New Software Beamforming Algorithm is Superior to Standard Hardware-Based Beamformer in Endocardial Border Detection

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Background

Technically limited echocardiogram studies can lead to non-diagnostic images that may require downstream testing, increasing healthcare costs. Software beamforming is a signal processing technique that acquires and temporarily stores multiple sequential data sets from each probe element before analyzing it with parallel processors. This optimizes and aligns signals received by the echo transducer to improve both the spatial and contrast resolution of the image. The purpose of the present study was to compare the standard, high-end hardware-based beamforming platform with the new software beamforming platform in the evaluation of endocardial borders and need for echo contrast to improve visualization. The standard hardware-based platform consisted of Philips EPIQ 7 and Siemens ACUSON SC2000™ devices. The software beamforming platform was the GE Vivid™ E95 with cSound.™

Methods

Eligible participants were inpatients and outpatients ≥ 18 years of age referred for clinically indicated transthoracic echocardiograms. In addition to the routine echocardiogram exam, a limited study, consisting of three additional views (apical-4, apical-3 and apical-2 chamber), was performed with the new software beamforming and standard platform. Images were obtained by the same experienced sonographer and were optimized with both platforms at the discretion of the experienced technician. An experienced physician echocardiographer blinded to the two platforms evaluated the number and quality of segments visualized using a 17-segment model. Physician reviewer was blinded to patient information and to any markings that could potentially reveal the source of the images. Quality of segments and endocardial borders were graded as 0=not visualized, 1=incompletely visualized, or 2=completely visualized. After individual segments were graded, physician reviewer reported an overall quality score for each study (0=poor, 1=adequate, 2=good) and whether contrast was needed. The need for additional contrast was based on the American Society of Echocardiography (ASE) guidelines. ASE guidelines define suboptimal images as those in which there is an inability to detect two or more contiguous segments in any three of the apical windows.[2] Paired T-Test and Chi-squared tests were used for statistical analysis.

Results

A total of 101 patients (84% inpatient, 17% outpatient, mean age 61 +/- 16 years, males 52%) were enrolled. The mean number of segments visualized in apical-4 (6.3 vs. 5.6, p<0.001), apical-3 (6.3 vs. 5.5, p<0.001), and apical-2 (6.3 vs. 5.7 p<0.001) chamber view were consistently higher with the new software versus standard platform. The average overall score for image quality was significantly better for the new software platform versus standard (Table 1, 1.4 versus 0.9, p=<0.001). With the new platform, 23% of the studies were judged as requiring contrast as per ASE guidelines as compared with 45% for the standard platform (Figure 1, p<0.001). **Thus, with the new software platform, the use of contrast can be avoided in 1 of the 5 patients, a relative reduction of 49%.** The mean quality score for the apical cap, apical lateral, mid anterolateral, basal anterolateral segments in the apical-4 chamber view were significantly better for the new platform. The mean quality score for the basal inferolateral, mid inferolateral, apical lateral, apical cap, apical anterior, mid anteroseptal, basal anteroseptal segments in the apical-3 chamber view were significantly better for the new platform. The mean quality score for the basal anterior, mid anterior, and apical cap in the apical-2 chamber view were significantly better with the new platform. (Figure 2.)

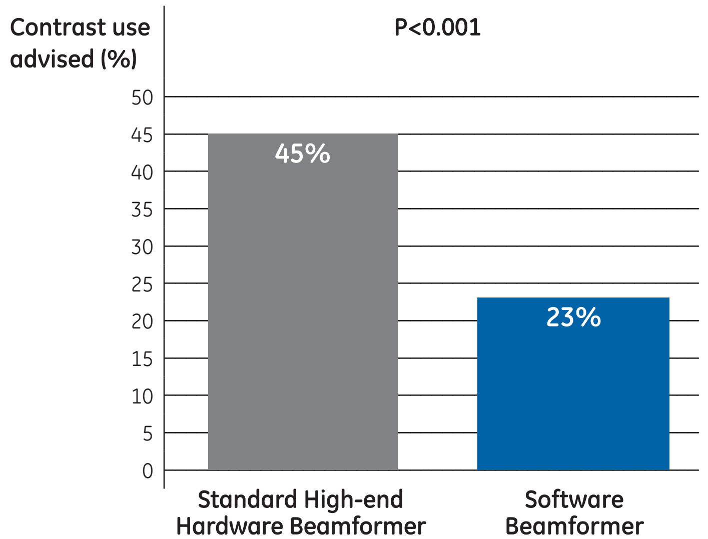

Figure 1. Proportion of patients requiring contrast for technically limited studies as per ASE guidelines, a relative reduction of 49%.

