AFI RV

Automated Function Imaging (AFI) of the right ventricle

White Paper

By Sten Roar Snare
Engineering Leader
Display & Image Analysis

Vivid

gehealthcare.com

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Introduction

Objective quantification of left ventricular function by means of speckle tracking echocardiography (STE) was pioneered by the GE Healthcare 2004 release of the 2D Strain tool with the EchoPAC™ software solution. Later, this technology has matured and steadily gained clinical acceptance. Since 2006, speckle tracking strain quantification has been available on all GE Vivid™ scanners by the Automated Function Imaging (AFI) package.

Whereas most focus has been on the left ventricle, there has been ongoing research activity for speckle tracking quantification of the right ventricle function. As a step to promote right ventricle speckle tracking echocardiography in clinical practice, in 2018, the EACVI/ASE Industry Task Force published a consensus paper on how to perform deformation imaging of the right ventricle using STE [1]. In response, GE Healthcare is now adding right ventricle support to the AFI package, enabling easy-to-use assessment of right ventricular strain parameters using a familiar workflow. The extension supports the recommended free wall (FW) deformation assessment[1]. It also allows computation of the global strain value (i.e. including the interventricular septum, IVS), which was stated in the recommendations as an optional parameter [1].

Method

AFI on the right ventricle (AFI RV) uses speckle tracking technology to quantify right ventricular systolic function. It uses the same core speckle tracking algorithm as AFI on the left ventricle, but with some tailored adaptions to better capture the right ventricular free wall (FW) movements. According to the standardization committee recommendations, AFI RV is intended to be used with RV-focused apical views only. It is important to capture the whole RV without foreshortening the view to capture the correct RV apex and obtain robust and reliable results.

The user must define the region of interest (ROI) that includes the complete right ventricular myocardium and interventricular septum (IVS). Using the 3-Click method, the user will place two points at the basal segments and one at the RV apex (Figure 1). Based on the user input, the system automatically provides a ROI estimate that can later be regionally edited if desired.

Once the ROI has been established, AFI RV will track the image speckles inside the ROI over time, extracting information about myocardial tissue movement (TAPSE) and deformation (longitudinal strain).

In addition to global strain (GS) and free wall strain (FWS), AFI RV provides segmental longitudinal strain values for the following 6 segments:

- Apical FW
- Mid FW
- Basal FW
- Apical IVS
- Mid IVS
- Basal IVS

AFI RV reports segmental and free wall strain peak systolic values per the ASE/EAVCI recommendation task force [1] and similar to the AFI LV tool, GS is reported as the global peak value.

AFI RV TAPSE approximates a M-mode TAPSE, by calculating the excursion relative to the image apex.

The system automatically rejects segmental strain values if the tracking is suspected to be unreliable; however, the user is able to override the rejected segment(s) by clicking on the X displayed on each rejected segment.

The rejection criteria for each segmental strain value is used to infer reliability of GS, FWS and TAPSE according to the following rules:

- GS is rejected if more than one segment is rejected.
- FWS is rejected if more than one segment in the free wall is rejected.
- TAPSE is rejected if the free wall base segment is rejected.

Workflow

The AFI RV workflow is similar to AFI LV except there is only a single imaging view required for analysis. AFI RV is to be performed using an RV-focused apical view with a transthoracic cardiac sector probe.

Note: not available in TEE

To ensure accurate speckle tracking, the frame rate must be at least 40 frames per second. A higher frame rate is recommended for higher heart rates.

The first stage is Define ROI, (Figure 1)

