An automated method for BRISQUE quantification of image quality in echocardiography

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Background: Echocardiography (echo) remains the most widely used imaging modality for the assessment, monitoring, and prognostication of the heart. Despite its prevalence, standardisation efforts for echo chamber quantification are ongoing, with challenges owing to subjectivity during acquisition and analysis. Furthermore, the confidence in derived functional indices is often dependent on the quality of the acquired images. However, few studies have investigated the accuracy of echo measurements compared to a reference modality such as cardiac magnetic resonance (CMR) imaging, when stratified by image quality.

Purpose: To develop an objective and automated method to quantify echo image quality, and subsequently to investigate the relationship between image quality and patient demographics, as well as the magnitude of bias in left ventricular (LV) functional indices compared to CMR.

Methods: Transthoracic apical 2D echo (2DE) and 3D echo (3DE) data from 128 participants (72 healthy controls and 56 patients with acquired heart disease) were used to train a BRISQUE (Blind/Referenceless Image Spatial Quality Evaluator) algorithm \([1]\). Briefly, feature extraction was performed by fitting pixel luminances to a generalised Gaussian distribution (GGD), followed by support vector regression to correlate features (i.e., shape, variance, and mean parameters of the GGD) to quality scores (Fig. 1). Independent BRISQUE models were trained on 580 2DE images (consisting of 2-, 3-, and 4-chamber views) and 128 targeted LV 3DE acquisitions at end-diastole, each assigned a subjective perceived quality score between 1 (poor) and 9 (excellent) by a single observer. LV indices including end-diastolic volume (EDV), end-systolic volume (ESV), ejection fraction (EF), and global longitudinal strain (GLS), were assessed according to standard guidelines. Resultant BRISQUE scores were plotted against patient demographics (age, height, weight) and the measurement bias by comparison to CMR (acquired within 1 hour of echo).

Results: Several linear relationships (where P-value of slope \(<0.05\)) were observed between demographics, cardiac indices, and BRISQUE scores. Increasing patient weight (and height in 3DE) were found to be associated with poorer image quality. There was no apparent relationship between image quality and age. Of interest, EF exhibited a relationship with image quality in both 2DE and 3DE (Fig. 2), whereby higher quality images tended to overestimate EF, while lower quality images underestimated EF. For 3DE, image quality dependency was also observed for ESV and GLS biases.

Conclusions: BRISQUE can objectively quantify image quality to produce scores which correlate to those of an expert observer, with potential utility for the standardised quantification of echo image quality. Using this method, it may be possible to predict patient characteristics which adversely impact echo quality, as well as the magnitude of measurement biases for certain functional indices.