

GE Healthcare

AutoEF

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Overview

AutoEF is an easy-to-use tool based on 2D strain technology to help the clinician track the tissue border for volume measurements and Ejection Fraction calculation. The AutoEF tool addresses issues, such as finding the contour and identification of the end systolic and the end diastolic frames in both the 2-chamber and 4-chamber apical views.

The AutoEF tool will automatically detect the border by tracking the motion of the entire myocardium. Unlike other automatic schemes that are based solely on edge detection, tracking the entire myocardium allows tracking also if the border itself becomes obscure in some of the frames.

Why AutoEF

Manual computation of LV EF is a tedious process requiring first the exact identification of the end systolic and the end diastolic frames in the apical 4-chamber and 2-chamber views. The user is then requested to exactly outline the endocardial borders in these four frames. This is a time-consuming meticulous task that is prone to errors and variations in both selecting the appropriate frames as well as in the endocardial border outlining, especially in images with poor quality in which these borders are not clearly visible.

AutoEF is easily integrated in routine clinical labs. It is easy to use, requires few steps, and saves time. Its semi-automatic raw data feature tracking algorithm allows for clinically accurate determination of LV volumes and EF.¹ As the method is highly automated, it has the ability to minimize manual interaction and possibly improve the reproducibility of Ejection Fraction calculations. The lesser user keystrokes will also improve user ergonomics.

The Procedure

Once the apical 4CH and 2CH views are acquired and stored, you are ready to begin.

- Select the stored 4CH or 2CH view
- Go to **Measure**, then select the **AutoEF** folder
- Define the view chosen (**4CH** or **2CH**)
- The algorithm can be configured to directly detect the border, or to first present three anchor points for confirmation

- If the three points are chosen:
 - Check the points to be in the endocardial border at the two basal edges and at the apex, adjust if not in the correct position and confirm with **Set** by following the guide text on cursor
 - Adjust **Edge shift Right** and/or **Edge shift Left**, if necessary, to optimize the adjustment of the contour to the endocardial border
 - Adjust individual contour points by trackball dragging and **Set**, if you deem necessary to correct minor tracking adjustments
 - **Process** will begin automatically (unless configured differently – in this case press the **Process** soft key)
- Select the red **Approve** under the image if you agree with the tracking results (Approve will now turn green)
- In case the results are not suitable, select one of the following options:
 - **Recalc** to edit and process again
 - **Layout** to adapt only the ESV/EDV traces
 - **ES frame/ED frame** to adjust the ES frame and/or the ED frameIf the results are edited manually, an “*” will appear on EF and Volume results indicating edit was performed
- Select the red **Approve**, approve will now turn green
- Answer “**Yes**” when prompted to store the results
- Select **Worksheet** to see the full results (EF, SV, volumes, length, HR, CO, etc.)

The Method – Technical Background

LV border finding

If the three-point method is chosen, it first proposes the three initial points (at both sides of the mitral ring and at the apex) in a frame close to the end systole. The user can check the correct positions, adjust if necessary and confirm. The algorithm then automatically defines the endocardial border, based on edge detection algorithms. The borders in all subsequent frames are determined by raw data feature tracking, based on the initial ROI close to the endocardial border. Thus, for example, the ROI in frame two is found by looking at features inside the ROI in frame one and finding them in frame two using a criterion of minimum SAD (Sum of Absolute Differences). The information is carried over from frame two to frame three and so on. This way the myocardium is tracked from frame to frame, so that the inner border is now defined in all frames.

Using the AutoROI option, the complete border finding process runs automatically.

1 Szulik et al: Clinical Validation of a Novel Speckle-Tracking-Based Ejection Fraction Assessment Method. JASE October 2011 (Vol. 24, No. 10, pages 1092-1100)

Minimal (ES) and maximal (ED) volumes detection and Volume calculation

The system will calculate LV volumes throughout the entire heart cycle applying Simpson's rule. It will further automatically detect the largest and the smallest volumes. The results (volumes, EF, CO) are calculated from these, as well in the 2CH as 4CH views.

The automatic detection of the minimal and maximal volumes and calculation of all relevant parameters supports a significant workflow improvement for the LV quantification for any lab with experienced and novice users alike.

Inherent Quality Control

Several Quality Control mechanisms are implemented in the AutoEF algorithm.

Tracking quality

The system automatically assesses the tracking quality at each segment. Good tracked segments are marked green. Segments with insufficient tracking quality are marked red. The figures to the right show two clips, with good (Figure 1: green points overlay), and insufficient tracking quality (Figure 2: red points overlay at the basal lateral segment).

A red tracking line part is a "warning" to the user: The algorithm assessing the tracking quality did not pick up proper quality in this area.

The automatic assessment is quite reliable, but leaves the last decision to the user. He should assess the tracking quality himself by checking how well the overlaid points move along with the tissue and can then agree with the system or correct its assessment.

Complete loop

The system will also verify that the first frame and last frame of the loop represent equal LV volumes, as criteria that the loop is complete. To do so, the maximal volumes at the begin and at the end of the heart cycle are compared. In addition, these maximums must not be from the first nor last frame of the acquired sequence, to be sure that they are real maximums.

