# Venue™ Family

# Real-Time EF

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# Work Smarter, Not Harder

## Key Points

1. Real-Time EF is an AI enabled tool that continuously calculates Real-Time ejection fraction during live scanning in apical 4CH view and allows users to capture instant, precise results.

2. A study found EF results are within ± 10 points of experts in 86% of cases. The heart rate value calculated by the Real-Time EF tool is within ± 5 bpm of experts in 92% of cases.[1]

3. The quality indicator helps the user know when they have an adequate view to generate results. The tool presents a contour in green, yellow, or red color based on the scanning quality, the tool's identification of the apical 4CH view, and consistency of the EF results per frame.

4. ECG is not required for the tool to work.

# Real-Time EF

## Overview

Evaluation of Left ventricular (LV) function could be critical to a patient's course of treatment. Unidentified LV dysfunction can significantly delay a critically ill patient's treatment, leading to complications including death. Using Point of Care ultrasound (POCUS) to evaluate LV function has been established to increase diagnosis accuracy and improve patient outcome from undifferentiated shock.[2]

Measuring the Ejection Fraction (EF) of the LV is one method used to quantify LV function. The EF refers to the percentage of blood that is ejected out of the ventricle with each heart contraction. Echocardiography is the most common and cost-effective method to assess the EF, although other imaging modalities also offer similar methods to assess the LV.

Traditionally, in echocardiography, the EF assessment is based on the Simpson's Biplane Method of Disks (modified Simpson's rule). In the Simpson Biplane measurement workflow, the Apical 4 chamber (A4CH) and Apical 2 chamber views are imaged and both the end diastolic and end systolic frames are identified. The LV endocardial border is traced manually to get the results of the end systolic and end diastolic volumes with the EF being calculated by the system according to the volumes measured.

Performing the measurement manually -- as described above -- can be very time consuming, a disadvantage in the short time window available for treating an unstable patient. Additionally, the manual EF measurement workflow is complicated and increases the user's margin of error.

Assessing only the A4CH for EF has been shown to be sufficient in obtaining an accurate diagnosis and detecting global LV dysfunction. Moreover, research shows that the skills necessary to perform a successful focused assessment of the LV can be taught to non-cardiac sonographers or physicians by providing a few hours of cardiac imaging training and interpretation.[2]

Based on these studies, many POCUS users perform only a qualitive assessment of LV function to determine the cardiac state of their patients. This qualitative assessment was established as accurate in multiple studies, for novice and experienced users.[4]

The Venue Family offers a novel semi-automated Real-Time EF tool. The tool assists the physician to gain a EF value. The EF may be obtained within 3 seconds of live scanning in A4CH view, when image quality is sufficient as determined by the Quality Indicator.

The Real-Time EF tool presents a multicolor Quality Indicator where the color of the contour line is green\ yellow\ red. The color is based on a combination of scan quality, identification of the A4CH view and consistency of the EF results.

Finally, the combination of live scanning and Quality Indicator feedback might be helpful in training and consistent scanning technique.

## Background

The Ejection Fraction (EF) is a method used to quantify the amount of blood that is ejected out of the ventricle in every heartbeat. The calculation is based on the following formula:

$$\text{EF}= \frac{(\text{End Diastolic Vol. - End Systolic Vol.})}{\text{End Diastolic Vol.}} \cdot 100$$
$$= \frac{\text{Stroke Volume}}{\text{End Diastolic Vol.}} \cdot 100$$

The Left Ventricle EF (LVEF) helps determine the efficiency of each heart contraction. A normal value is approximately between 50-70%, although some variation exists depending on gender, demographic origin and Body Surface Area (BSA).[5] A low value of LVEF might indicate systolic heart failure, arrhythmia, cardiomyopathy or other abnormal conditions. On the other hand, a high LVEF value could be related to hypertrophic cardiomyopathy, hypovolemia or systolic anterior motion of the mitral valve causing left ventricular outflow obstruction. Finally, a preserved LVEF value may indicate diastolic dysfunction.

The symptoms of heart failure (HF) are common complaints in the ED: dyspnea, persistent coughing and wheezing sounds in the breath, edema, fatigue, nausea, confusion and increased heartrate. In 2017 it was reported that 6.5 million HF patients live in the USA and by 2023, 8 million patients are predicted.[6]

In addition, almost 8 million patients present in the emergency departments in the USA with atraumatic chest pain.[7] This makes the assessment of the LV function very important for the diagnosis of heart conditions, which carry high morbidity rates.[7]

## "How fast it works is impressive"

**Dr. Davinder Ramsingh, Loma Linda University Medical Center**

The traditional method to measure the LV A4CH EF by echocardiography is a multistep workflow that includes the following:

1. Scan the A4CH view
2. Freeze and scroll the image to identify a full heart cycle and the End Diastolic frame
3. Select the appropriate measurement from the menu
4. Manually trace the LV endocardum and store the image
5. Place the apex point
6. Repeat steps 2-5 for the end systolic frame.

