PHILIPS

Ultrasound

White paper

First-of-kind automated segmental wall motion assessment of the left ventricle

AI-powered Auto Segmental Wall Motion Scoring (Auto SWM)

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Overview

Transthoracic echocardiography is the most-used noninvasive imaging tool for detecting regional wall motion abnormalities (RWMA) in routine echo exams. Left ventricular (LV) wall motion abnormalities are an independent indicator of adverse cardiovascular events and death in patients with cardiovascular diseases such as myocardial infarction, dyssynchrony and congenital heart disease.[1,2] The wall motion score index (WMSI) numerically averages the scores for all left ventricular segments into a single parameter. The prognostic value of WMSI has been investigated in patients with acute myocardial infarction, suggesting superiority to left ventricular ejection fraction (LVEF) in predicting mortality.[3–5] Another recent study suggested the WMSI is a superior predictor of 12-month mortality over LVEF in ST-segment elevation myocardial infarction (STEMI) patients treated with primary percutaneous coronary intervention (PCI).[6]

Accurate assessment of RWMA is critical to identify acute and chronic myocardial infarction. It's also important to differentiate the ischemic from nonischemic causes such as cardiomyopathy. Currently, the assessment of wall motion is still performed visually with high dependence on training and expertise. Therefore, visual assessment of RWMA could cause inter-observer variability.[7–9]

Using artificial intelligence, Philips developed a robust Auto Segmental Wall Motion Scoring (Auto SWM) assessment tool that is embedded on the ultrasound system within the 2D Auto LV application for fast and objective assessment of LV RWMA. Auto SWM is a first-of-kind application that automatically suggests wall motion scores for the left ventricle.

SWM algorithm description

The Philips Auto SWM tool provides an assessment for each of the American Society of Echocardiography (ASE) defined 17 segments pertaining to the LV.[10] The tool automatically classifies each segment into one of three categories:

1 – Normal
2 – Hypokinetic
3 – Akinetic
(note – the application also includes dyskinetic and aneurismal in this category)

In our approach, we use artificial intelligence (AI) to determine a score for 16 LV segments, and the 17th segment is calculated as an average of the four apical segments. An overall WMSI is then computed as the statistical mean of the 17 segments.

We leverage AI by extracting a set of features pertaining to each segment and then use a machine-learning model to determine a score for each segment based on these features. The features are calculated by first determining the LV border and then leveraging this border to extract three categories of features pertaining to each segment:

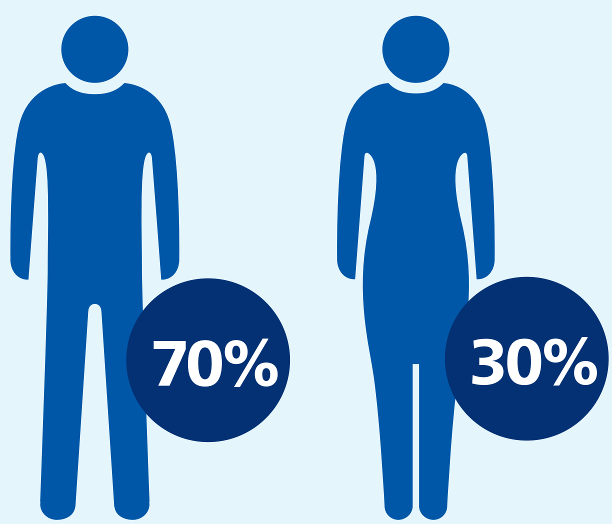
- **Velocity**
  The speed at which a segment is moving
- **Displacement**
  The distance that a segment travels within a heart cycle
- **Strain**
  The distance that a segment moves relative to its original length

These features are weighted by the AI algorithm to then determine a classification for each segment into one of the three categories listed above (normal, hypokinetic, akinetic).

