EDITORIAL

A Perspective on Color-Coded Doppler Echocardiography: Utility or Just Another Pretty Picture?*

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M-mode color-coded Doppler system. Color-coded Doppler echocardiography has been available for over a decade. Early use of a noncommercially available M-mode multigate system with color-coded Doppler ultrasound (1) was mainly investigational, and results demonstrated little utility beyond those which could be accomplished by the parent range-gated pulsed Doppler technology. The major advantage of the M-mode multigate system was easier localization of blood velocities. At a more basic level, certain velocity patterns could be elucidated more easily by the M-mode multigate system than by conventional pulsed Doppler ultrasound. For example, the first observation in the cardiovascular system that velocities increased before an obstruction was made by the M-mode multigate Doppler system. Bidirectional blood flow, although detectable by conventional range-gated pulsed Doppler ultrasound, was better displayed by the M-mode multigate Doppler system. This early phase of M-mode color-coded Doppler echocardiography did not significantly enhance clinical detection of abnormal cardiac velocities beyond those that could be detected by conventional range-gated pulsed Doppler.

Two-dimensional color-coded Doppler imaging. Commercial systems became available in about 1983 that allowed superimposition of color-coded velocities on a two-dimensional image or an M-mode tracing. Superimposition of color-coded velocities on a two-dimensional image was a major advantage over superimposition on an M-mode tracing because spatial Doppler information could be depicted in a format that was easier to comprehend. Many illustrations were published that well depicted cardiac lesions, but early publications did not provide the cardiology community with a new modality that could accomplish more clinically than could conventional range-gated pulsed Doppler echocardiography. Further, early and present systems are limited to displaying only relatively low velocities because aliasing occurs at relatively low velocities. Because of the principles of physics, the maximal nonambiguous velocity that can be detected by color-coded Doppler phased array systems without aliasing is even lower than could be detected by a single crystal Doppler system. Early color-coded Doppler ultrasound was used mainly to detect velocity characteristics that could be detected equally well by conventional range-gated pulsed Doppler ultrasound. One early incentive to perform color coded Doppler examinations was the ease with which the instrumentation allowed Doppler imaging and, in particular, mapping of flow areas. Additionally, color-coded Doppler imaging made teaching of Doppler echocardiography somewhat easier although it did not reduce the burden of understanding Doppler physics; color-coded Doppler principles are generally identical to those of conventional range-gated pulsed Doppler ultrasound. Thus, the question became, "Beyond the ease of imaging and imparting education, does color-coded Doppler imaging offer utility that cannot be offered by a simpler, less costly single sample volume range-gated Doppler system combined with continuous wave Doppler ultrasound?"

Present status of color-coded Doppler imaging. Answers to this question were several years in coming. Although some investigators initially suggested that alignment of the Doppler beam with jets was easier using color-coded Doppler ultrasound (2), even earlier work showed that continuous wave Doppler ultrasound was quite adequate for beam-jet alignment without structural imaging (3,4). Color-coded Doppler imaging has been touted for mapping of regurgitation (5), but it appears to be merely easier and faster, rather than better for this purpose. Further, the exact relation between regurgitation mapping and regurgitation volume remains controversial. During the past several years, however, color-coded Doppler imaging has been shown to provide diagnostic information that would be difficult to attain with conventional single sample volume range-gated pulsed Doppler ultrasound. Less controversial uses of color-coded Doppler imaging include detection of: 1) multiple ventricular septal defects; 2) the site of pulmonary venous entry; and 3) small atrial septal shunts.

Further, a recent issue of the Journal contained a report by Shakudo et al. (6) concerning identification of coronary artery fistulas. Detection of such fistulas by color-coded

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Doppler imaging in two patients had previously been reported (7). Shakudo et al. (6) demonstrated in a substantial series of patients the usefulness of the color-coded Doppler technique for detecting fistulas into the right atrium, right ventricle and pulmonary artery. Although the authors did not address the number of fistulas that were first detected by the color-coded Doppler method, they demonstrated clinical utility in an area where other noninvasive methods work less well. Further, they documented the intraoperative use of color-coded Doppler imaging to be certain that each fistula was closed and that other fistulae were not present. Intraoperative application of conventional single sample pulsed Doppler ultrasound, or even continuous wave Doppler ultrasound, would have been less appropriate for accomplishing their goals. Both the detection and intraoperative results of Shakudo et al. (6) have been confirmed in infants and small children by Velvis et al. (8). Both of these studies show that color-coded Doppler study combines the speed required during surgery and the ability to localize the defect (7,8).

**Conclusion.** Evidence is now available to demonstrate that color-coded Doppler imaging can provide clinically useful and important information for some applications that cannot be obtained, in as convincing a manner, by a conventional single sample pulsed Doppler system. Color-coded Doppler imaging has graduated from a method of providing pretty pictures to a diagnostic modality with specific indications already identified and more to come in the future.

**References**