

SPECKLE TRACKING ECHOCARDIOGRAPHY: BASIC CONCEPTS AND CLINICAL APPLICATIONS

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Contribution

IH conceived the idea and
designed the study, collected data
and drafting and finalized the
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ABSTRACT:

Assessment of the mechanical performance of heart usually means evaluation of left ventricular function and this can be done most easily by echocardiography by measuring 'ejection fraction'. However, ejection fraction tells us the story of myocardium as a whole. Deeper understanding of cardiac mechanics has shown that this is a multi-layered phenomenon, as LV wall is composed of three layers of fibers. A deterioration in the function of one layer is compensated by others so the numerical value of ejection fraction is not compromised in the beginning. Speckles are produced due to ultrasound scattering and movement of these can be recorded by 2D imaging, frame to frame. This tracking of speckles is done in three directions viz. longitudinal, radial and circumferential, so that drop in global longitudinal strain is ascertained much before any change in ejection fraction is noted, "subclinical LV dysfunction". In this review, the basics of speckle tracking, acquisition of echocardiographic data and the clinical applications of this new modality have been discussed.

Key words: Echocardiography, Speckle tracking, Deformation, Sub-clinical LV dysfunction, Global longitudinal strain

INTRODUCTION:

The heart, as we know, is a mechanical organ, the primary function of which is to pump an effective amount of blood to meet the requirements of our body. This mechanical function is most commonly measured by echocardiography and expressed in numbers of various units. The most important parameter in this regard is Ejection Fraction which is calculated for every patient. This is the difference in diastolic and systolic volumes of left ventricle per diastolic volume and expressed as a percentage. The parameter which gets the most attention in an Echo report is EF, but is this really that robust? If the same expression is used taking diameters as dimensions, we get Fractional Shortening, a parameter less recognized than EF but, still applicable. Other parameters of mechanical performance like Circumferential Fiber Shortening (Vcf), Mitral Annular Plane Systolic Excursion (MAPSE) and E-point Septal Separation (EPSS) receive even less attention, figure 1.

- Variability in measurements, both inter and intra-observer, is too much.
- A compromised EF usually signifies a point of no return.
- Limited or no assessment of radial and circumferential strains as well as of twist and torsion.

So, another parameter is needed for assessment of cardiac (mainly LV) function; 'strain' is such a parameter. It has been defined as "the ratio of change in length (ΔL) to resting length (L_0) upon application of force to a muscle", expressed as percentage and symbolized by Epsilon, figure 2.

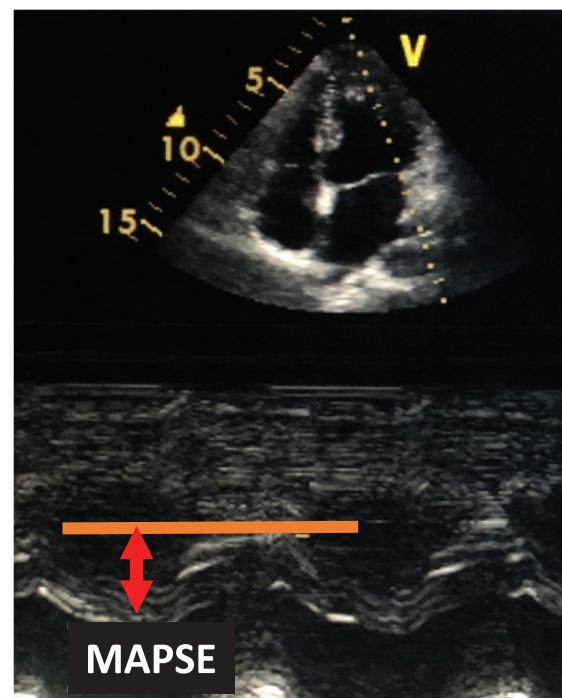
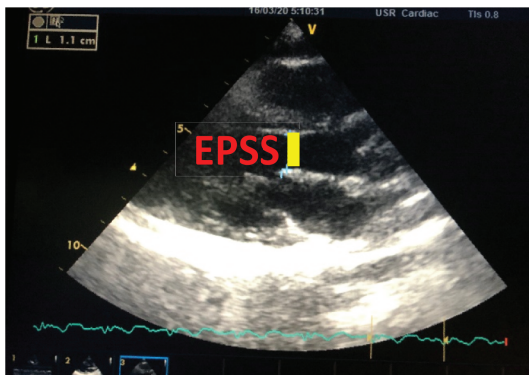
FIG. 2 DEFINITION OF STRAIN

