (*right*). The numbers on both panels indicate TV commissures (1 = anteroposterior, 2 = anteroseptal). *AL*, Anterior TV leaflet; *AoV*, aortic valve; *PL*, posterior TV leaflet; *SL*, septal TV leaflet.

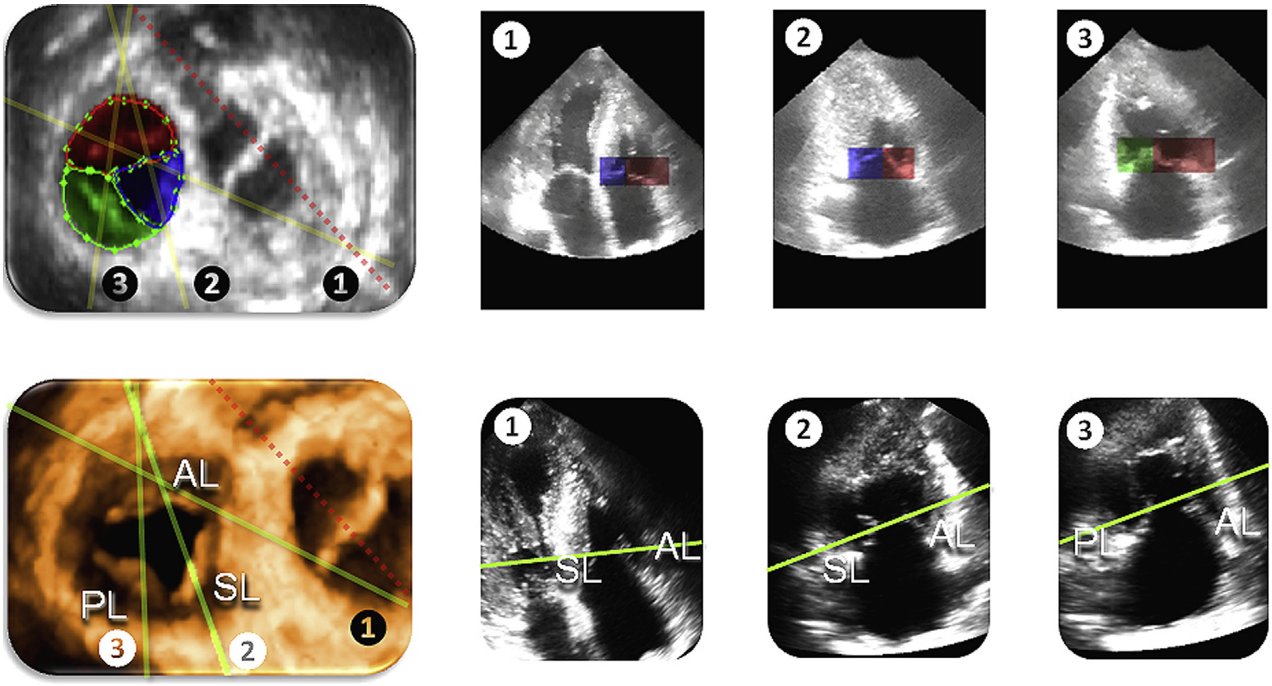

Figure 8 TV leaflet identification in the parasternal RVI view, by Speqle_3D (*top*) and EchoPAC (*bottom*). The numbers indicating cutting planes on the 3D volumetric images *(left)* correspond to the numbers on reconstructed 2D views (*middle*, *right*). The *dotted line* indicates the parasternal long-axis imaging plane. The transducer position, angulation, and rotation determine which TV leaflets are seen in this view. *AL*, Anterior TV leaflet (*red*); *PL*, posterior TV leaflet (*green*); *SL*, septal TV leaflet (*blue*).

anatomy of the normal TV, do not allow the schematic identification of TV leaflets in standard 2DE views. According to our data, only one leaflet is constantly the same in all standard 2DE views, while the other one depends on the transducer position. This possibility was suggested in only one influential textbook,[6] while all other currently available identification schemes propose only one combination of TV leaflets in all views.[2-5,7]