Training data

The core AI model for the Auto SWM application was trained using 735 clinical echo exams and their corresponding 17-segment LV wall motion scores. These scores were extracted from clinical echo reports that were reviewed and signed by board-certified cardiologists. The patient population was 70% male and 30% female, with a mean age of 63.5±14.5 years. Of these patients, 20% had normal LV function, and 44% (330 patients) had a previous MI. Moreover, this data was assessed to have satisfactory image quality for Automated SWM evaluation using the apical 2-, 3- and 4-chamber views.

Patient population
mean age of 63.5±14.5 years



Simple workflow

Use of the Auto SWM algorithm consists of the following four steps, which are described in detail and shown in **Figure 1**:

1. **Image acquisition and selection of appropriate apical 2-, 3- and 4-chamber images.**
2. **Automatic scoring of LV wall motion by the Auto SWM algorithm.**
3. **Review automated wall motion scores and, if necessary, make edits of the Auto SWM results.**
4. **User acceptance of the final scores.**

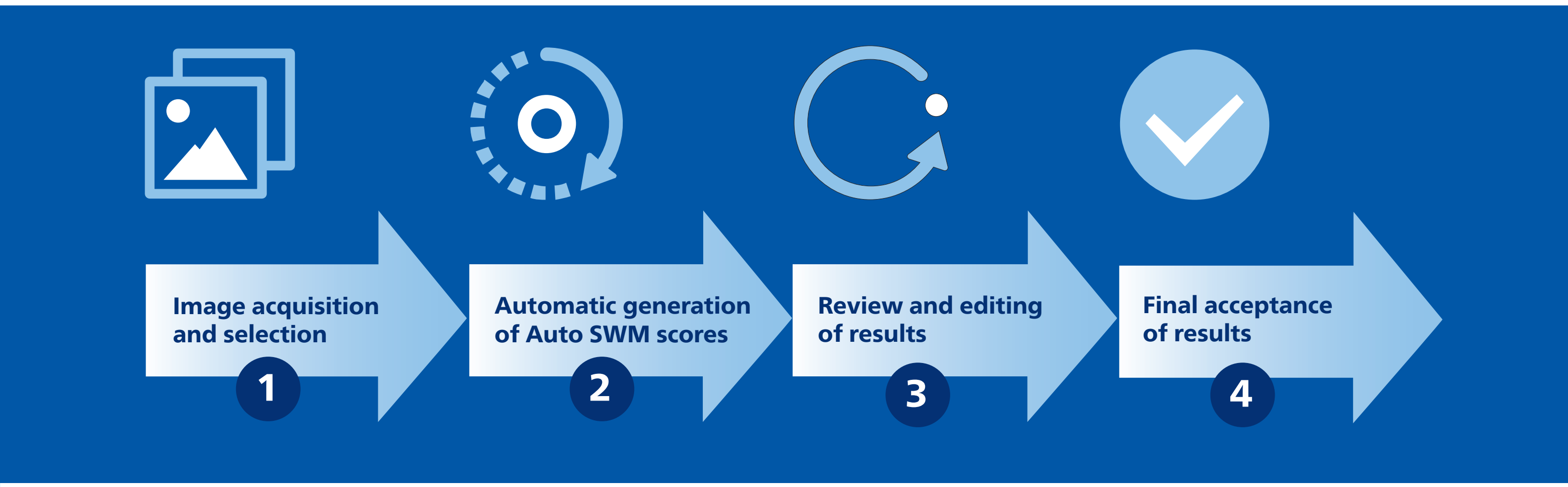


Figure 1 Overview of Auto SWM workflow.

Image acquisition and selection

To use Auto SWM, the user must first acquire apical 2-, 3- and 4-chamber images, in accordance with ASE guidelines.[10] Using the Auto SWM algorithm on data that deviates from sufficient image quality may produce nonideal results. Following acquisition, the user should select these apical images and launch the 2D Auto LV application. These images can be selected either manually or automatically using the Smart View Select (SVS) feature, if SVS is enabled on the system. Note that an asterisk will appear on the 2D Auto LV button if SVS is enabled and has automatically identified the appropriate images for the 2D Auto LV application. (See **Figure 2**)

Figure 2 On-screen button that launches the 2D Auto LV application, which contains the Auto SWM feature.

