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IMAGING VIGNETTE

Practical Guidance in Echocardiographic Assessment of Global Longitudinal Strain

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THERE HAS BEEN INCREASING INTEREST IN THE MEASUREMENT OF GLOBAL MYOCARDIAL STRAIN because it is a sensitive and robust index to detect subclinical myocardial dysfunction, with a defined normal range (1). Numerous commercially-available versions of speckle tracking software are available for strain analysis, and measurement involves 6 steps that are common to different methods (**Figure 1**). Surprisingly, however, there are no standard instructions for measuring it adequately. This could be one of the causes of interobserver variation, especially in different echocardiography laboratories (2).

The authors developed a set of 9 cases as a step to establishing reader uniformity in an international multicenter trial of the incremental value of myocardial strain for the detection of cardiotoxicity (SUCCOUR [Strain sUrveillance during Chemotherapy for improving Cardiovascular Outcomes]; ACTRN12614000341628). The authors reviewed the tracings of collaborators and used this experience to develop an atlas of traps for the unwary, as well as lessons to avoid them. To emphasize the required image quality, the cases included a range of image quality.

The key points listed in **Table 1** and shown in **Figures 2 to 9** and Online Figure 1 and in corresponding Online Videos 1 to 8 can be used to optimize strain measurement.

FIGURE 1 Steps for Myocardial Strain Measurement

Step 1: Acquisition/Selection of appropriate image(s)

Step 2: Assessment of adequacy for strain measurement

Step 3: Detection/marking of fiducial landmarks (annulus and apex)

Step 4: Tracing of the endocardial border

Step 5: Adjustment of ROI width (avoid the pericardium)

Step 6: Evaluation of tracking quality

Step 7: Repeat steps 5 and 6, until adequate tracking is achieved.

These steps are generic to speckle tracking techniques for the assessment of strain. ROI = region of interest.

TABLE 1 Checklist for Strain Measurement

Record the optimal possible quality image
Watch the wall motion very carefully before tracing
Be cautious where you put the region of interest, especially:
the annulus
the apex
Pay attention to the region of interest width (not too wide or too narrow)
Avoid confusing anatomic structures (the papillary muscles, trabeculation)

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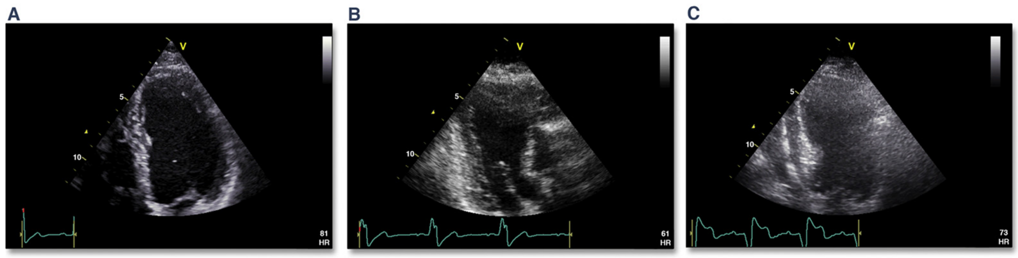
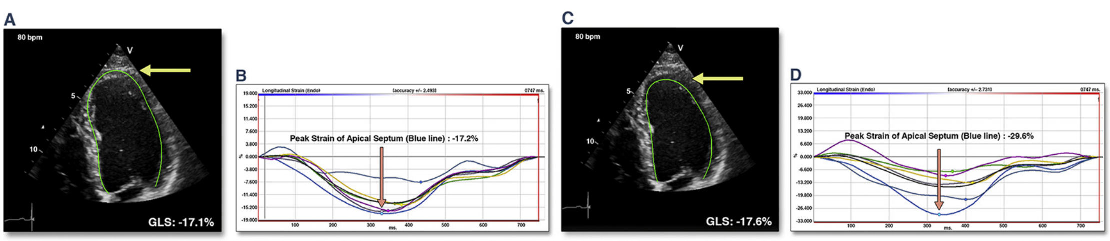
FIGURE 2 Image Quality



