Three-Dimensional Reconstruction of Color Doppler–Imaged Flow Convergence Region: Limitations

To the Editor:

I would like to congratulate Ishii et al. for a very interesting study in the February 6, 2001, issue of Circulation on the use of 3D reconstruction of the color Doppler–imaged flow convergence region in ventricular septal defects. Their study, however, fails to mention 2 significant limitations of the flow convergence method.

First, color Doppler isovelocity contours are distortions of the true isovelocity contours because there is loss of the velocity signal on color flow Doppler wherever flow is nonparallel to the Doppler beam. This usually affects the appearance of the color Doppler isovelocity surface closest to its outer edges near the tissue boundaries. Such distortions lead to underestimation of the area of the true isovelocity surface and thus underestimation of flow rates.

The second limitation arises from the fact that the flow convergence method was derived from continuity and control volume principles. The flow rate \( Q \) is obtained by integrating the velocity component normal to the isovelocity surface over that surface:

\[
Q = \int V \cos \theta \, dS,
\]

where \( \theta \) is the angle between the actual velocity vector \( V \) and the vector normal to the isovelocity surface \( S \). Flow convergence methods use an approximation of this, where flow rate is estimated by:

\[
Q \approx V \times ISA,
\]

where ISA indicates isovelocity surface area and \( V \) indicates isovelocity. With this, one assumes all velocity vectors along an isovelocity surface are normal to its surface. The only case in which this assumption holds true is in the idealized case of inviscid flow approaching an infinitesimally small orifice in a plate with infinite dimensions in which the hemispheres are hemispheric in shape. For orifices of finite size, inaccuracies will be introduced because the total magnitudes of the velocity vectors along an isovelocity surface are used instead of the magnitude normal to the isovelocity surface. This will lead to overestimation of flow rates.

In summary, no matter how sophisticated the color Doppler imaging medium used to measure an isovelocity surface is, these sources of error will remain and thus need to be addressed.

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