LV stroke volume measurement using 2D and 3D contrast echocardiography: comparison with Doppler measurements

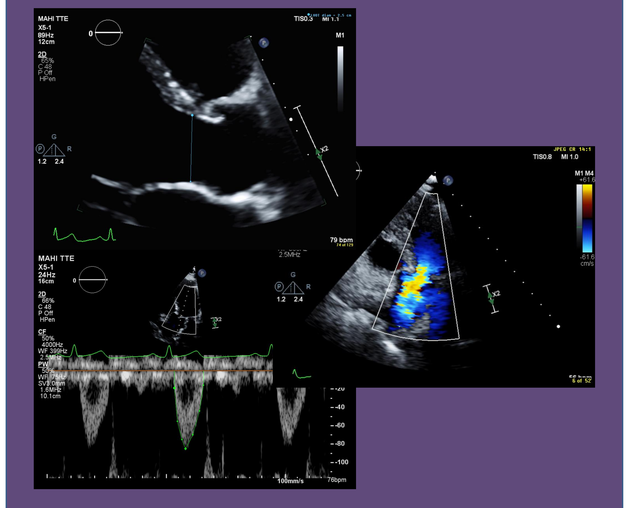
Marina Choy, Alana Durand, Victoria Sarban, Hayrapet Kalashyan, Eila Mirhadi, Jonathan Choy, Harald Becher. Mazankowski Alberta Heart Institute, Edmonton, Canada.

BACKGROUND

Contrast echocardiography (CE) has been shown to improve the reproducibility and accuracy of left ventricular (LV) volume and ejection fraction (EF) measurements compared to non-contrast echocardiography. The difference between the end diastolic and end systolic volume is stroke volume (SV) which is a relevant parameter for the assessment of valvular disease. In most echocardiographic laboratories, SV is assessed by pulsed wave (PW) Doppler echocardiography and 2D echocardiography measuring the diameter of the LV outflow tract (LVOT). There have been no studies comparing SV measurements using Doppler echocardiography with SV assessed by CE. When SV measured with CE and SV measured by Doppler are not different in patients without mitral and/or aortic valvular disease, there will be an opportunity for more accurate measurements of regurgitant fraction in patients with mitral regurgitation.

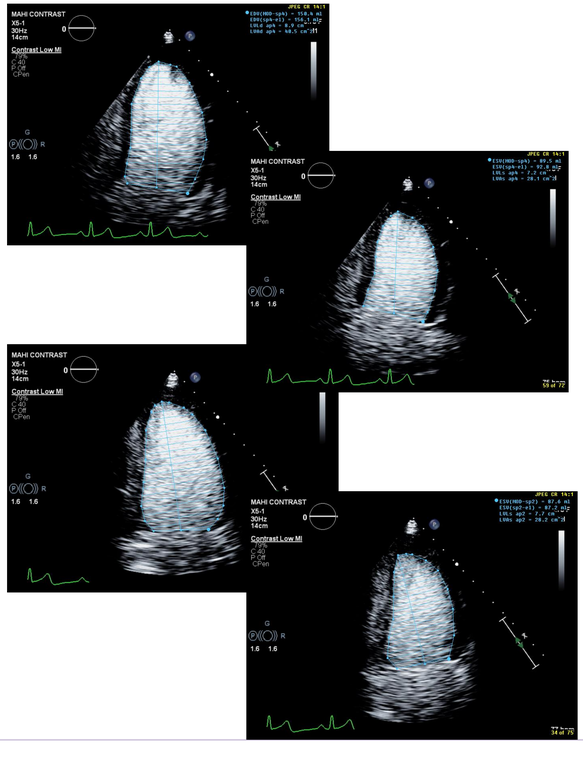
OBJECTIVE

To compare indexed SV measured with 2D CE, 3D CE and an automated 3D non-contrast method with indexed SV measured by PW Doppler echocardiography.



