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Automated Real-time Analysis of Intraoperative Transesophageal Echocardiograms

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Background: Although transesophageal echocardiography (TEE) produces real-time images depicting left ventricular (LV) filling and ejection, the quantitative analysis of these images has been too time consuming to be of practical value in the operating room. Therefore, the authors investigated whether a new automated border detection system (ABD) could track the endocardial border continuously and compute the cross-sectional area of the LV cavity.

Methods: Using data from 25 patients who were monitored with TEE as part of their routine clinical care, the authors compared ABD estimates of LV end-diastolic area (EDA in square centimeters), end-systolic area (ESA in square centimeters), and fractional area change (FAC) with the laboratory measurements made independently by an expert.

Results: ABD slightly underestimated EDA (10.7 ± 1.0 vs. 11.2 ± 1.0 cm²) and slightly overestimated ESA (5.6 ± 0.7 vs. 4.8 ± 0.6 cm², mean \pm standard error). However, when ABD tracking of the endocardial border was judged as "good" or "excellent" (84% of the patients at end diastole and 72% at end systole), the limits of agreement between ABD and the expert's findings were within the limits expected for two experts. By contrast, ABD significantly underestimated FAC (0.44 ± 0.03 vs. 0.56 ± 0.03) and the limits of agreement between ABD and the expert were more than twice as great as expected for experts, even when ABD performance was judged as "excellent."

Conclusion: The authors conclude that, when ABD appears to be performing adequately, it underestimates LV FAC, but provides valid real-time estimates of LV EDA and ESA. Thus, it warrants further evaluation as a potentially powerful clinical and research tool. (Key words: Monitoring, transesophageal echocardiography; image processing, computer-assisted.)

TRANSESOPHAGEAL echocardiography (TEE) produces real-time cardiac images which, if quantitatively analyzed, provide a more accurate guide to filling of the left ventricle (LV) than that obtained by pulmonary artery pressure monitoring.^{1,2} However, the required analysis has been too time consuming to be of practical value in the operating room. Therefore, we designed this prospective study to investigate whether a new automated border detection system (ABD) could track the endocardial border continuously and compute the cross-sectional area of the LV cavity.

Materials and Methods

With the approval of our committee on human research, we studied 36 consecutive patients during cardiac or vascular surgery who were monitored with TEE as part of their routine clinical care. We learned how to use ABD in the first five patients and excluded data from these studies in our analysis. The ABD-equipped ultrasonograph we used was a prototype; however, a commercially available version has been introduced recently (Acoustic Quantification, Hewlett Packard, Andover, MA). The ABD device is a hardware-based algorithm that processes acoustic data before their compression into a video format. The physical principle underlying ABD is that the myocardium has a markedly higher efficiency in returning (scattering) the ultrasound signal back to the transducer than does blood. However, the returning signal contains noise (coherent speckle) that significantly impedes the identification of its scattering source.³ Earlier, off-line methods for border detection reduced speckle by filtering,⁴ but even with subsequent improvements in this approach, en-

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REAL-TIME TEE ANALYSIS

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