QUANTIFICATION OF MITRAL PARAPROSTHETIC REGURGITATION, COMPARISON OF VENA CONTRACTA WIDTH AND PROXIMAL CONVERGENCE METHODS

B. YAYMACI, MD,
Y. BAŞARAN, MD,
B. SAY, MD,
F. NURÖZLER, MD,
H.C. ERMEYDAN, MD,
A. İZGİ, MD,
F. GÜZELMERİÇ, MD,
İ. DİNDAR, MD,
C. YAKUT, MD

From: Koşuyolu Heart and Research Hospital, İstanbul, Türkiye

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Adress for reprints:
Dr. Bengi Yaymacı
Karlıdere cad. Cumhuriyet sitesi
B4 Blok D: 16 Bulgurlu, İstanbul, Türkiye
Tel : +90 216 4436176
Fax : +90 216 3390441
e-mail: kosuyolu@superonline.com

In patients with a prosthetic valve in the mitral position, detection of paraprosthetic regurgitation and assessment of its severity are crucial in management and prognosis. In the assessment of severity of the mitral regurgitation (MR), vena contracta width (VCW) and proximal flow convergence region (FCR) methods are quantitative, more sensitive and reliable compared to color Doppler mapping. The aim of this study is to compare these two methods in patients with mitral paraprosthetic regurgitation (MPR) with the use of TEE.
The study population consisted of 26 patients with MPR; 12 male, 14 female with a mean age of 44±6 years. Largest diameter of contracted zone during systole on the ventricular side was measured and average values were used for VCW. Regurgitant stroke volume (RSV) was calculated according to the formula validated earlier. Routine cardiac catheterization was performed in each patient. Mitral paraprosthetic regurgitation was obtained semi-quantitatively by cardiac catheterization and TEE was graded as mild (grade I-II), moderate (grade III) and severe (grade IV). VCW values were found as 0.25±0.04 cm for mild regurgitation, 0.42±0.11 cm for moderate regurgitation, 0.54±0.11 cm for severe regurgitation. There was a good correlation between VCW and severity of mitral regurgitation. (r=0.78, p<0.0001). Regurgitant stroke volumes calculated by FCR method were 23.8±3.63 cm3 for mild regurgitation, 44.4±8.92 cm3 for moderate regurgitation, 69.6±7.83 cm3 for severe regurgitation. Also there was a good

RESULTS

Cardiac catheterization

Mitral regurgitation was not observed in 3 of the patients despite positive physical examination and TEE findings. In the remaining 23 patients, the severity of mitral regurgitation was: mild in 5 patients, moderate in 12 patients, severe in 6 patients.

Transesophageal echocardiography

The mitral valve was scanned in the long axis view to obtain optimal vena contracta width in all patients. Mitral paraprosthetic regurgitation obtained semi-quantitatively by cardiac catheterization and TEE was graded as mild (grade I-II), moderate (grade III) and severe (grade IV). In patients with mild, moderate and severe MR, the measured mean VCW were as follows; 0.25±0.04 cm, 0.42±0.11cm and 0.54±0.11 (Table 2). There was a good correlation between VCW and severity of mitral regurgitation [r=0.78, p<0.0001] (Figure 3).
In patients with mild, moderate and severe MR, the mean RSVs were as follows: 23.8±3.63cm^3, 44.4±8.92 cm^3 and 69.6±7.83cm^3. The positive correlation was found between FCR-derived RSV and severity of MR [r=0.9, p<0.0001] (Table 3) [Figure 4]. The positive correlation was also found between FCR-derived RSV and measured VCW in the subgroups classified according to severity of regurgitation [r=0.89, p<0.0001](Figure 5). Cut-off point values were as follows: 55cm^3 for RSV and 0.51 cm for VCW .

Table 2. Vena contracta width according to the degree of mitral regurgitation.

	Vena contracta width (cm)		
Degree of MR	**n=26**	**average**	**sd**
mild	8	0.25	0.04
moderate	12	0.42	0.11
severe	6	0.54	0.11
		r =0.78, p<0.0001	

MR: mitral regurgitation

Table 3. FCR derived RSV according to the degree of MR.

	Regurgitant stroke volume (cm^3)		
Degree of MR	**n=23**	**average**	**sd**
mild	5	23.8	3.63
moderate	12	44.4	8.92
severe	6	69.6	7.83
		r =0.9, p<0.0001	

FCR: flow convergence region,
RSV: regurgitant stroke volume,
MR: mitral regurgitation.

Interobserver variability

The measurement data of the two observers were closely related to each other for both VCW measurements and FCR-derived RSVs with correlation coefficients of R_1=0.96 and R_2=0.92.

