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Supplementary Materials

DETAILS, DEFINITIONS, AND EVALUATION OF THE IMAGE QUALITY SCORING SYSTEM

The 68-point image quality scoring system assesses the 2-dimensional appearance of standard cardiac structures from 10 standard views using the parasternal, apical, and subcostal windows. Each view comprises between 1 and 10 binary assessment questions, which assess adequate visualization of cardiac structures and axis alignment (eg, absence of foreshortening of the left ventricle [LV] or ascending aorta, positioning the region of interest in the center of the sector, and a suitable sector depth). The views included the parasternal long-axis view (10 points), right ventricular inflow view (4 points), parasternal short-axis view at the level of the aortic valve (7 points), the mid LV (8 points), apical 4-chamber view (9 points), apical 5-chamber view (1 point), apical 2-chamber view (8 points), apical long-axis view (9 points), subcostal 4-chamber view (8 points), and the subcostal inferior vena cava view (4 points). The total image quality score is the sum of points from each view expressed as a percentage of the maximum score (68 points). The score also may be expressed for each window and view and may be applied to both the iHeartScan protocol[21] and conventional comprehensive transthoracic echocardiography (TTE) protocols. A graphical illustration of the image quality scoring system is shown in Supplemental Fig 1.

Definitions

For visualization of cardiac structures, the following definitions were used: left ventricular borders, right ventricle and atriums, and at least 75% of endocardial border visible at end-diastole; interatrial and interventricular septa, visible throughout systole and diastole; and aortic, pulmonary, mitral, and tricuspid valves, all leaflets separating and coapting.

Foreshortening of the LV was defined as rounding of the apex, contraction of the apex toward the center of the left ventricular cavity, complete collapse of the left ventricular walls during systole, or missing cone shape of the left ventricular cavity. Circular LV in the parasternal short-axis view was defined as no more than 20% difference between any perpendicular diameters.

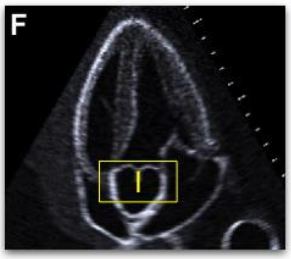
Evaluation

The image quality scoring system was evaluated before the study by performing a standard TTE protocol by 2 expert echocardiographers on 5 normal adult volunteers. To simulate differing grades of image quality, each echocardiographer performed 3 TTE studies with differing image quality (best effort, good effort, and poor effort) on each of the 5 volunteers. The images of the 15 TTE studies were stored digitally in de-identified DICOM format. The order of the studies was randomized and assessed offline by 2 observers, who did not perform the TTE studies and who were blinded to both model and image quality effort.

Interobserver agreement was assessed by measuring the mean difference and 95% limits of agreement, and the agreement between observers was considered to be acceptable if the 95% limits of agreement were less than 30% of the mean value. The mean difference between observers was 6% ± 7% with limits of agreement that were 29% of the mean value, which was

within the acceptable range. The ability of the image quality scoring system to discriminate among the differing grades of image quality was confirmed by separation of scores (Supplemental Fig 2).

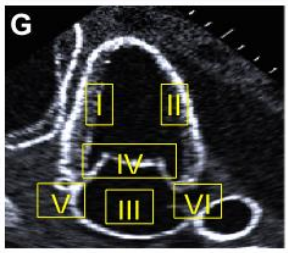
Supplemental Fig 1. Image quality scoring system. Overview of the image quality scoring system showing the number of points obtainable in each view (from A to J), with each of the binary assessment questions representing 1 point. The following definitions were used: (1) left ventricular borders, right ventricle, and atriums—at least 75% of endocardial border visible at end-diastole; (2) interatrial and interventricular septa—visible throughout systole and diastole; (3) aortic, pulmonary, mitral, and tricuspid valves—all leaflets separating and coapting. Foreshortening of the left ventricle was defined as rounding of the apex, contraction of the apex toward the center of the left ventricular cavity, complete collapse of the left ventricular walls during systole, or missing cone shape of the left ventricular cavity. Circular left ventricle in the parasternal short-axis view was defined as no more than 20% difference between any perpendicular diameters. LV, left ventricle.