Score generation and review of results

After launching Auto SWM within the 2D Auto LV application, the algorithm automatically generates scores for each of the LV segments. Users should then review the scores and consider whether they agree with the automatic assessment. In the event of disagreement, the user can modify the score to match their own assessment. An asterisk (*) indicates the score is modified. (See **Figures 3** and **4** for a description of Auto SWM editing workflow).

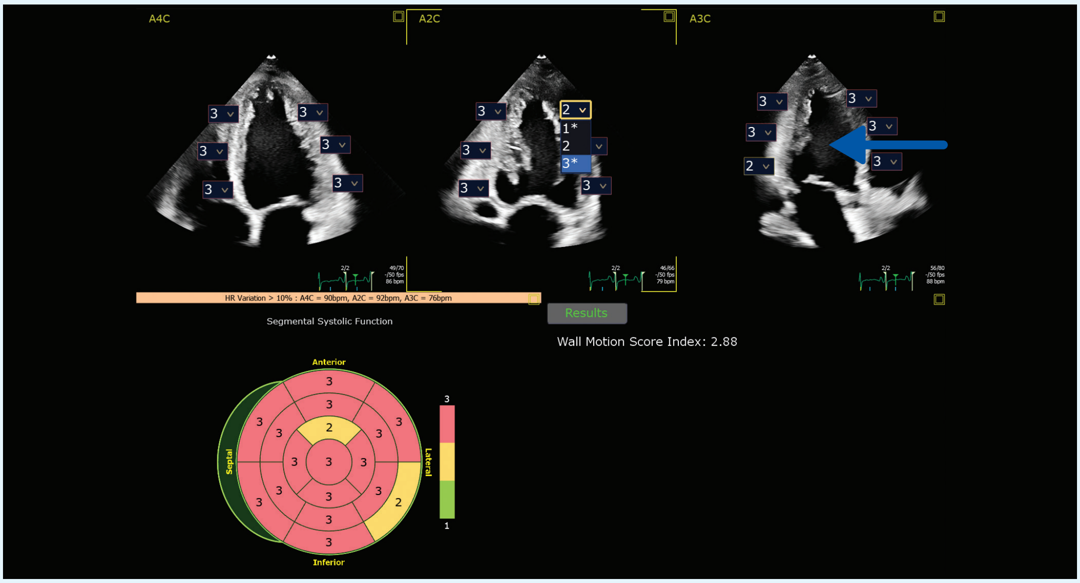


Figure 3 Example of Auto SWM editing – part 1. To change one of the wall motion scores, select the upside-down caret symbol ('ʌ'), which is located next to each of the wall motion scores in the apical views (highlighted by the blue arrow above). Once selected, this will reveal a drop-down menu, enabling the user to change the score. Auto SWM editing workflow is continued in **Figure 4**.