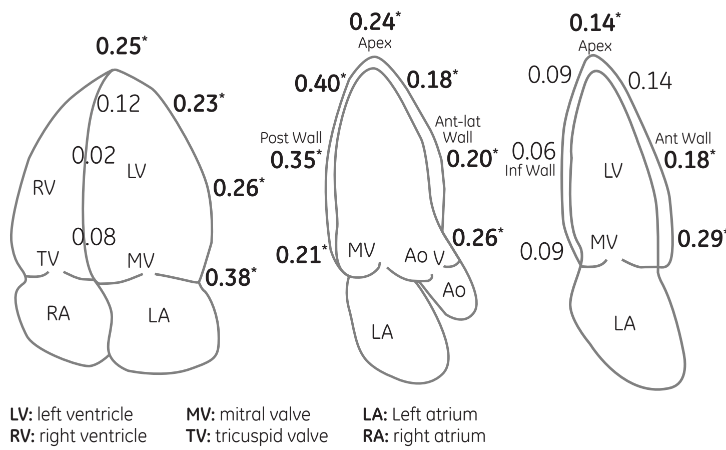

Figure 2. Mean quality score difference in favor of Software Beamforming Platform for each segment. *P=<0.05.

Adapted from https://web.stanford.edu/group/ccm_echocardio/cgi-bin/mediawiki/index.php/TTE_views_to_assess_the_mitral_valve

Conclusions:

The new software beamforming platform identified more segments with better image quality when compared to the standard high-end platform, decreasing the need for contrast usage. In particular, visualization of endocardial borders was significantly improved in the anteroseptal, anterolateral, inferolateral, inferior, anterior, and apical wall segments. In our current healthcare climate, significant efforts are being made toward decreasing healthcare expenditures. As demonstrated in this study, the utilization of this new software beamforming technology may lead to a reduction in the use of contrast and potentially the need for additional diagnostic testing leading to downstream cost savings.

	Software Beamformer	Standard High-end Hardware Beamfowrmer	P-value
Apical 4 Chamber			
# of Segments Seen	6.28	5.65	<0.001
Quality Score	1.4	1.07	<0.001
Apical 3 Chamber			
# of Segments Seen	6.27	5.54	<0.001
Quality Score	1.38	0.93	<0.001
Apical 2 Chamber			
# of Segments Seen	6.26	5.72	<0.001
Quality Score	1.33	1.15	0.0078
Overall Study Quality Score	1.35	0.85	<0.001

Table 1. Average number of segments visualized and average quality score for the two platforms.

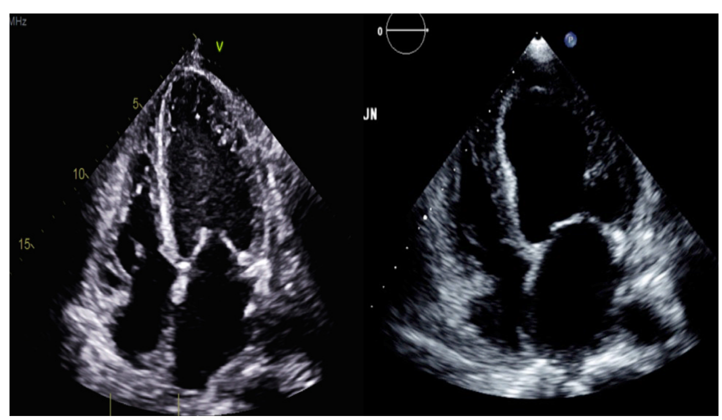

Figure 3. Apical-4 chamber view. Left: Software beamformer (GE Vivid E95 with cSound). Right: Standard High-end hardware beamformer (Philips EPIQ7).