Apical 5-chamber view (1 point)

Structures

I	Aortic valve



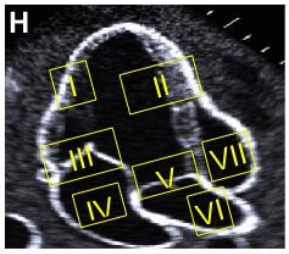
Apical 2-chamber view (8 points)

Structures

I	LV inferior border
II	LV anterior border
III	Left atrium
IV	Mitral valve
V	Coronary sinus
VI	Left atrial appendage

Other

VII	No foreshortening of the left ventricle
VIII	Left atrium and LV apex in the centre of the image



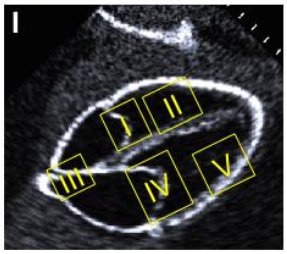
Apical long-axis view (9 points)

Structures

I	LV inferolateral border
II	LV anteroseptal border
III	Mitral valve
IV	Left atrium
V	Aortic valve
VI	Aorta fully open
VII	Right ventricle

Other

VIII	LV apex in the centre of the image
IX	No foreshortening of the LV



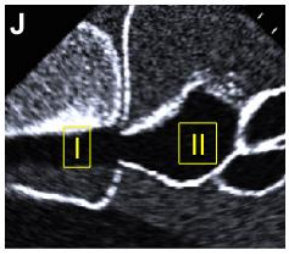
Subcostal 4-chamber view (8 points)

Structures

I	Tricuspid valve
II	Right ventricle
III	Interatrial septum
IV	Mitral valve
V	LV lateral border

Other

VI	No foreshortening of the left ventricle
VII	Depth setting increased compared with previous loop
VIII	Mitral and tricuspid valves in the centre of the image



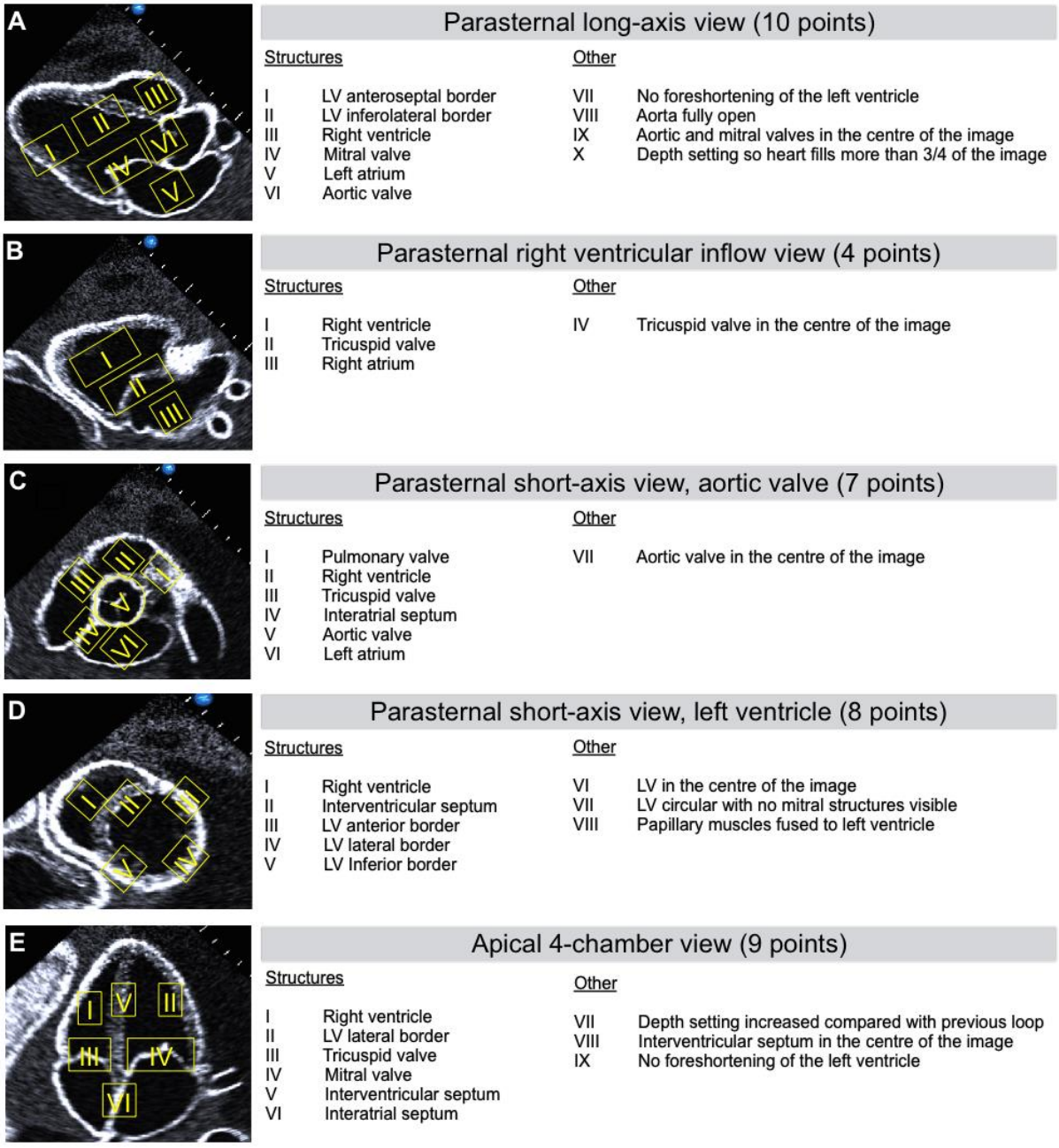
Inferior cava vein view (4 points)

