Is 2-D velocity encoded cardiac MRI accurate at 3T?

L. M. Zeeb[1], J. Kaye[2], C. E. Green[1], T. J. Andrews[2], and G. E. Gentchos[1]
[1]Radiology, University of Vermont, Burlington, Vermont, United States, [2]University of Vermont, Burlington, Vermont, United States

Purpose

2-D velocity encoded MRI (VEC-MRI) is the principal method for assessing valvular heart disease with cardiac MRI. This pulse sequence has been well validated as a robust method for cardiac and large vessel flow measurements at 1.5 Tesla field strength in vivo and in vitro, however it has not been extensively validated at 3.0 Tesla field strength. The purpose of this study is to assess the accuracy of 2-D VEC-MRI for cardiac flow measurements at 3.0 Tesla over a range of acquisition parameters in normal volunteers.

Materials and Methods:

22 healthy volunteers without evidence of underlying cardiac disease underwent cardiac MRI (3.0 Tesla Philips Achieva) using a 6-channel cardiac coil with parallel imaging. Multiple VEC-MRI flow measurements were obtained of the proximal ascending aorta varying the velocity encoding range (180 to 250 cm/s), flip angle (10 to 20 degrees), slice thickness (5 or 8 mm), and offset angle to the direction of flow (perpendicular or 10 degree offset angle). Other imaging parameters were kept constant including field of view, (320 mm), TR/TE (5.1/3.1 ms), and number of phases (20). Q-flow images were analyzed on a Philips Extended Workspace (figure 1). Stroke volume was calculated from short axis cine images (balanced steady state free precession) using Simpsons method and compared to the volume calculated from the VEC-MRI sequences. Hotelling's T-squared test was used to compare the differences in the stroke volume obtained by VEC-MRI versus the stroke volume from cine images and the percent difference of these techniques.

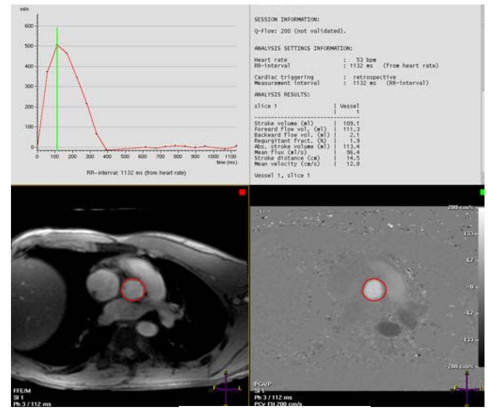
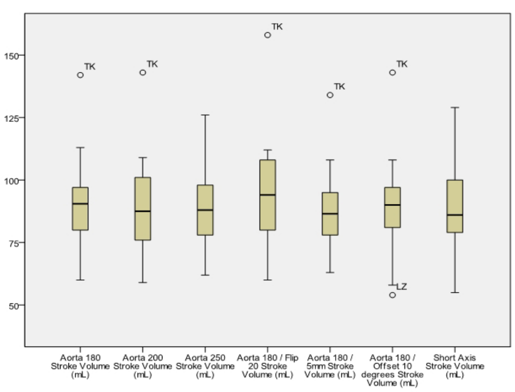


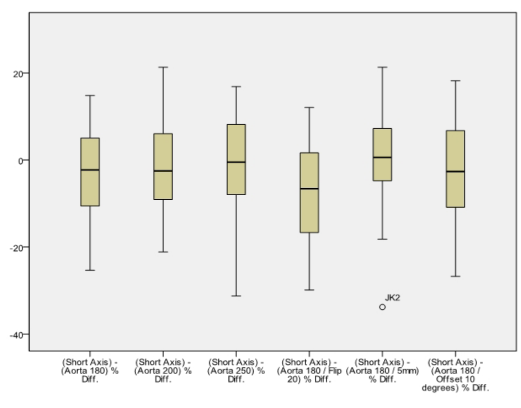
Figure 1

Results

VEC-MRI was highly accurate over a range of velocity encoded values. The mean stroke volume differed by 2.0 mL (± 9.4 mL) at 180 cm/s, 1.2 mL (± 9.3 mL) at 200 cm/s and 0.5 mL (± 10.5 mL) at 250 cm/s. Likewise, VEC-MRI was highly accurate at higher spatial resolution and when the imaging plane was slightly offset to the direction of flow, differing by 0.8 mL (± 11.0 mL) at 5 mm slice thickness and 1.0 mL (± 10.1 mL) offset 10 degrees to the direction of flow. VEC-MRI with larger flip angles (20 degrees), demonstrated the least accuracy, differing by 6.4 mL (± 11.1 mL) compared to the reference stroke volume. Graph 1 and 2 demonstrate a box plot of the difference in stroke volume obtained by VEC-MRI versus the stroke volume from cine images and the percent difference. Hotelling's T-squared test indicated that differences in the stroke volume obtained by VEC-MRI versus that obtained from cine images were not all similar ($p<0.01$). When VEC-MRI with larger flip angles (20 degrees) was removed from consideration, differences in the stroke volume obtained by VEC-MRI versus cine images were not statistically significant ($p>0.10$).



Graph 1



Graph 2

Conclusion

The results at 3.0 Tesla suggest that 2-D VEC-MRI is highly accurate in vivo over a wide range of imaging parameters, with the exception of VEC-MRI with larger flip angles. This suggests that small errors in prescribing the imaging plane or overestimating the peak velocity do not affect the overall accuracy of this method for useful clinical flow and volume measurements. Likewise, efforts to further increase spatial resolution or signal to noise are probably not necessary to optimize accuracy of this technique at 3.0 Tesla field strength.