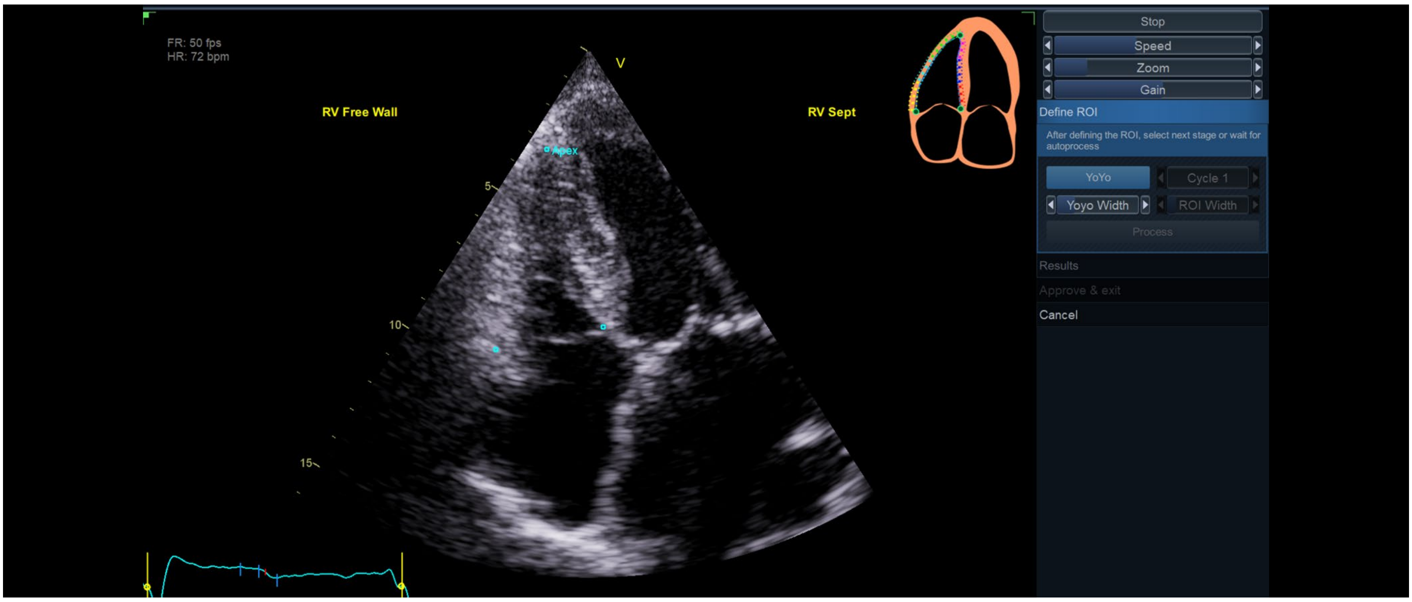

Figure 1 The AFI RV Define ROI stage.

Select an RV-focused apical view from the clipboard. Select **AFI RV** from the Measurement and Analysis package. Define the ROI by using the 3-Click method placing a point at the RV Free Wall Base, Sept Wall Base and at the Apex according to the guiding pictogram in the upper right of the imaging screen.

Once the three points are placed, the ROI will appear. The endocardial and epicardial contours can be edited together or independently to adjust for anatomy. (Figure 2)