$$\epsilon = \frac{\Delta L}{L_0}$$

FIG. 1: ECHOCARDIOGRAPHIC PARAMETERS OF LEFT VENTRICULAR CONTRACTILE FUNCTION

$$EF = \frac{EDV - ESV}{EDV} \quad \Bigg| \quad FS = \frac{EDD - ESD}{EDD}$$

$$Vcf = \frac{EDD - ESD}{EDD \times ET}$$



Estimation of EF has the following drawbacks:

- Eyeballing is frequently employed in its estimation.
- Quantification methods are cumbersome.
- Tracing of endocardial borders for volume assessment is not possible in many patients and interpolation can be erroneous.

Victoria Delgado et al in their article 'imaging in 2018' published in European Heart Journal ascertained the importance of strain over 2D EF in the following words, "In 2018, strain imaging with echocardiography has provided important patho-physiological insights in various cardiovascular diseases and the evidence demonstrating its incremental prognostic value over left ventricular ejection fraction is growing."¹

Kalam K, in his article on the prognostic implications of

global LV dysfunction, mentions that, “as compared to LVEF, GLS has superior prognostic value for predicting all-cause mortality, cardiac death, malignant arrhythmia, hospitalization due to heart failure, urgent valve surgery, or heart transplantation and acute coronary ischemic event”.²

LITERATURE SEARCH:

Google and PubMed search with the words ‘speckle tracking’ and ‘basic concepts’ and ‘clinical applications’ yielded 384 citations. By manual search, 37 articles were found pertinent, from which material for this manuscript has been extracted.

TEXT:

To understand it better, we have to look into the basics of cardiac muscle architecture and the mechanics of cardiac contraction.

CARDIAC MYOCYTE ARCHITECTURE:

Left ventricular muscle fibers, as shown in figure 3 are arranged in a helical fashion with the sub-endocardial fibers

forming a right handed helix. As these come in mid layers, they get a more horizontal orientation and further on as they become sub-epicardial form a left handed helix³. The sub-endocardial fibers are more vertically aligned so they are responsible for the longitudinal shortening of left ventricle whereas the fibers of the other two layers cause contraction in radial and circumferential directions.

BASIC CARDIAC MECHANICS:

Left ventricular contraction, as mentioned above, occurs in three different directions, figure4, as per orientation of muscle fibers⁴. The longitudinal fibers of sub-endocardial region produce longitudinal shortening, hence, are responsible for deformation in this direction called “longitudinal strain” whereas deformation in radial and circumferential directions is known as “circumferential” and “radial” strain respectively.

Myocardial strain can thus be evaluated along three axes according to cardiac muscle deformation. Electromechanical activation would result in a shortening in the longitudinal and circumferential directions (resulting in a negative strain) and a thickening in the radial direction (resulting in a positive