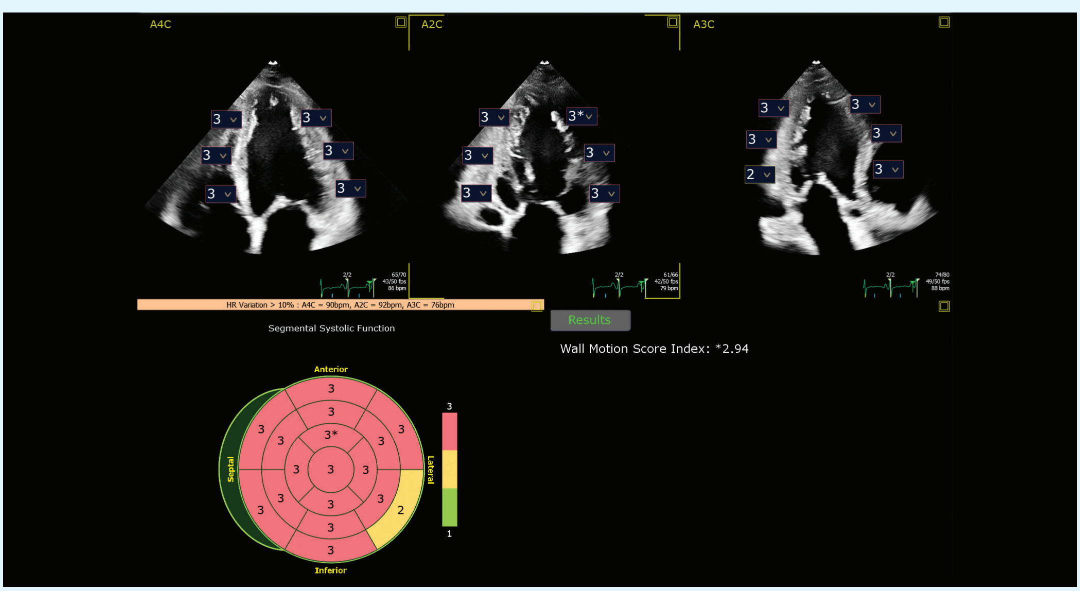


Figure 4 Example of Auto SWM editing – part 2. If the wall motion score for a given segment is changed from the automatically-generated score, then an asterisk ('*') will appear next to that score in both the apical view and in the bull's-eye plot. Moreover, an asterisk will also appear next to the wall motion score index.

Acceptance of results

Following manual review of the results, the user must place a check mark ('√') in the "Accept All Measurements" panel if they agree to accept the results. Once accepted, the WMSI will appear in the report. (See **Figure 5**.)

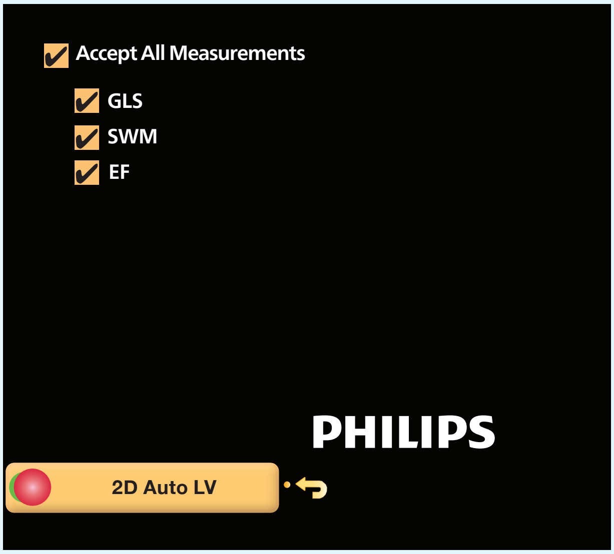


Figure 5 Acceptance of Auto SWM results. Once review and editing of Auto SWM results are completed, the user must place a check mark ('√') in the "Accept All Measurements" panel, indicating that the results are accepted by the user.

Validation study

A validation study was performed internally on retrospective data, which compared the automatically-generated WMSI from the Auto SWM application to a visual assessment from a consensus panel of four board-certified cardiologists The study population included adult patients (age >18) who were referred for an echocardiographic examination (ambulatory and hospitalized patients) with normal and abnormal LV function, in sinus rhythm without multiple premature beats. Patients with left bundle branch block (LBBB) or exams with no eligible clips for SWM evaluation were excluded.

The patient population consisted of 161 echo exams that were 64% male and 36% female, with the mean age of 60.26 ±16.45 years. Among these patients, 48 (29.8%) had normal LV function, 83 (51.6%) had CAD, and within the CAD group, 76 patients (91.6%) had a previous MI. The algorithm was applied automatically to preselected apical 4 chamber, apical 2 chamber and apical 3 chamber clips from 161 examinations. Exams that yielded results for all three views were included in the analysis. In total, automated analysis was possible in 143/161 (89%) of the exams.