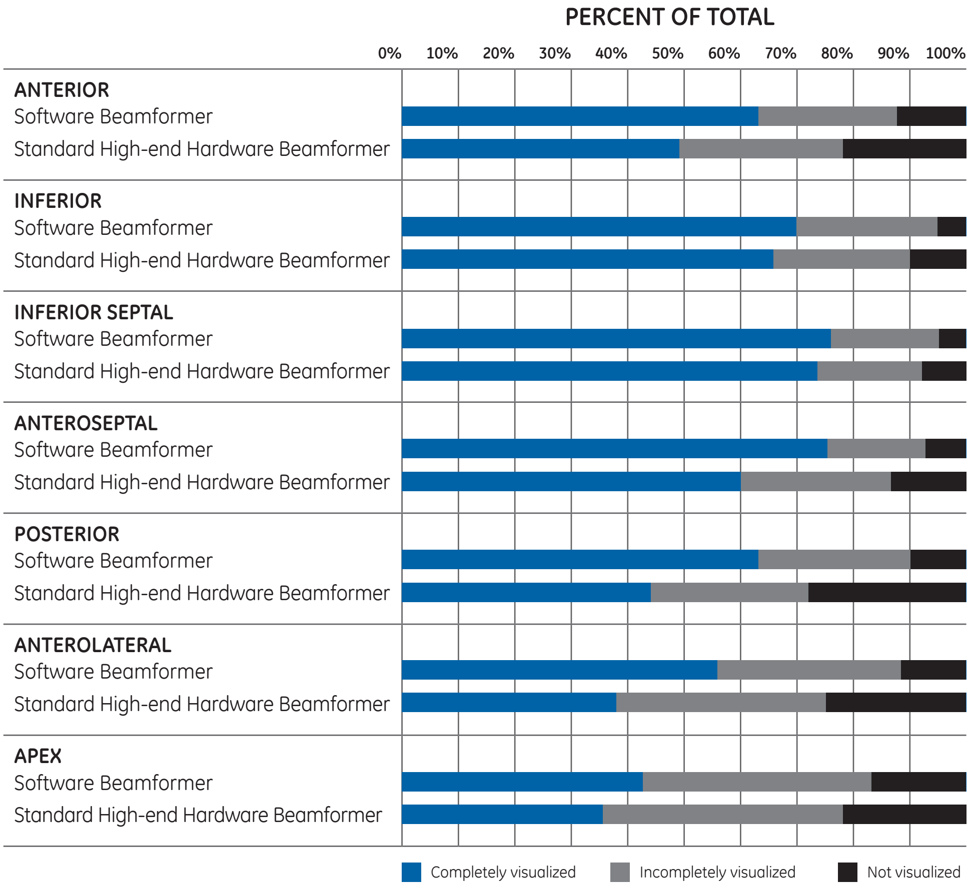

Figure 4. Percentage of total number of segments for each quality score.

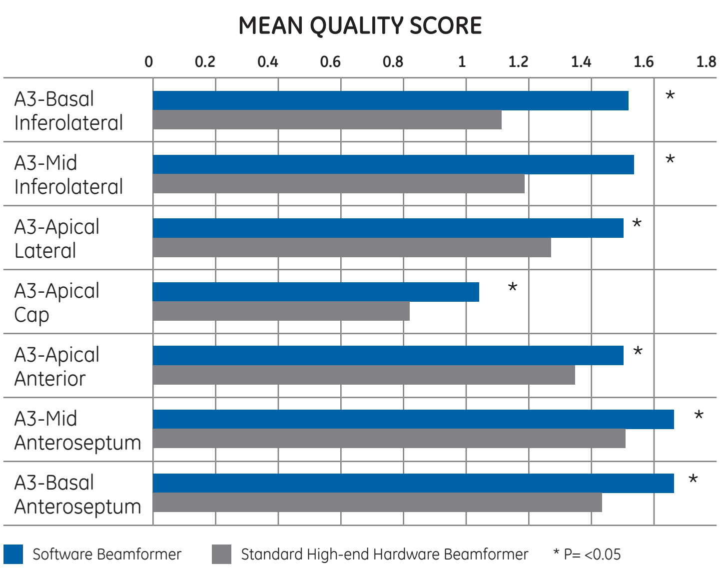

Figure 5. Mean quality score for each segment in Apical-3 Chamber.