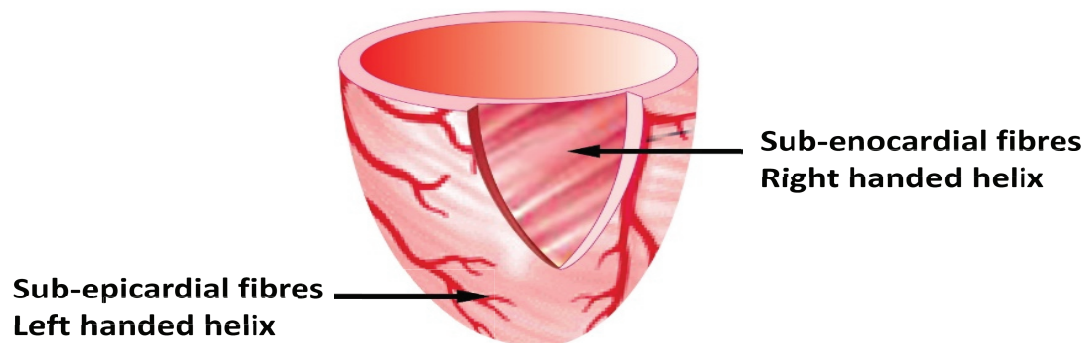


FIG. 3 ORIENTATION OF CARDIAC MUSCLE FIBRES

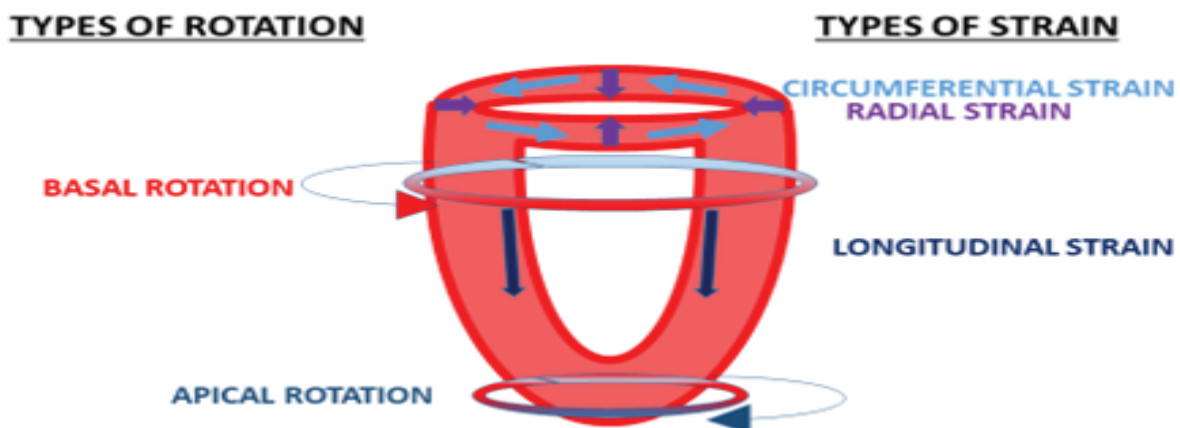


FIG. 4 THE TYPES OF STRAIN AND ROTATION

strain). 4-chamber view can be used to track longitudinal strain while short axis view can be used to track circumferential strain. Radial strain can be tracked in either view.⁵

The apex and base of the heart show a rotational movement in opposite directions with the base in a clock-wise direction (about 10 degrees normally) and the apex in a counter-clockwise direction (about 5 degrees normally). The difference of these two rotations is known as “TWIST”, and is responsible for squeezing blood out of the left ventricle. Due to all these motions the base of LV moves towards the apex during systole and thus shortens in length, TWIST divided by this shortening of LV length is known as “TORSION”. Twist and Torsion movements produce a wriggling effect. All these movements ensure that a 15% decrease in the length of myocyte results in an Ejection Fraction of 60%.

HOW TO MEASURE STRAIN:

To measure deformation or strain various modalities have been used in research and clinical practice. The gold standard in this regard is “Sono-micrometry” in which crystals are attached to the surface of the left ventricle which shorten their distance during systole and this parameter is measured sonically. This can only be applied in research and obviously cannot be used in routine practice.

Another gold standard method is MRI Tagging. Due to its high cost and non-availability as a routine procedure, this is also not very useful.

Doppler, as we know, is a differential effect due to the direction of movement of an object towards or away from the recording source (as initially shown by Christian Andreas Doppler, during his study of the stars). This phenomenon has very aptly been applied in Echocardiography for decades now to record velocity of blood flow in different directions for quantification of stenotic, regurgitant and shunt blood flow. However, blood, as compared to tissues, moves at a very fast pace. To measure the velocity

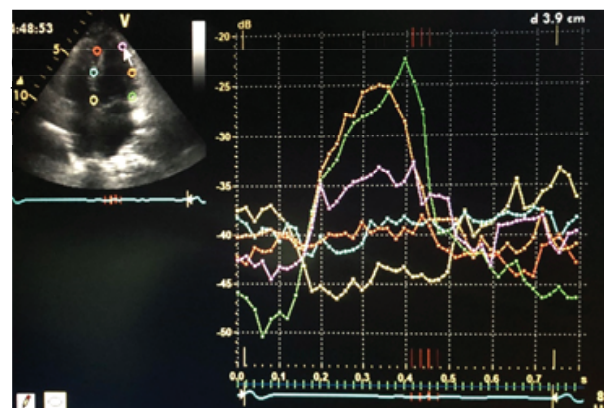


FIG. 5: TISSUE DOPPLER IMAGING

For deformation imaging, this has been used extensively but because of the following reasons has gone out of favor:

- TDI is angle dependent.
- Tissue movement is assessed in relation to transducer position.
- Movement can be assessed in one direction only.
- Spatial resolution is limited.
- Time consuming.