This workflow incorporates multiple pitfalls including but not limited to:

1. Variability in the location of the basal points between users
2. Variability in the location of the apex point between users
3. Different user preferences for tracking the walls
4. Incorrect A4CH view is (foreshortened, not fully included in the image, unstable, contains an arrhythmia etc.)
5. User errors or complexity in system operation

Since ED physicians treat up to 3 patients an hour on average,[8] and only 25% of their time is spent on direct patient care,[9] this process may be too complex and time consuming. Therefore, it has become common for many ED/CC and other physicians to provide a qualitative assessment of LV function commonly termed 'eyeballing': The physician roughly assesses the LVEF based on wall movement, contractility, estimated volume of the LV and heartrate, instead of performing the full protocol or measurements.[4]

Even though "eyeballing" has been shown to be accurate enough,[4] there is still a high interobserver variability between users. Most physicians don't document the estimated values and novice users may not feel sufficiently confident to provide the assessment. In addition, novice users may find it challenging to acquire an adequate A4CH view and thus find it harder to recognize that the view should be corrected. Until a physician becomes experienced enough to use the "eyeballing" method, treatment quality may be compromised.

### Solution

The high frequency of use and a large impact on patient management motivated the design of this tool. The result is a robust and easy to use, semi-automated tool that combines the benefits of qualitative and quantitative methods:
The Real-Time EF tool provides a combination of high accuracy,[1] live feedback and rapidly updating results (Fig. 1). This allows the physician to evaluate the LVEF efficiently with high confidence over multiple cardiac cycles during continuous scanning. Introducing automation to this measurement potentially reduces operator interaction with the system and time spent on patient care by the medical staff.

The algorithm produces a Quality indicator based on view accuracy, ventricle completeness and temporal stability. The Quality Indicator is mapped to a scale of Green/ Yellow / Red to indicate High, Medium and Low Quality of the view.

Additionally, the Real-Time EF tool could help reduce the gap between novice and expert users, and reduce interobserver variability in measuring the LVEF. More research is required to establish standardization and if interobserver variability decreases over time using the tool.

### Methods

Once the User scans an A4CH view, the Real-Time EF tool identifies the view using Artificial Intelligence (AI) and Machine Learning (ML) algorithms. The semi-automatic tool traces the walls of the ventricle per frame and identifies end diastolic and end systolic frames based on the maximal and minimal volumes measured in each heart cycle. After approximately 3 seconds, the tool provides the heartrate based on the frequency detected in the image processing analysis. The heartrate value in 92% of cases is with ±5 bpm of experts. [1]

Additionally, the tool calculates the quality of the image based on scanning quality, the tool's identification of the A4CH view, and consistency of the EF results. The quality indicator is reflected in the color of the contour. Additionally, if the A4CH view is not detected for more than a few seconds the tool can indicate the expected location of the LV on the image to the user.

Once the user freezes the image the tool enables quick navigation between the acquired heart cycles and end diastolic and end systolic frames in the last 4 seconds. This allows for quick review and selection of the preferable cycle to store and document.

Validation was performed by comparing the tool's results to manual measurements by an echocardiography physician and two experienced cardiac sonographers on the same clips. The tests showed that the tool was able to provide a result that is ± 10 percentage points from the experts' results in 86% of the cases.[1]

## Conclusion

Emergency and Critical Care departments are overly crowded worldwide. Providing a fast and accurate tool can help elevate the standard of care that patients receive from their physician. This tool reduces the time it takes to reach a EF result and can possibly provide consistency in the EF results.

In the long run, the Real-Time EF tool could affect the clinical outcomes of critically ill patients by potentially reducing hospital stays and possibly lowering complication rates by replacing time-consuming manual measurements.

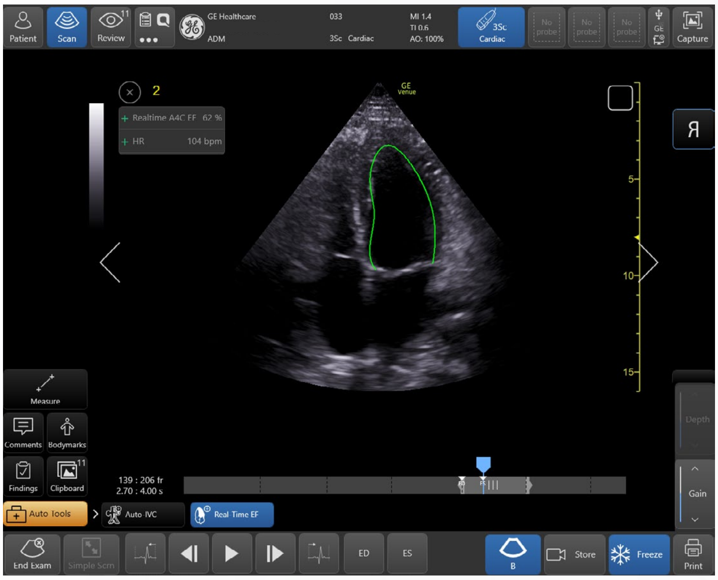


Figure 1: Real-Time EF screen layout

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JB02198XX