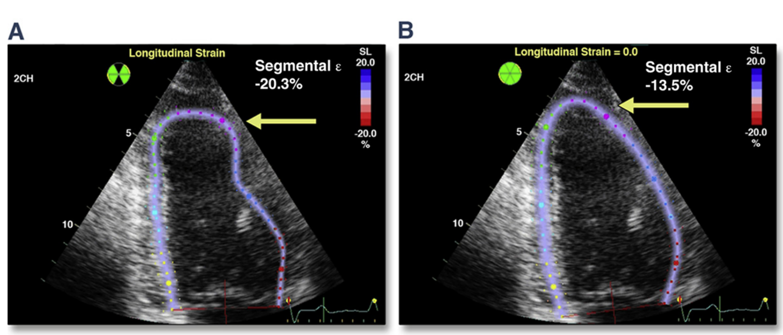
This falls into 3 categories. Image 1 **(A)** is considered adequate for strain measurement. In image 2, the apical segments would be excluded because of artifact **(B)**, but global longitudinal strain is still measurable. The quality of image 4 is too poor to analyze **(C)**. Despite the subjectivity of this assessment, all readers recognized that quality was insufficient for strain measurement (Online Videos 1A, 1B, 1C, and 1D). Lesson: always try to acquire an image where the endocardial border is clearly visible for the entire cardiac cycle so that tracking quality can be assessed.

FIGURE 3 Location of the ROI 1: The Apex in 4CV



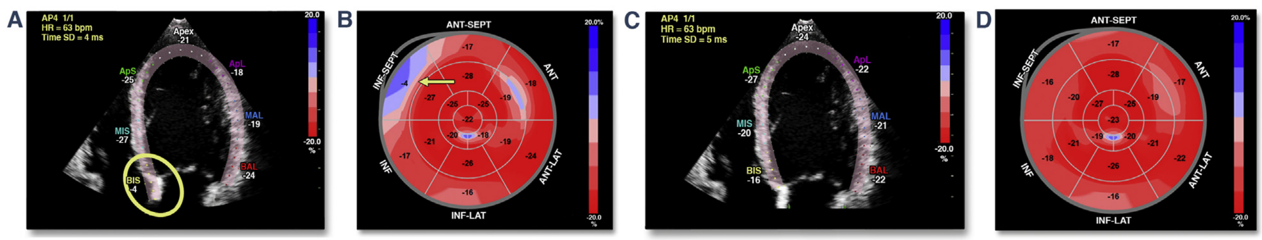
Accurate placement of the region of interest (ROI) is an important step in myocardial strain measurement. This example illustrates the same image, analyzed by 2 readers. Appropriate tracing (global longitudinal strain [GLS] = −17.6%) is shown in the **bottom row (C and D)**. The ROI of **upper images** (GLS = −17.1%) is placed into the myocardium **(A)**. The resulting ROI includes the pericardium and, therefore, underestimates the peak longitudinal strain **(B)** (Online Videos 2A and 2B). Lesson: in checking tracking, always ensure that the location of the apex is appropriate. Inclusion of a single inaccurate segment can have repercussions on GLS. Visually assess tracking of the moving image; this remains important even if the software has a tracking quality marker. If screening for subclinical dysfunction in a normal-appearing ventricle, beware of localized inhomogeneity in the waveform (and bull's eye map). 4CV = 4-chamber view.