The receiver operating curve (ROC) curve and calculated area under curve (AUC) are presented in **Figure 6**, showing the WMSI ROC curve for Auto SWM, compared to the reference results. The area under the curve (AUC) was 0.79.

ROC curve for model

Area under the curve = 0.7933

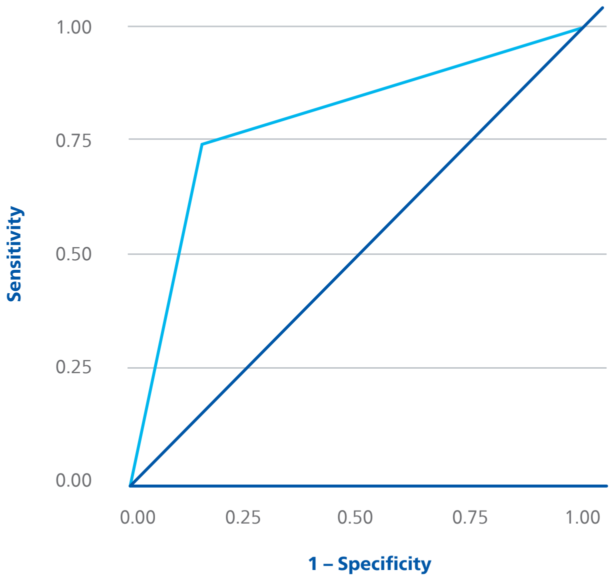


Figure 6 WMSI ROC curve for Auto SWM compared to the reference results. The area under the curve (AUC) was 0.79.

For both methods, the results were grouped into two classes: normal and abnormal (where a WMSI of 1.26 was used as the threshold for abnormal). The obtained specificity and sensitivity were 0.85 CI (69.5, 94.1) and 0.74 CI (64.1, 82.1), respectively. The overall agreement was 77% CI (69.2, 83.6). The correlation between reference WMSI and automatically-calculated WMSI is described in **Figure 7**.

This feature was cleared by the FDA based on the results we described. Moreover, the study result was also published at ASE 2024 as an abstract.[11]