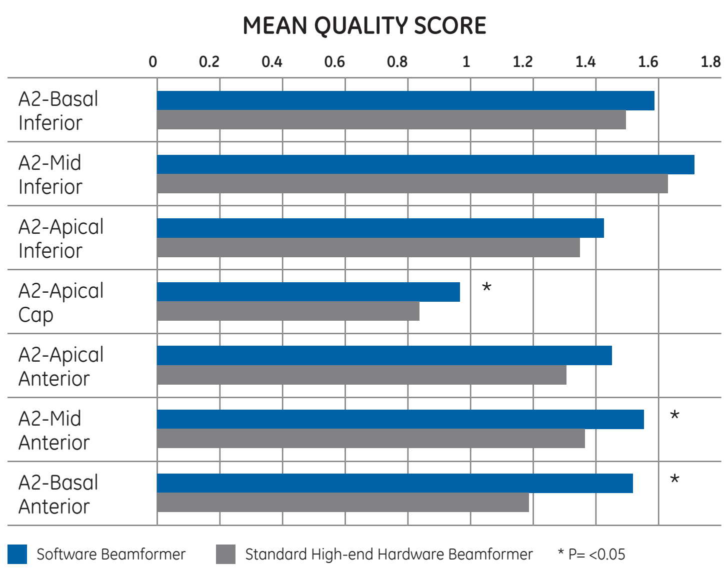

Figure 6. Mean quality score for each segment in Apical-2 Chamber.

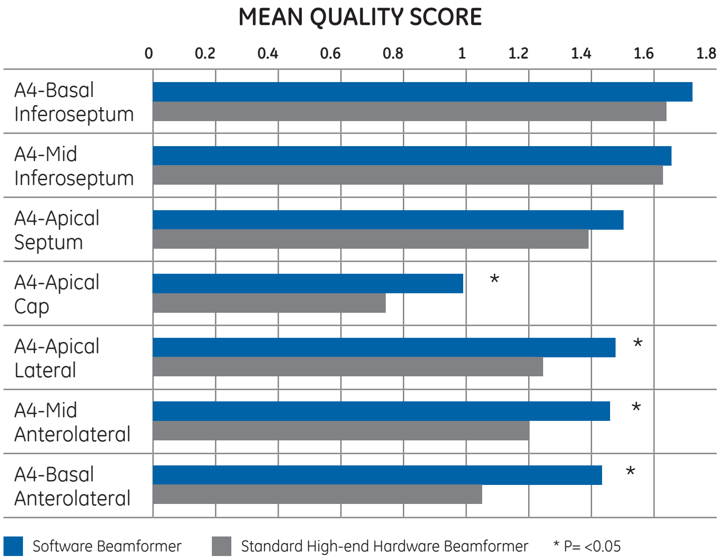

Figure 7. Mean quality score for each segment in Apical-4 Chamber.

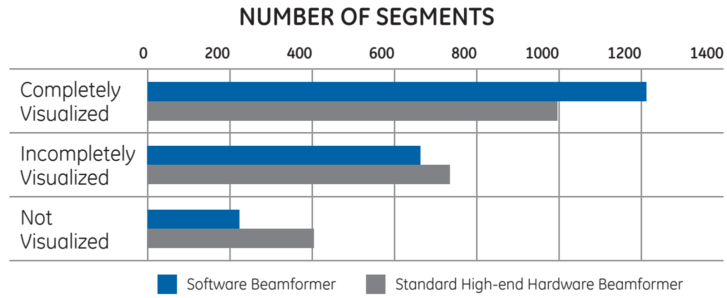

Figure 8. Number of segments visualized in each quality category.

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2. Mulvagh SL, Rakowski H, Vannan MA, et al. American Society of Echocardiography Consensus Statement on the Clinical Applications of Ultrasonic Contrast Agents in Echocardiography. J Am Soc Echocardiogr. 2008;21(11):1179-201; quiz 281.