The latest addition to our armamentarium for the assessment of strain is: “SPECKLE TRACKING”.

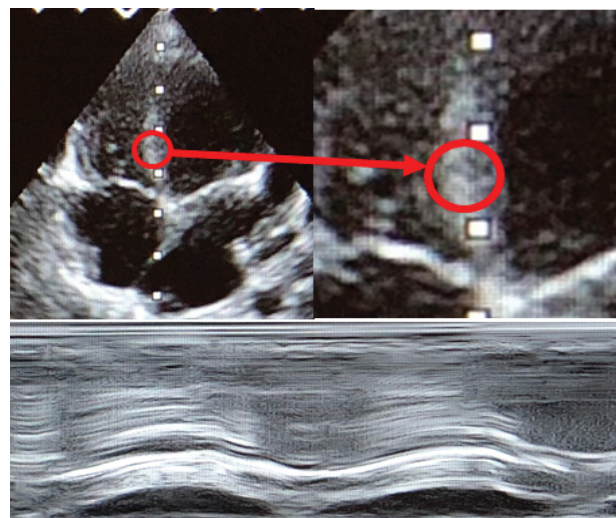
BASICS OF SPECKLE TRACKING:

Ultrasonic images are created by reflection of sound waves by targets at least half the size of the wavelength, rest of it is refracted or back-scattered. ‘Speckles’ are produced by the constructive and destructive interference of ultrasound backscattered from structures smaller than the wave length.

If an M-mode cursor is applied, ‘lines’ would be created as ‘Finger Prints’, figure 6.

In speckle tracking we track the backscatter created by ultrasound comprising of 20 to 25 pixels, frame by frame, thus, comparing the velocities of two points in a given segment which gives the strain rate from which strain value can be derived easily. It is non-Doppler and independent of the angle of insonation. It holds promise to reduce inter-observer and intra-observer variability in assessing regional LV function and to improve patient care by identifying sub-clinical disease.⁶

FIG. 6: SPECKLES AND FINGER PRINTS-LINES ON APPLICATION OF M-MODE



ACQUISITION AND ANALYSIS OF DATA:

To standardize strain imaging, European Association of Echocardiography and the American Society of Echocardiography along with technical representatives from all interested vendors made a concerted effort to reduce inter-vendor variability of strain measurement and the three of them prepared a technical document which provided definitions, names, abbreviations, formulae, and procedures

for calculation of physical quantities derived from speckle tracking echocardiography to create a common standard.⁷

The foremost consideration for data acquisition is the frame rate, which should ideally be between 60-100 fps. For this first get a good quality apical view and as other chambers are not needed, focus should be on Left Ventricle. Frame rate can be increased by decreasing the depth of image and reducing the size of ROI, making sure that the quality of