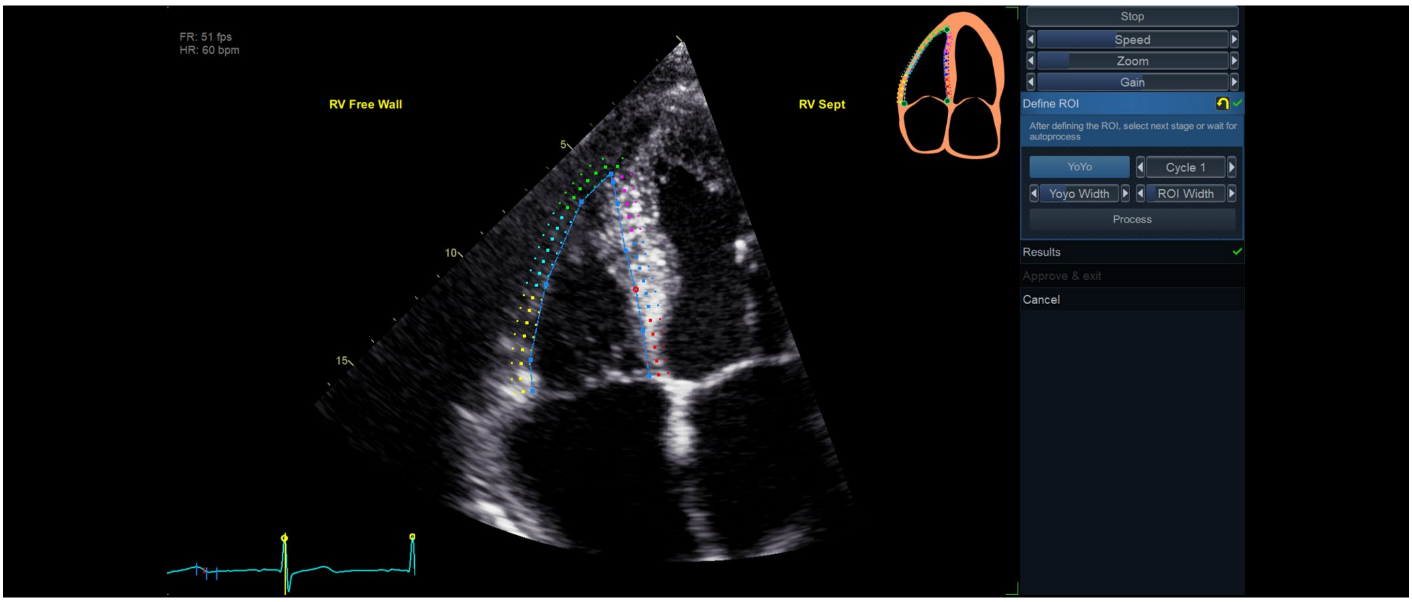

Figure 2 System generated ROI

Once satisfied with the ROI placement, either stop moving the cursor and wait for the system to auto process the dataset or click the **Process** button to advance to the **Results** screen. (Figure 3)

From the **Results** stage, the tracking quality, and values for Global Strain (GS), Free Wall Strain (FWS) and Tricuspid Annular Plane Systolic Excursion (TAPSE) are displayed. The segmental values are shown within the ROI in the lower left image of the quad screen. Segment(s) can be rejected by clicking on the value and an **X** will be displayed in its place. If segment(s) are rejected by the analysis, the user can either leave it as rejected or approve the segment by clicking on the **X** to display the value.

If the tracking quality is difficult to assess, the ROI color overlay can be turned off by selecting the **Color** button or select **Single** under the **Layouts** section for better visualization of the tracking mesh.

If a new ROI is desired, select either the **Define ROI** button or **Reprocess** to return to the beginning stage.

Select **Approve and Exit** to approve the results and move the measurements to the Worksheet. This file can be recalled in a Raw DICOM dataset and reprocessed by selecting the **AFI RV** folder from the Measurements and Analysis package.

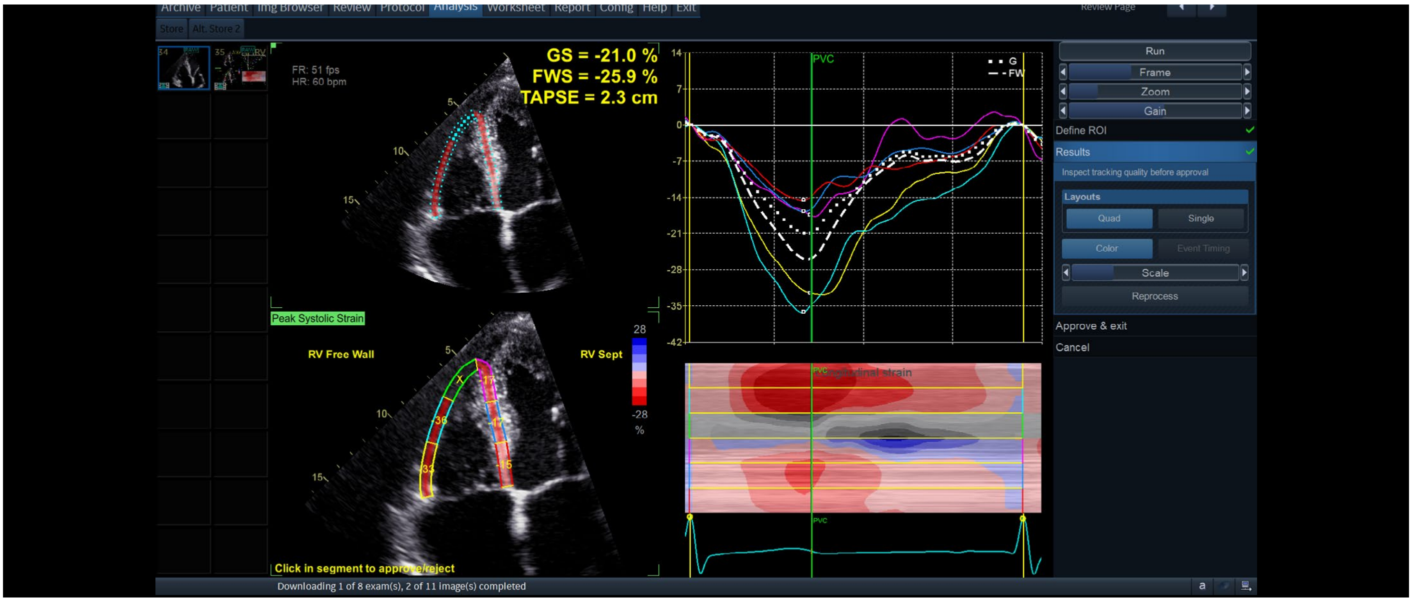

Figure 3 The Results stage with an illustration of a rejected segment in the free wall apex.