Structures

I	Inferior cava vein
II	Right atrium

Other

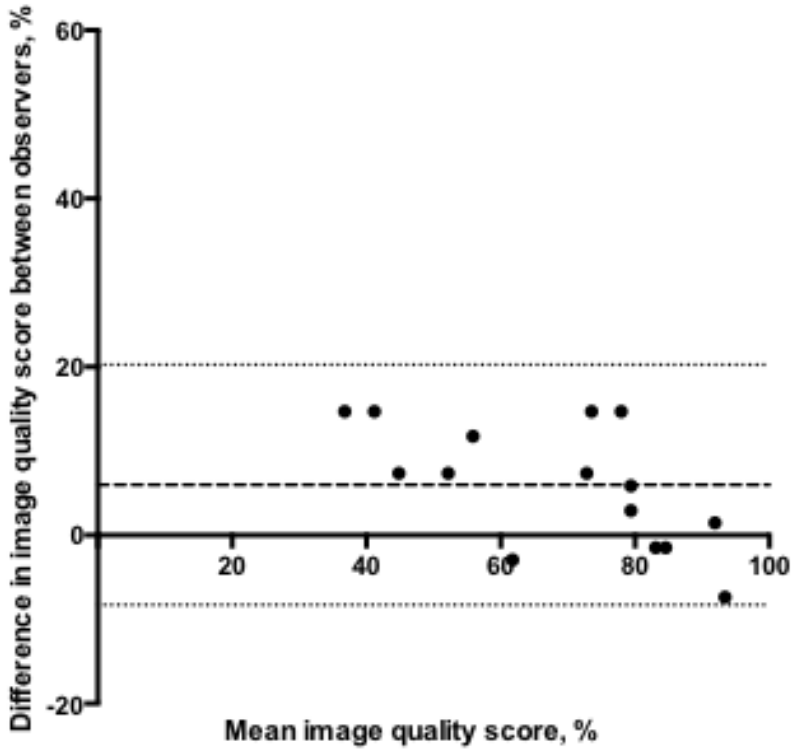
III	Junction of inferior cava vein/right atrium in the centre
IV	Inferior cava vein parallel walls, reach edge of sector



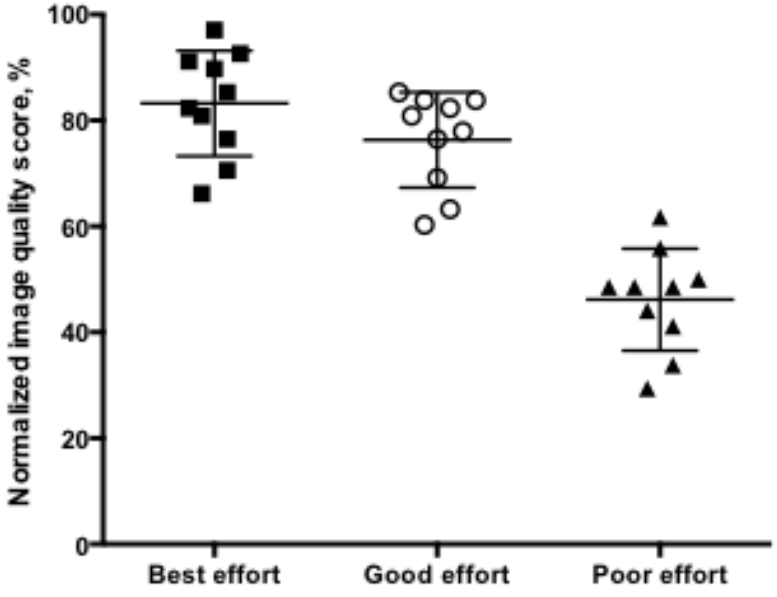
Supplemental Fig 2. Graphical evaluation of the image quality scoring system. Image quality scores after performance of a standard transthoracic echocardiography (TTE) protocol by 2 expert echocardiographers on 5 normal adult volunteers for whom each echocardiographer performed 3 TTE studies with differing image quality (best effort, good effort, and poor effort).

(A) A Bland-Altman plot with mean bias (*dashed line*) and 95% limits of agreement (*dotted lines*). (B) The scoring system's ability to discriminate among differing grades of image quality.

A


Difference in image quality score between observers, %
60
40
20
0
-20
20
40
60
80
100
Mean image quality score, %

B


Normalized image quality score, %
100
80
60
40
20
0
Best effort
Good effort
Poor effort