Accordingly, standard 2DE imaging may not be the best imaging modality for assessing TV morphology in patients with TV pathology. Three-dimensional echocardiography obviates the limitations of 2DE, but there is currently no robust evidence that either precise determination of the individual leaflet involvement or comprehensive 3DE assessment of TV anatomy may improve surgical results. The results of current strategies for TV repair are, however, unsatisfactory, and there is increasing motivation among both echocardiographers and cardiac surgeons to achieve better preoperative assessment of the TV's complex anatomy and function.[19-22] An improved understanding of mechanisms underlying various TV abnormalities, as was the case with the mitral valve, may improve current or introduce new strategies for TV repair and replacement.

Study Limitations

The feasibility of 3DE imaging for TV leaflet reconstruction in the present study was lower than reported in previous studies.[7] This may be in part explained by the fact that in approximately one third of patients, a 3V probe was used, which produces somewhat lower image quality compared with the newer 4V probe. Furthermore, previous 3DE studies reporting higher feasibility of TV leaflet reconstruction[7] preselected patients on the basis of good 2DE image quality, whereas we analyzed consecutive patients without preselection. Finally, the subcostal approach to obtain the 2DE en face view of TV is not used routinely by most echocardiographers, and a learning curve may result in feasibility lower than reported in the present study.

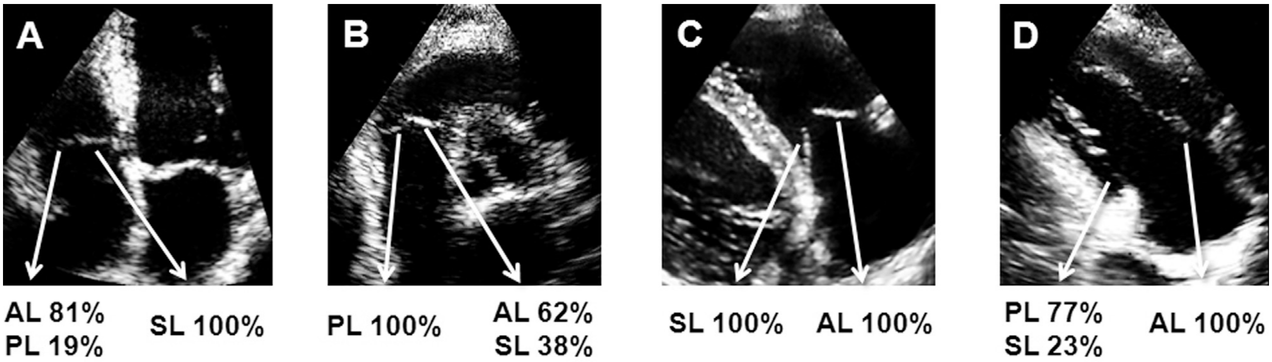

Figure 9 The appearance of the different TV leaflets in standard 2DE views. The numbers are the percentages of leaflet occurrences in each view. **(A)** A4C view. **(B)** PSAX view at the aortic valve level. **(C)** RVI view with the part of the left ventricle within a scan plane. **(D)** True RVI view. *AL*, Anterior TV leaflet; *PL*, posterior TV leaflet; *SL*, septal TV leaflet.

CONCLUSIONS

Large anatomic variations of the TV leaflets together with a difficult-to-define transducer position do not allow simple schematic leaflet identification in standard 2DE views. All existing TV leaflet identification schemes are therefore only partially correct. An en face visualization of the TV by either 2D or 3D echocardiography has incremental value, and it should be used for definitive leaflet identification. In comparison with 2DE imaging, 3DE imaging has superior feasibility for acquiring the en face view and offers comprehensive assessment of the TV.

Supplementary Data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.echo.2013.12.017.

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