Validation method used in this white paper

AFI RV has great potential to be a robust and reliable tool, using the same validated and robust core algorithm as AFI LV. The most challenging parameters of RV speckle tracking are related to the movements of the free wall, and in particular the free wall base. This is due to the extensive systolic motion. To validate the ability of AFI RV to perform speckle tracking in the rapidly moving free wall, the following experiments were performed:

- FWS parameter was compared to relative free wall shortening by using the Caliper tool on the scanner. The free wall length was measured in end-diastole and end-systole and the manual free wall strain was found as

$$FWS_{man} = \frac{L_{FW,ES} - L_{FW,ED}}{L_{FW,ED}} \, [\%]$$

- TAPSE was compared to a manual anatomical M-mode TAPSE measurement on the scanner.

The experiments were performed on RV-focused apical views from 23 different randomly selected patients. Three clinical expert observers performed the measurements to assess interobserver variability.

Interobserver variability

The intraclass correlation coefficient [2] was calculated for both manual caliper measurements and AFI RV measurements. The results are presented in Table 1

Parameter	Measurement Method	
	Caliper	AFI RV
FWS	0.47 (fair)	0.91 (excellent)
TAPSE	0.63 (good)	0.91 (excellent)

Table 1 Intraclass correlation coefficient and interpretations as in Cicchetti [3].

The interobserver variability was also assessed by paired comparison between the observers. The results are presented in Table 2.

The results in this study clearly demonstrate that using a semi-automatic tool as AFI RV significantly improves the interobserver variability of the measurement.

	Observer 1 vs Observer 2		**Observer 1 vs Observer 3**		**Observer 2 vs Observer 3**	
	Difference (mean +/- stdev)	Correlation Coefficient	Difference (mean +/- stdev)	Correlation coefficient	Difference (mean +/- stdev)	Correlation coefficient
FWS (Caliper)	0.61 +/- 7.47 pp	0.46	-1.48 +/- 7.66 pp	0.48	-2.09 +/- 7.21 pp	0.46
FWS (AFI RV)	0.62 +/- 3.08 pp	0.91	1.11 +/- 3.08 pp	0.92	0.23 +/- 3.28 pp	0.89
TAPSE (Caliper)	0.15 +/- 0.38 cm	0.65	0.12 +/- 0.37 cm	0.71	0.14 +/- 0.57 cm	0.57
TAPSE (AFI RV)	0.04 +/- 0.40 cm	0.91	0.02 +/- 0.19 cm	0.95	0.09 +/- 0.23 cm	0.89

Table 2 Pair-wise interobserver variability by mean, standard deviation and correlation coefficient.

Agreement

To assess the agreement between manual and semi-automated measurements, median values of the manual Caliper and AFI RV measurements from the three observers were compared. The results are presented in Table 3.

Good correlation between the manual and semi-automatic measurements were observed, and the differences between manual and semi-automatic measurements are significantly smaller than the differences between the observers performing manual measurements.

In conclusion of the here referenced experiments, AFI RV provides measurements of right ventricular free wall strain and TAPSE with interobserver variability and accuracy better than the interobserver variability of manual caliper measurements.

Parameter	Caliper – AFI RV (mean +/- stdev)	Correlation coefficient
FWS	0.13 +/- 4.74 pp	0.72
TAPSE	-0.16 +/- 0.28 cm	0.86

Table 3 Agreement between caliper and AFI RV measurements

References:

1. *Standardization of left atrial, right ventricular, and right atrial deformation imaging using two-dimensional speckle tracking echocardiography: a consensus document of the EACVI/ASE/ Industry TaskForce to standardize deformation imaging*, Luigi P. Badano et. al. European Heart Journal - Cardiovascular Imaging (2018) 0, 1–10

2. *A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research*, Terry K. Koo and Maye Y. Li, J Chiropr Med (2016). 15(2): 155–163.

3. *Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology*, Domenic V. Cicchetti, Psychological Assessment (1994). 6 (4): 284–290

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