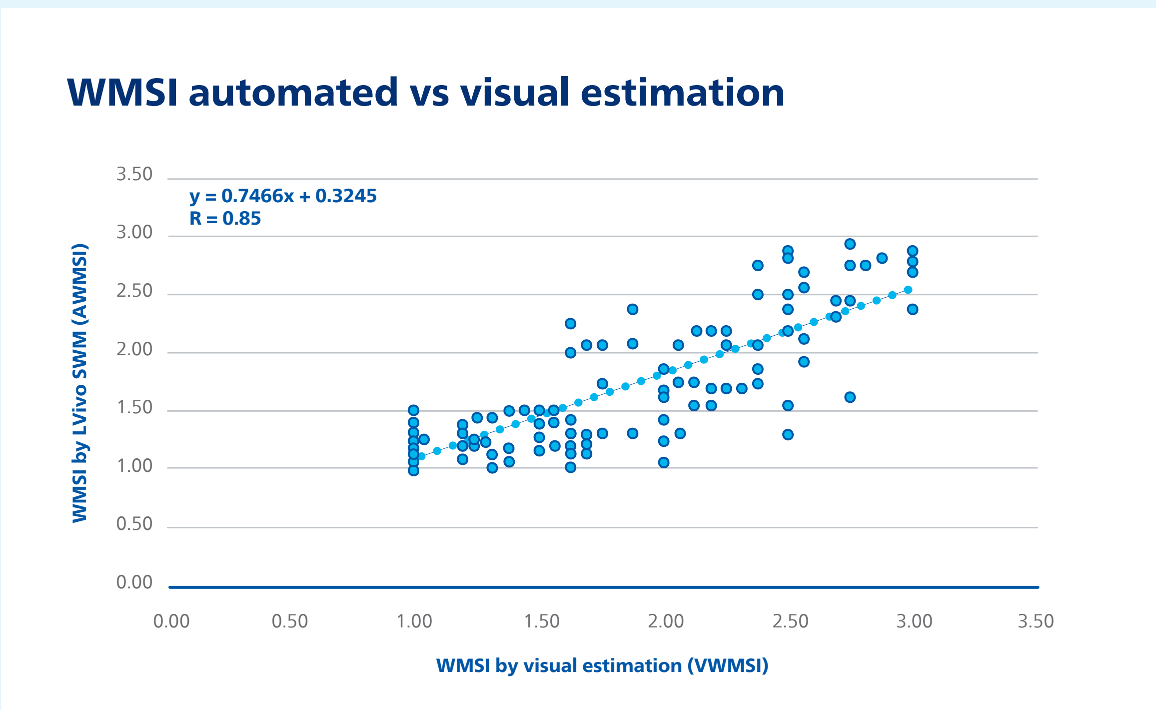
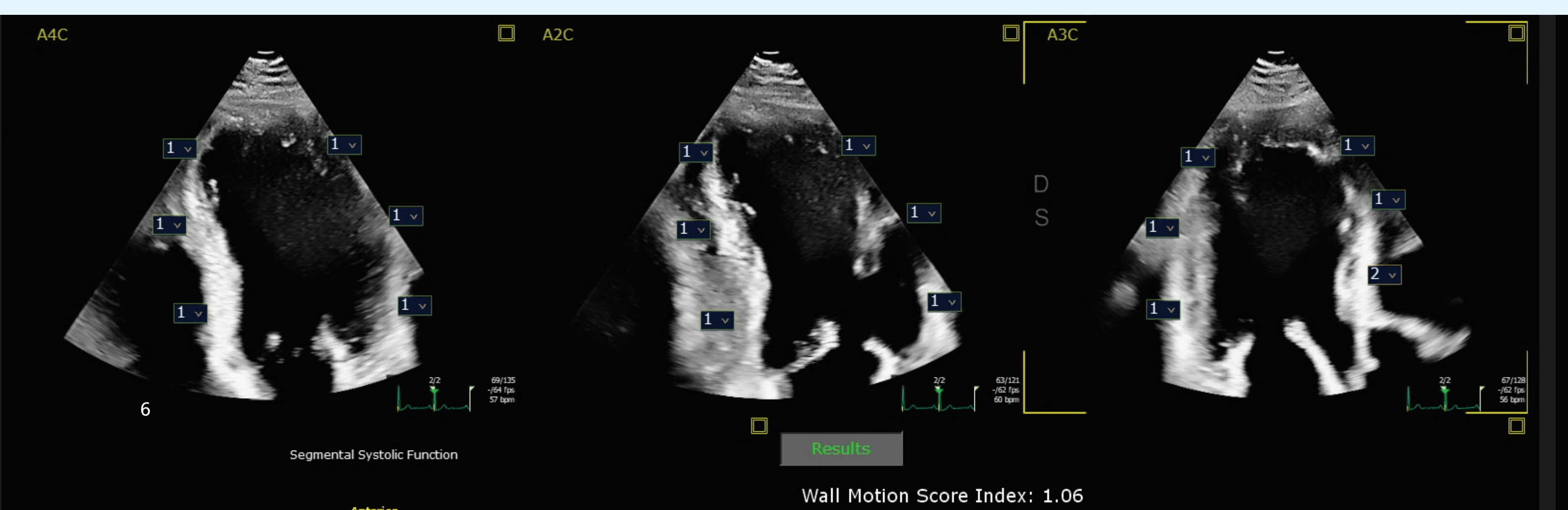


Figure 7 WMSI correlation compared to the reference results. The correlation was 0.85.