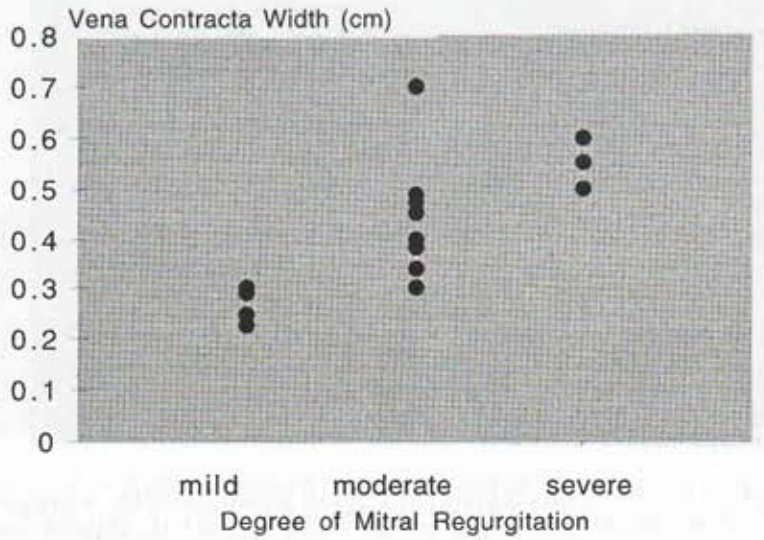

Figure 3. Relation between long-axis diameter of vena contracta and degree of mitral regurgitation (r=0.78, p < 0.0001).

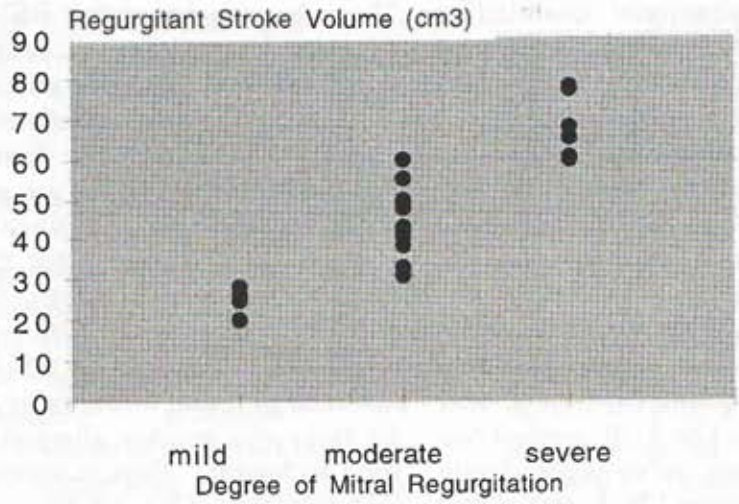

Figure 4. Relation between long-axis diameter of flow convergence region derived regurgitant stroke volume and degree of mitral regurgitation ($r=0.9$, $p < 0.0001$).

DISCUSSION

Color Doppler mapping is the most commonly used parameter for assessing the severity of both native and prosthetic mitral valve regurgitation (2-4). Proper Doppler penetration is prevented by materials that constitute prosthetic valves, which either absorb or reflect most of the ultrasound beam (21). Since the distance between the transducer and left atrium prevents receiving the Doppler signals, TTE may accurately visualize the jet area in 60% of the cases (22). However, transesophageal approach overcomes this limitation due to masking effect because the transducer is located in close proximity to the left atrium, and Doppler ultrasound is not impaired by the prosthetic valve (10-12). In clinical practice, contrast left ventriculography (25) and color Doppler mapping (26,27) are commonly used methods for assessment of severity of MR. However, these methods are semi-quantitative and dependent on hemodynamic and technical

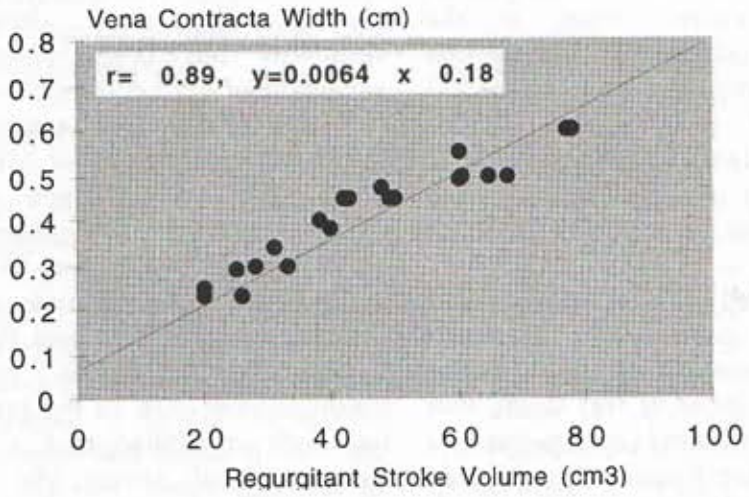

Figure 5. Linear regression plot showing good correlation between vena contracta width and flow convergence region derived regurgitant stroke volume in paraprosthetic regurgitation.