FIGURE 4 Location of ROI 2: Tracing Papillary Muscles (2CV)



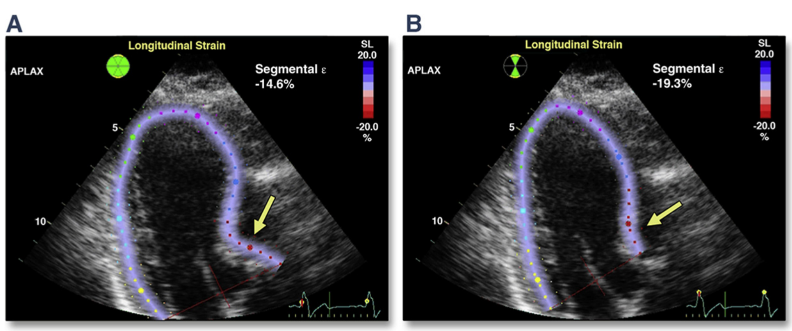
The pitfall here is the inclusion of the papillary muscle **(A)**, which is leading to an exaggeration of apical motion. **(B)** Appropriate location is shown (Online Videos 3A and 3B). Lesson: remember that the tracking algorithm is partially informed by the expected contour of the left ventricle. Deviations from the expected left ventricular shape may cause tracking problems and may require extra attention to tracking. It is always helpful to compare wall motion with the strain waveforms and bull's eye map visually and to ascertain whether they agree. In doing this, keep in mind that global longitudinal strain is different from ejection fraction, and it is important to focus on the longitudinal movement of the wall, rather than entire (radial or transverse) wall motion. 2CH = 2-chamber; 2CV = 2-chamber view; AntAP = anterior-apical; AVC = aortic valve closure; ROI = region of interest.

FIGURE 5 **Location of ROI 3: The Mitral Annulus**



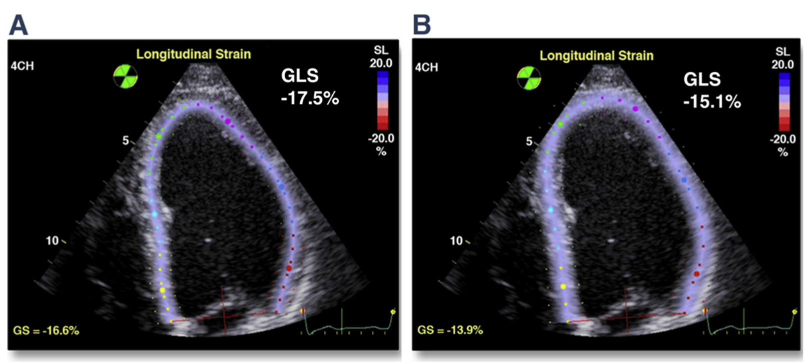
The annulus position is misplaced in the direction of the atrium **(A, circle)**. The bull's eye map and strain waveform for that segment **(arrows)** show apparent reduction of regional strain **(A and B)**, despite the absence of wall motion abnormality. **(C and D)** The results of adequate tracking are shown (Online Videos 4A and 4B). Lesson: the mitral annulus should be marked at the insertion of the mitral valve leaflets. Irrespective of the method for detection of the annulus (different types of software require marking fiducial points or detect this automatically), the location of the mitral annulus requires careful attention. ANT = anterior; HR = heart rate; INF = inferior; LAT = lateral; ROI = region of interest; SEPT = septum.

FIGURE 6 **Location of ROI 3: The Anteroseptum**



Tracing of the anteroseptum (AntSep) may be difficult in the apical long axis (APLAX) view. In this example, tracing of the anteroseptum goes beyond the basal septum to include the aortic root **(A)**, which will create or exaggerate a septal bulge of the ROI. **(B)** Adequate tracking is shown (Online Videos 5A and 5B). Lesson: again, the allocation of the basal segments requires care, and the ROI should not include the left ventricular outflow tract. Abbreviations as in **Figure 4**.