FIG. 7 ACQUISITION OF 3 APICAL VIEWS- 3C, 4C AND 2C IN THAT ORDER, CLOSURE OF AORTIC VALVE IS TAKEN AS END SYSTOLIC TIME

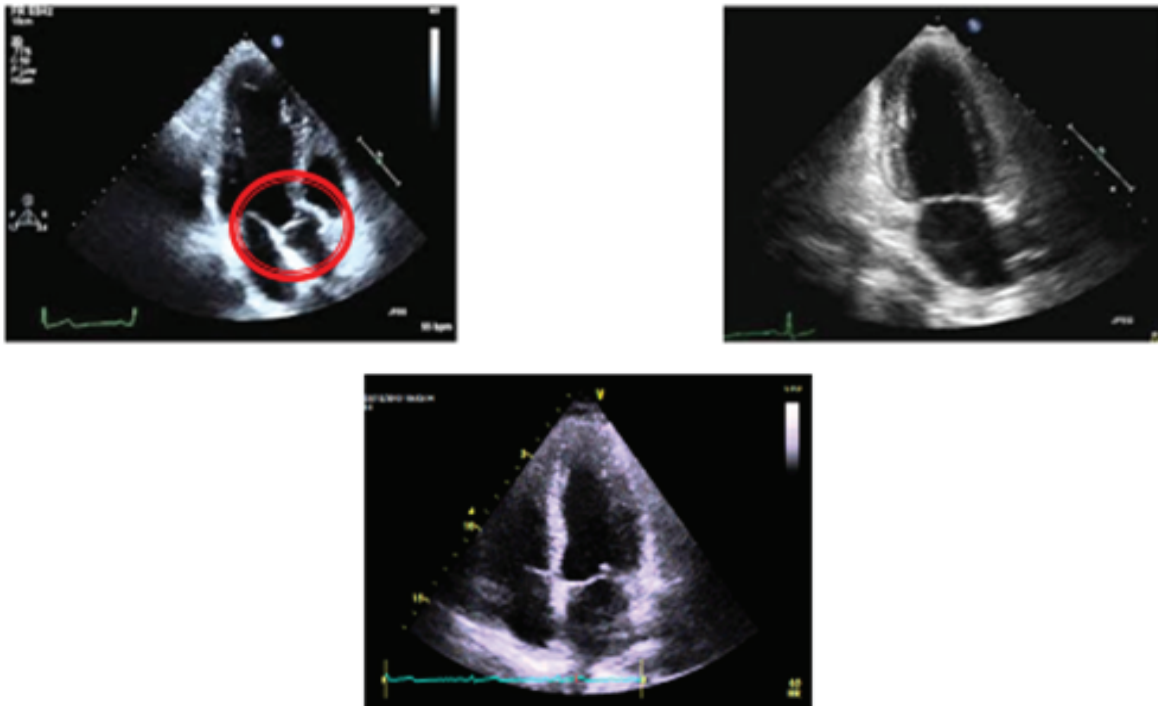


FIG. 8. ACQUISITION OF DATA WITH MARKING OF REGION OF INTEREST, THE BAR BELOW WILL SHOW WHETHER THE ROI HAS BEEN MARKED CORRECTLY WITH BUTTON FOR APPROVAL

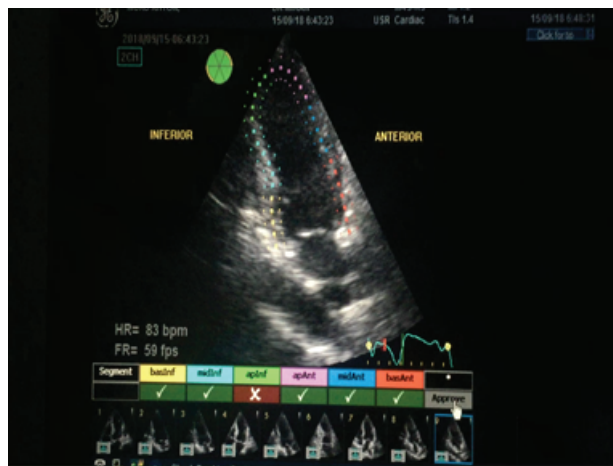


image is good and both endocardial and epicardial borders are clearly seen.

From apical position acquire the three images i.e. 3, 4 and 2 chamber views, as shown in figure 7, in that order and store the clips because assessment can only be done on stored images, the requirements of frame rate, image resolution and heart rate should be the same for all views. Define the end systolic frame, by Aortic valve closure, as a landmark easily visible in this view. Other methods for it are either the end of T wave or from Doppler of aortic valve with its closing sign as a landmark.

