

3D WALL MOTION TRACKING: A NEW TOOL ... A NEW CONCEPT ... AND MORE TIME FOR YOU!

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In the following pages, we would like to present a new diagnostic tool developed by Toshiba Medical Systems, Tokyo, Japan, and implemented in their new Artida system: 3D wall motion tracking (3D WMT). This technology offers relevant advantages over other systems, namely a new way to analyze the left ventricle and a new concept to assess its function. Nevertheless, we would like to focus on one feature of this new tool: unlike other systems, 3D WMT is not time-consuming and is thus suitable for use as a routine analysis tool in daily clinical practice.

What is wall motion tracking?

Speckle in ultrasound images is caused by interference of energy from randomly distributed scatterers, too small to be resolved by ultrasound technology. Speckle degrades both the spatial and

the contrast resolution by creating fine false structures, the so-called speckle noise. Speckles have two crucial features: Firstly, each structure in the body has a unique speckle pattern and secondly, speckles move with the tissue (Fig. 1). Wall motion tracking (WMT) exploits these features by recognising the identifying speckle pattern of each region of the myocardium and following its displacement.

Strain and strain rate are parameters obtained from tissue Doppler data (2). WMT technology offers a new and more direct approach to determine these values. 2D WMT analyses the displacement of a myocardial region (Fig. 2) in order to calculate circumferential, radial and longitudinal strain (3–5). Furthermore, other parameters such as rotation, shear, twist and torsion can be evaluated. WMT-derived strain and strain rate provide clinically

relevant information in a huge number of cardiac diseases.

Do I need 3D WMT?

The interpretation of echocardiography requires mental integration of different planes. Consequently, 3D more closely represents reality than 2D. The heart has three dimensions, cardiac motion is 3D and speckle noise moves in the three spatial directions. 2D WMT is limited because it cannot assess movement in the third dimension: since 2D WMT follows wall motion in a 2D plane, only a portion of the real motion can be detected. This is where 3D WMT comes in: The new 3D WMT technology enables us to follow speckle in the three spatial directions and to assess real 3D movement. 3D WMT is a new tool that combines the usefulness of WMT with improved integration of the heart structures (Fig. 3).

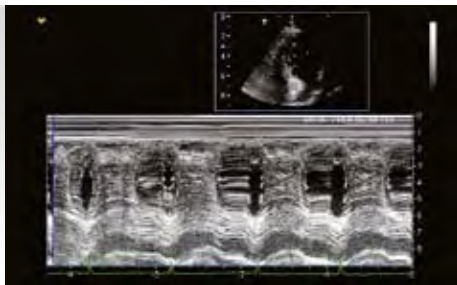


Fig. 1: Left ventricular wall M-mode shows how speckle moves with tissue.



Fig. 2: Left ventricular 2D WMT evaluation. The analysis of a short axis view is shown. The analysis of the whole left ventricle is very time-consuming.

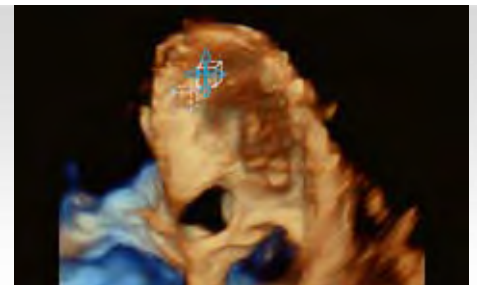


Fig. 3: 3D WMT uses a box-template to detect speckle motion in three dimensions.

Do I need a very good acoustic window to use 3D WMT?

The new 3D WMT system works well with medium-quality echocardiographic images. In a recently published study, only two patients out of 30 were excluded because of poor acoustic windows (6). Furthermore, the results of that study show that the 3D probe can acquire a more complete analysis because the entire left ventricle can be analyzed from a single apical position and the sonographer does not need to change position to obtain different planes. In short: 3D WMT can assess more myocardial segments than 2D WMT regardless of whether a patient had a good or bad transthoracic window.

How should I do a 3D WMT study?