EF vs. longitudinal contraction

The Software determines in addition in the background the maximal systolic longitudinal contraction of the myocardium (Global Strain in the ROI area). A warning will result if EF and global strain are markedly incompatible.

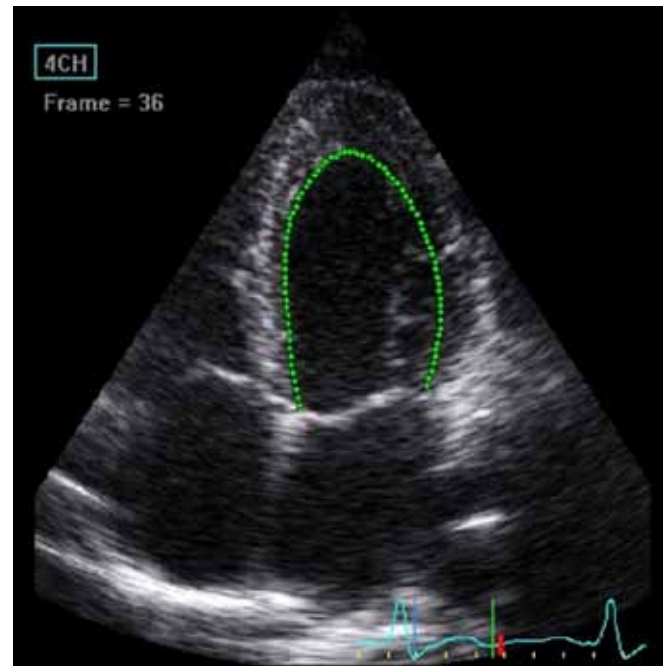


Figure 1.

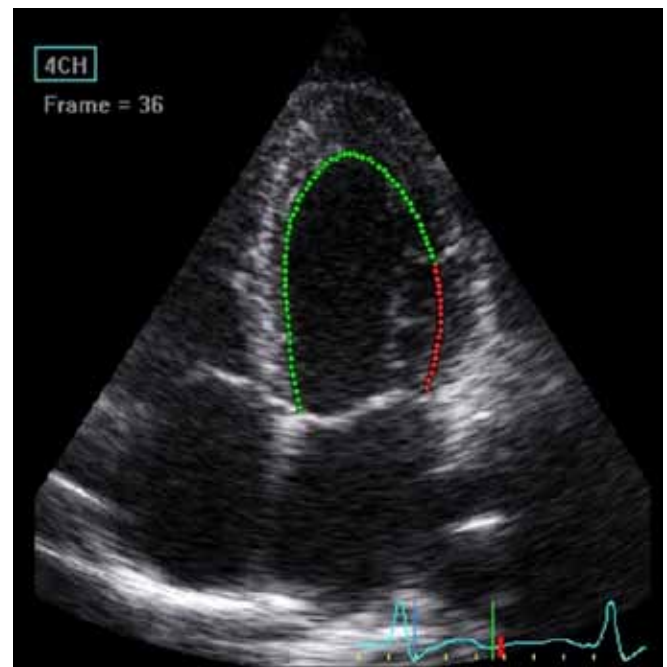


Figure 2.

Any quality issue in one of the three criteria, tracking quality, loop completeness or compatibility between EF and myocardial contraction, is shown by a red warning message on screen, in the prompt line. The user has to decide to which extent he trusts the results.

Advantages:

Fast... easy to use... reproducible

The method is only minimally dependent on user input. The border outlining proposed by the algorithm needs to be confirmed by the user. The end systolic and end diastolic frames are identified automatically. As a result, it is possible to improve the reproducibility compared to manual measurements according to the modified Simpson rule. "This is of particular interest in clinical scenarios, in which repetitive measurements of EF are needed, but for practical reasons, different echocardiographers are involved in the follow-up of patients (e.g., monitoring EF in chemotherapy patients)."¹

The fact that the user's input is minimal further results in a very short and highly efficient workflow.

The inherent Quality Control points the user to potentially inconsistent results and allows high reliability.

1 Szulik et al: Clinical Validation of a Novel Speckle-Tracking-Based Ejection Fraction Assessment Method. JASE October 2011 (Vol. 24, No. 10, pages 1092-1100)

Requirements/Recommendations

- Fair Image Quality with endocardial borders sufficiently visible to visually assess the algorithm's tracking quality
- Clear ECG signal
- Frame Rates should be 40-80 fps
 - On clips with frame rates less than 37 fps, the AutoEF will not operate
 - Lower frame rates may not allow adequate tracking; the features can move too far between consecutive frames
 - Clips exceeding 100 fps will result in a warning message in the prompt line
 - Higher frame rates may cause too low line density
- Heart rate ≤ 100 bpm
 - Heart rate and frame rate need to stay in a certain relation to allow proper tracking, else the features move too far between consecutive frames
- Store three or more consecutive heart cycles, or expand the time before and after the heart cycle (100 ms each recommended) in cases of one heart cycle
 - The loop completeness check needs this margin before and after the heart cycle

Note: If a cell image has "EF" in the right upper corner, AutoEF has been performed and approved on this image. Recalling such loop and starting the AutoEF measurement on it will automatically re-process and display the results. (It is of course possible to Edit the initial points via Recalc.)

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