variables. An independent and quantitative method has been searched for the assessment of the severity of MR. An alternative method using proximal flow convergence has been developed to quantitatively measure regurgitant stroke volume and flow rate (13,17). This method has been reported as reliable for MR > grade 2, especially with the use of multiplan TEE (13,17). Although, it is more sensitive than color Doppler mapping for eccentric jets, proximal flow convergence may overestimate the regurgitant flow in a flail mitral valve (13,23,24). The FCR method has been applied to prosthetic valve regurgitation by Bargiggia and associates(13). In this study, color Doppler visualization of the FCR was demonstrated as a reliable method in the diagnosis of paraprosthetic valve regurgitation with a 95% accuracy in patients with MR > grade 2 in angiography. However, the correlation between regurgitant volume and regurgitation grade was not searched in this study. Similarly, we were able to detect a FCR in 100% of the patients with MR > grade 2 in angiography. Because FCR method has some advantages for the evaluation of paraprosthetic valve regurgitation, this high sensitivity is not surprising. These advantages include: 1) Unlike color Doppler mapping, FCR is constituted by laminar flow and highly accurate spatial resolution of color Doppler makes it an ideal technique for the investigation of organized laminar flows. 2) Since FCR is located on the ventricular side of the paraprosthetic valve, closer to the transducer, theoretically, it should be unaffected by flow masking phenomena. 3) Since it is located in the high-pressure chamber, upstream from the orifice, FCR would be independent of the direction of the jet, which can make the visualization of the jet area difficult (11-13).

In an in vitro study, Vandervoort and associates have used regurgitant orifice area (ROA) as a parameter to assess valvular insufficiency. In this study, it was found that an effective ROA of<10 mm^2 corresponds to a mild mitral regurgitant lesion with a mean RSV of 10.2±4.2 cm^3 and ROA>30 mm^2 corresponds to a severe mitral regurgitant lesion with a mean RSV of 67.6±15.9 cm^3. They also concluded that RSV> 50 mm3 can confirm the presence of severe MR. In the other previous studies, although a positive correlation between calculated RSV and the severity of MR has been found, a consensus has not been reached for a corresponding MR grade according to an estimated RSV. In our study, it was observed that calculated RSVs cumulated at certain levels in patients with paraprosthetic regurgitation and a mean calculated RSV of 69.9±7.83 cm^3 was obtained in severe mitral regurgitant lesions.

VCW is also another alternative for routinely used techniques. First described by Triboillay and associates (28), VCW was considered as the narrowest central flow region of mitral regurgitant jet. This technique has been easily recognized and used by many centers due to its independence from hemodynamic and technical variables and high diagnostic sensitivity for eccentric jets over color Doppler mapping (29,32). Regurgitant orifice area, transvalvular gradient and systolic duration have been well-known parameters to obtain RSV and to assess the severity of MR. Nevertheless, ROA is the most important parameter for the assessment of MR (30). VCW, which is in fact the measurement of ROA with the use of color Doppler has been proven to be independent from hemodynamic variables by in vitro studies (29). A correlation between VCW and RSV obtained from both angiography and echocardiography has also been shown by in vivo studies (15,28). Similar to our observation, low interobserver variability has been reported as another advantage of vena contracta width (31,32).

Although FCR is a quantitative and sensitive method for assessment of MR severity, it has some disadvantages such as: 1) requires special technical equipment, experienced personnel and longer time 2) is unreliable for grade I MR 3) overestimates the regurgitation flow in eccentric jets and flail mitral valve. However, VCW does not have those disadvantages (32). In the previous studies, it has been concluded that a VCW >0.5 cm associates with severe MR (31-33). In our study, in patients with severe MR, mean VCW was 0.54±0.11 cm; this observation confirms the previous studies. We concluded that the

measurements of RSV> 55 mm^3 and VCW> 0.51 cm can confirm the presence of severe paraprosthetic MR and necessitate re-operation.

Study Limitations

In this study, angiography and color Doppler mapping techniques were used to confirm the severity of MR found by FCR and VCW methods. Both angiography and color Doppler mapping techniques are semi-quantitative and have imperfect reference standard for quantitating MR (19,34). However, their results were correlated with the results obtained from the methods used in this study. In several studies, FCR has been reported as a sensitive method for differential diagnosis between paravalvular and transvalvular regurgitation. We were not able to confirm paravalvular regurgitation in most of the patients other than six patients with severe MR who underwent re-operation. With currently available devices, long-axis diameter of the vena contracta is not always representative for the cross section of the whole orifice (15) while FCR may overestimate the regurgitation flow in eccentric jets (24). In the future, improved data will be provided by 3-D reconstruction technique. Regurgitant area varies during systole (36). Our aim was to minimize this problem by using the mean of three subsequent measurements. However, to obtain a more accurate value performing some more measurements may be advisable.

CONCLUSION

Our data revealed that both FCR and VCW were sensitive methods for the assessment of the severity of paraprostetic mitral regurgitation and there was a perfect correlation between these methods. However, VCW seemed advantageous because it does not require special technical equipment, experienced personnel and longer time. Using these methods together may improve the accuracy of the assessment of mitral regurgitation in patients with a prosthetic mitral valve.

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