The new Artida system and the PST-25SX 1-MHz to 4-MHz phased-array matrix transducer (both by Toshiba Medical Systems, Tokyo, Japan) are required to carry out a 3D WMT study. These two components optimize 3D image acquisition. The matrix transducer scans a user-selected volume that can be adjusted from 15°x15° to 90°x90°. For real-time purposes, a one-beat acquisition is used and for advanced analysis, a triggered acquisition mode is selected. In the triggered mode (the mode used for 3D WMT evaluation), a live

monitoring mode allows the user to monitor the reconstruction of the full-volume data set. The standard application setting uses four subvolumes of 90°x22.5°, which results in a 90° x 90° triggered full volume in four heart cycles. During the acquisition, a five-plane view of the four- and two-chamber apical views and short axis planes at apex, mid and base of the LV is guiding the user to keep the best transducer position and updates the acquisition process continuously. During acquisition matching of the sub-volumes, which can be monitored on the screen, is crucial. If a mismatch occurs, the examiner can continue the acquisition process until the mismatch disappears in later heart cycles which are shown on the monitor. A retrospective acquisition method is used and after 'freeze' the best full-volume datasets can be selected from the image memory. A template for the B and C planes is available to orientate the A,B and C planes in order to achieve the best possible plane selection.

Each 3D data set is displayed in a five-plane view: (A) an apical four-chamber view; (B) a second apical view orthogonal to plane A; and (C) three short-axis planes: plane C1 in the apical region, plane C2 in the mid-ventricle, and plane C3 at the basal portion of the left ventricle. The user then

sets three markers on planes A and B; in each plane, one marker is set at the apex and the other two at the edges of the mitral valve ring. The software then detects the LV endocardium and the user sets a default thickness for the myocardium (Fig. 4). The software automatically splits the LV into 16 or 17 segments as suggested by ASE and AHA respectively. After the markers have been selected, the system performs the 3D WMT analysis through the entire cardiac cycle. The selection of the LV shape is semiautomatic and the tracking process is automated, but the user can adjust the results of the tracking process when needed. Finally, the results of the 3D WMT analysis are presented as averaged values for each segment.

How does the system display the 3D WMT analysis results?

The 3D WMT analysis results can be displayed in different ways, for example the so-called "plastic bag" (Fig. 5), the "doughnut view" (Fig. 6) or the "dynamic polar map" (Fig. 7). The user can choose among many different displays and all data may also be obtained in numeric format.

Is 3D WMT time-consuming?

Saving time is one of the main advantages of 3D

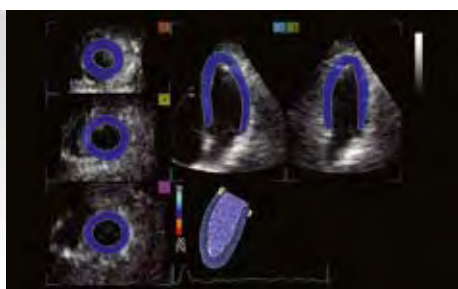


Fig. 4: Left ventricular semi-automatic tracking. The user sets 3 markers in planes A and B. The software then detects the LV endocardium, and the user sets a default thickness for the myocardium. See text for more details.

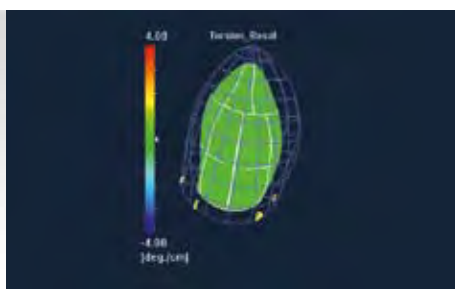


Fig. 5: The patient presented with dilated cardiomyopathy and severely depressed left ventricular ejection fraction. The selected display shows the results of the analysis of the left ventricular torsion in the so called "plastic bag" view.

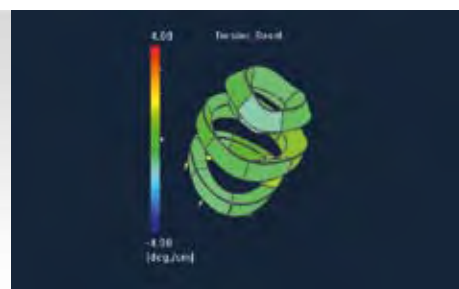


Fig. 6: The same patient as above. The selected parameter is again the left ventricular torsion, but the selected display is the "doughnut view".