FIGURE 7 **Thickness of ROI: Not Too Wide**



Adequate thickness of the ROI includes the myocardium but not the pericardium **(A)**. ROI width in the **lower row** is too wide **(B)**, with inclusion of the pericardium. Deformation is reduced, with underestimation of global longitudinal strain (GLS) on the bull's eye map and waveforms (Online Videos 6A and 6B). Lesson: exclusive reduction of basal segmental strain, especially if it does not exist in the original image, requires rechecking of ROI width to exclude the pericardium. 4CH = 4-chamber; POST = posterior; other abbreviations as in **Figures 4 and 5**.

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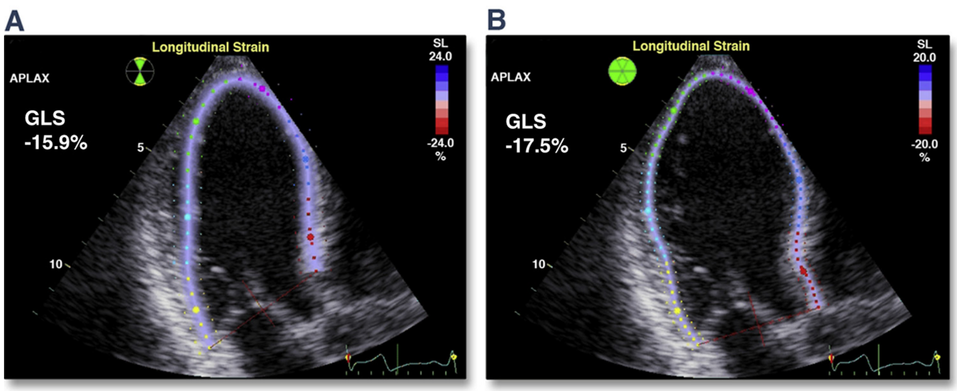
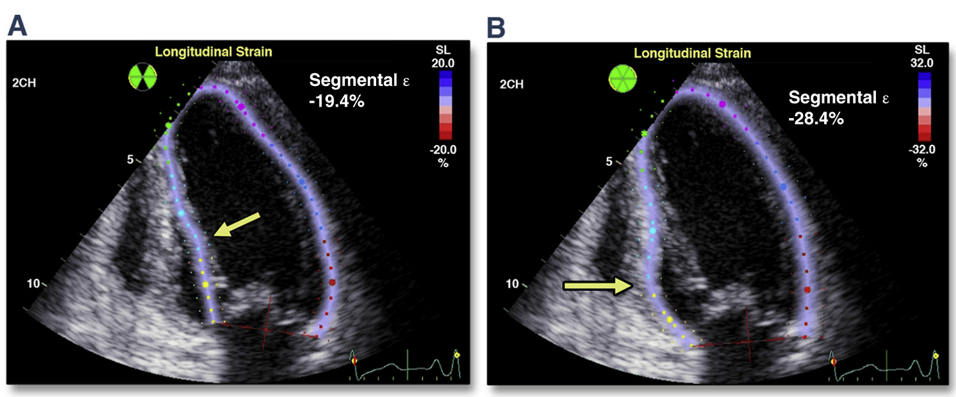
FIGURE 8 **Thickness of ROI: Not Too Thin**



In this example, the ROI width is too thin. **(A)** Adequate tracking is shown. The epicardial side of the myocardium is traced, and the ROI tracks some of the pericardium **(B)**. The impact on global longitudinal strain is less than excessive ROI width (Online Videos 7A and 7B). APLAX = apical long axis; other abbreviations as in **Figure 4**.

FIGURE 9 **Beware Mimicking Structures**



The papillary muscles were tracked in the **upper images (A)**, with resulting lower regional peak systolic strain. **(B)** Adequate tracking is shown (Online Videos 8A and 8B). Lesson: be especially wary in the 2-chamber view (2CV), especially if there are hypertrophied papillary muscles or off-axis images; the software cannot tell whether it is left ventricular wall or not. AVC = aortic valve closure; Bas-Inf = basal inferior.

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APPENDIX For an additional figure and supplemental videos and their legends, please see the online version of this article.