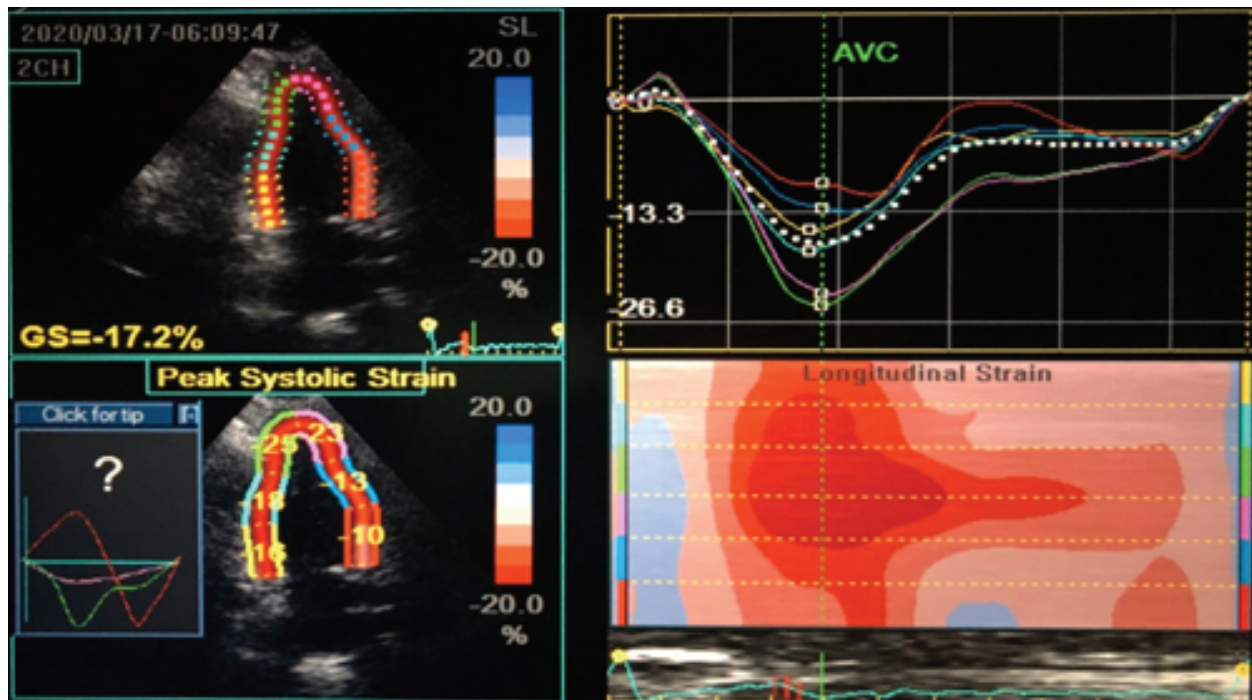
ROI of each view is drawn and adjustments are made if needed, the bar below will show if the system considers movement of speckles satisfactory, figure 8, there is a provision that if the system cannot recognize the movements as satisfactory for a given segment but the observer thinks it satisfactory he can change the X to \checkmark sign and when OK is clicked the software reads the segmental values and ROI overlying the 2D image would be seen in shades of blue and red.

Four images are obtained as follows:

The upper right corner image shows the strain changes of different segments in one view (here 2C) in a graphical pattern of different colors corresponding to the color of segments of parametric view. The peak value is marked by a circle and the average of all the six segments is represented by a white dotted line. The picture in the lower right corner "ribbon graph", shows the change of strain (according to color) during one complete cardiac cycle. The ribbons are marked by the same colors with which individual segments have been colored in the first picture, so that one ribbon shows the complete strain changes in one cardiac cycle of a particular segment. Arrangement of ribbons is: basal inferior, mid-inferior, apical inferior, apical anterior, mid-anterior and basal anterior (in that order from top to bottom of the picture). With ECG, phase of cardiac cycle can easily be correlated.

Lastly, the strain values of all the analyzed segments are shown as bull's eye view, figure 10, with the outer circle showing the basal segments, middle ones the mid segments and the inner one the apical segments. The color of each segment corresponds with the strain value of that segment as per the vertical bar on the right, in normal cases, all segments should appear red. Numerical strain

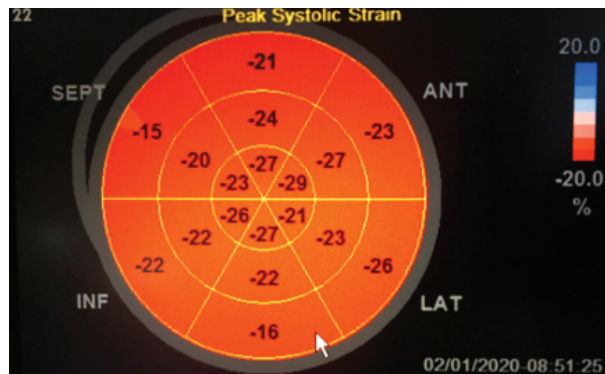
FIG. 9. FOUR TYPES OF DATA FOR THE ASSESSMENT OF STRAIN ARE RECORDED IN EACH VIEW