Conclusion

Philips Auto SWM is an AI-empowered, first-of-kind application that assists clinicians in assessing the LV segmental wall motion in everyday practice. It provides fast, consistent and objective LV segmental wall motion assessment for comparison.

References

1. Carluccio E, Tommasi S, Bentivoglio M, Buccolieri M, Prosciutti L, Corea L. Usefulness of the severity and extent of wall motion abnormalities as prognostic markers of an adverse outcome after a first myocardial infarction treated with thrombolytic therapy. Am J Cardiol. 2000;85:411–5. doi: 10.1016/s0002-9149(99)00764-x. PMID: 10728942.
2. Cicala S, de Simone G, Roman MJ, et al. Prevalence and prognostic significance of wall-motion abnormalities in adults without clinically recognized cardiovascular disease: the Strong Heart Study. Circulation. 2007 Jul 10;116(2):143-50. doi: 10.1161/.
3. Jurado-Román A, Agudo-Quílez P, Rubio-Alonso B, et al. Superiority of wall motion score index over left ventricle ejection fraction in predicting cardiovascular events after an acute myocardial infarction. Eur Heart J Acute Cardiovasc Care. 2019 Feb;8(1):78-85. doi: 10.1177/2048872616674464. Epub 2016 Oct 13. PMID: 27738092.
4. Kan G, Visser CA, Koolen JJ, Dunning AJ. Short and long term predictive value of admission wall motion score in acute myocardial infarction. A cross sectional echocardiographic study of 345 patients. Br Heart J. 1986 Nov;56(5):422-7. doi: 10.1136/hrt.56.5.422. PMID: 3790378; PMCID: PMC1236887.
5. Xiang L, Wang M, You T, Jiao Y, Chen J, Xu W. Prognostic value of ventricular wall motion score and global registry of acute coronary events score in patients with acute myocardial infarction. Am J Med Sci. 2017 Jul;354(1):27-32. doi: 10.1016/j.amjms.2017.03.029. Epub 2017 Mar 23. Erratum in: Am J Med Sci. 2019 Jun;357(6):522. doi: 10.1016/j.amjms.2018.09.008. PMID: 28755728.
6. Savage ML, Hay K, Anderson B, et al. The prognostic value of echocardiographic wall motion score index in ST-segment elevation myocardial infarction. Crit Care Res Pract. 2022 Nov 10;2022:8343785. doi: 10.1155/2022/8343785. PMID: 36405398; PMCID: PMC9671736.
7. Hoffmann R, Borges AC, Kasprzak JD, et al. Analysis of myocardial perfusion or myocardial function for detection of regional myocardial abnormalities. An echocardiographic multicenter comparison study using myocardial contrast echocardiography and 2D echocardiography. EUR J ECHOCARDIOGR. 2007;8:438-448. https://doi.org/10.1016/j.euje.2006.07.009.
8. Schnaack SD, Siegmund P, Spes CH, et al. Transpulmonary contrast echocardiography: effects on delineation of endocardial border, assessment of wall motion and interobserver variability in stress echocardiograms of limited image quality. Coron Artery Dis. 2000 Oct;11(7):549-54. doi: 10.1097/00019501-200010000-00006. PMID: 11023243.
9. Slivnick JA, Gessert NT, Cotella JI, et al. Echocardiographic detection of regional wall motion abnormalities using artificial intelligence compared to human readers. J Am Soc Echocardiogr. 2024 Jul;37(7):655-663. doi: 10.1016/j.echo.2024.03.017. Epub 2024 Mar 30. PMID: 38556038.
10. Lang RM, Bierig M, Devereux RB, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography’s Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. J Am Soc Echocardiogr. 2005 Dec;18(12):1440-63. doi: 10.1016/j.echo.2005.10.005. PMID: 16376782.
11. ASE Abstract: 24-A-1052-ASE.

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Printed in the Netherlands.
4522 991 87111 * OCT 2024