WMT. The Artida system equipped with 3D WMT provides a very fast analysis of both the global function and the regional function of the left ventricle. Moreover, this tool allows you to perform the analysis in every patient in your daily work. Within 20 seconds, the result of 3D WMT is available offering a broad range of parameters describing myocardial function. Different parameters such as displacement and strain in longitudinal, radial and circumferential orientation are provided in addition to the 3D vector-based variants. Further parameters such as twist and torsion are selectable based on rotation information which is also available as a display parameter.

The results of the above-mentioned study (6) furthermore show that not only can 3D WMT assess more myocardial segments, but data can also be acquired and analyzed in less time. The acquisition and analysis of the data sets is easy and fast. Within a few minutes we can obtain several parameters such as strain, rotation, twist and torsion of every cardiac segment derived from the 3D data set. This new technology provides a fast and global approach to the analysis of these parameters and avoids its under-use due to the time-consuming nature of 2D-derived speckle technology.

Average study times for 2D and 3D WMT are shown in table 1.

And ... what about variability?

Inter- and intraobserver variability is not a problem with the new 3D WMT system. A recently published article (6) shows good interobserver agreement for radial and longitudinal strain measurements on 3D WMT: the intraclass correlation coefficients were 0.79 and 0.81 for the measurements of radial and longitudinal strain respectively and similar results were recorded for intraobserver agreement analysis (the intraclass correlation coefficients were 0.91 and 0.85 for radial and longitudinal strain, respectively).

Does the system provide any other information?

Definitively yes. The new Artida system and the 3D WMT analysis not only provide information regarding the segment analysis of the left ventricular myocardium but they also provide a robust evaluation of LV volume during the heart cycle. The detection of the endocardium for wall motion purposes is also useful to obtain the inner dimensions of the LV 3D shape and the myocardial volume. Thus, the system also provides information regarding LV volumes and LV ejection fraction, and

the related volume curves are presented time-aligned with the segmental parametric imaging curves. The detection of the endocardium is based on 3D tracking information and not on 2D plane assumptions. The 3D shapes can be corrected by the user when needed in five orthogonal planes. Thus, the assessment of the LV volume is anatomically correct and robust and offers reproducible calculations of LV volumes and ejection fraction (Fig. 8).

Which are the applications of this new tool?

3D WMT is a new tool which has demonstrated its usefulness in several clinical scenarios. It is promising with regard to the evaluation of different heart diseases such as dilated cardiomyopathy, left ventricular asynchrony evaluation or ischemic heart disease.

Conclusion

3D WMT is a new technique that can quickly and completely assess global and regional left ventricular function. It is a potential clinical bedside tool for quantifying global and regional left ventricular function and it may help the clinician save time without having to forego a complete and accurate analysis.

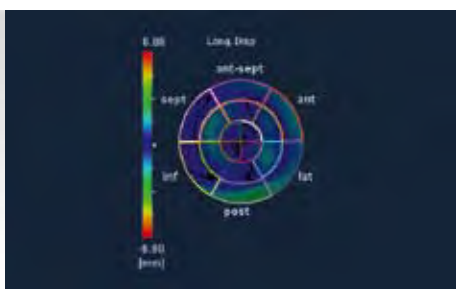


Fig. 7: Another type of display is the “dynamic polar map”.

	2D WMT	3D WMT
Acquisition time in minutes	4.1	1.7
Analysis time in minutes	9.9	3.3

Table 1: Comparison of average time required for data acquisition and LV analysis with 2D and 3D Wall Motion Tracking (6).

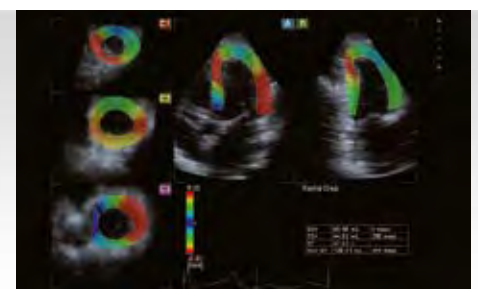


Fig. 8: Automatic calculation of left ventricular volumes and ejection fraction based on 3D WMT technology. The system automatically displays this information together with the wall analysis.

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