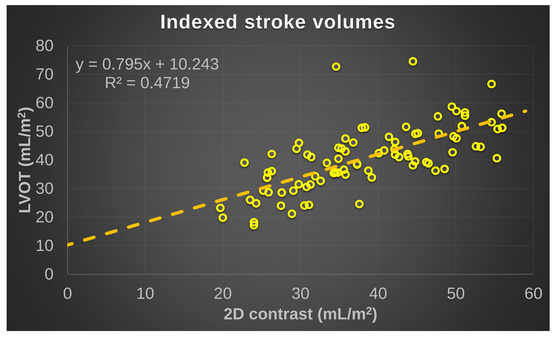
METHODS

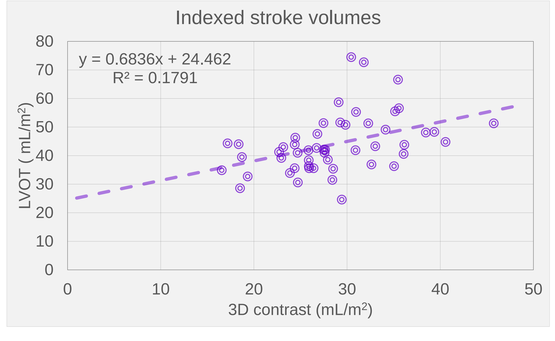
51 patients referred for CE for the monitoring of cardiotoxic effects of chemotherapy were included. Inclusion criteria were adequate 2D and 3D contrast recordings. All echocardiograms and contrast injections were performed mainly by three experienced sonographers. Non-contrast 3D echocardiography was performed using a fully automated method. Perflutren injectable suspension (0.5 mL) was diluted into a 10 mL solution with saline. Bolus injections of the diluted solution (0.5 mL) were administered using a low mechanical index (MI ≈ 0.10 – 0.18) contrast specific imaging modality in order to provide optimal LV delineation. In all patients a minimum of two 2 beat loops of the apical four, two and three chamber views were acquired in all patients as well as 3D datasets. PW Doppler measurements of the flow in the LVOT and measurements of the LVOT diameter were performed according American Society of Echocardiography (ASE) and European Association of Cardiovascular Imaging (EACVI) guidelines.



RESULTS

There were no statistically significant differences between indexed SV measured by PW Doppler 44 ± 10 mL/m^2 (mean, SD) and 2D CE (Simpson's biplane method) 41 ± 8 mL/m^2, p = 0.48; 3D CE 29 ± 6 mL/m^2; p = 0.12 and automated non-contrast 3D echocardiography 37 ± 10 mL/m^2, p = 0.74. The smallest variance of the differences was between PW Doppler and 2D CE. The best agreement was found between the indexed SV measured by 2D CE and Doppler echocardiography (Graph 1).





DISCUSSION

Theoretically, SV should be equivalent whether it is measured by LVOT, 2D Simpson's biplane or 3D volumetric methods provided that the heart is in normal sinus rhythm. Each method of calculation has its own potential sources of error.

The cross sectional area of the LVOT is assumed to be circular, therefore, errors in measurement are squared. Non-circular LVOT shape can also lead to error in the LVOT area. Tracing the LVOT area from X-plane or 3D imaging would give a more accurate measurement of non-circular LVOT but there would still be image quality issues. Poor image quality can lead to errors in the measurement of the LVOT. The LVOT velocity time integral is assumed to be measured from the same site and time at the LVOT diameter with the sound beam parallel to flow. Any deviation from this would result in error. High flow states could inflate SV.

Limitations of 2D CE that could affect SV calculation include foreshortening of the apex, shape distortions not seen in the apical 2 and 4 planes, acoustic shadowing in the basal segments , apical destruction of contrast, and movement of left ventricle long axis out of the scan plane between end diastole and end systole.

2D CE limitations are compounded in 3D CE due to the lower temporal resolution and the off axis imaging that can be performed in 2D to avoid apical foreshortening is not possible with 3D imaging.

CONCLUSIONS

2D CE provided the best agreement to the indexed SV measured by PW Doppler. However, the differences are such that it would not be useful for the measurement of regurgitant fractions.

AUTHOR DISCLOSURES

Jonathan Choy: Philips Healthcare Speakers' Bureau

Harald Becher: Bracco Research Grant, Bracco Speakers' Bureau

No disclosures for other authors