It has been shown in figure 9 (upper left) that the region of interest is laid over a 2D image with the segments shown in particular colors; ROI should be so adjusted to encompass the whole myocardium, "Parametric view". The picture in the lower left corner shows the strain values of individual segments overlaid over a 2D image, "Peak systolic strain.

value of each segment is also inscribed on each segment and an average value of global strain is calculated by the software. A value of -20% or less is clearly normal whereas anything more than -16% is clearly abnormal for all the vendors, whereas the significance of an intermediate value needs to be clarified.

FIG. 10 BULL'S EYE VIEW



Demarcation of LV walls is as per ASE guidelines for LV regional function assessment.

Since no clear-cut guidelines are available for demarcation of normal limits of LV strain, three references can be cited in this regard until the leading echocardiographic societies come to a conclusion, as follows in Table 1.

TABLE 1: GLOBAL PEAK SYSTOLIC LONGITUDINAL STRAIN	
REFERENCE	NORMAL RANGE
European Society of Cardiology (Echo Education Tool) ⁸	-18% - -20%
Meta-analysis by Christopher Johnson et al ⁹	-15.9% - -22.1%
NORRE Study ¹⁰	19.8% - 25.2%

RIGHT VENTRICULAR SPECKLE TRACKING:

RV strain assessment is important in diseases leading to RV dysfunction, such as congenital anomalies (e.g. Tetralogy of Fallot, arrhythmogenic RV dysplasia, pulmonary arterial

Jae-Hyeong Park et al.¹², in a Korean study of 493 normal subjects, found the RV strain values as shown in Table 3.

TABLE 2: RV STRAIN	
RV Global Strain	RV Free Wall Strain
-24.5 ± 3.8	-28.5 ± 4.8

However, Roberto M. Lang et al., in their recommendations for cardiac chamber quantification by echocardiography in adults,

TABLE 3: NORMAL VALUES OF RIGHT VENTRICLE GLS		
Total	Male	Female
-22.3 ± 3.3	-20.5 ± 2.8	-22.9 ± 3.2

hypertension, and pulmonary thromboembolism).

For analysis of right ventricle by speckle tracking, an RV-focused apical four-chamber view is obtained and the region of interest (ROI) is drawn encompassing RV free wall and

inferior septum. Each wall is divided into three equal segments, figure 11. The rest of the procedure is the same as for LV assessment. However, the cut-off values for normal RV strain are much higher than those for LV.

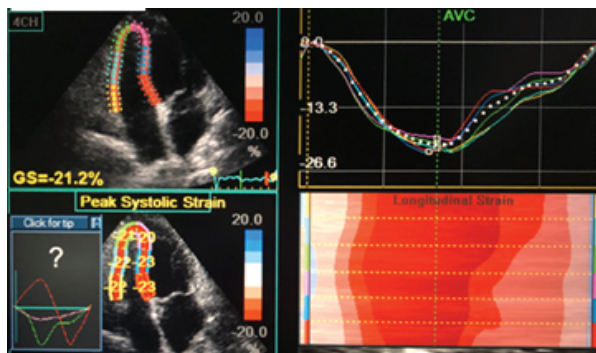


FIG. 11 RIGHT VENTRICULAR STRAIN ANALYSIS

Daniel A Morris et al.¹¹, in their study, state that although, for RV function assessment, conventional methods like TAPSE, S' velocity and FAC are adequate but evaluation of a single

segment and angle-dependence are the limitations. On the contrary, RV strain can detect subtle RV dysfunction when conventional measurements are normal in case of HFrEF and in some cases of HFpEF. The normal values of RV strain reported by these investigators are shown in Table 2.

suggest that global longitudinal RV free wall strain greater

than -20% is likely abnormal. They further emphasize, "until a universal standard is established, the interpretation of RV longitudinal strain values should take into account the methodology and vendor- and hyphen- specific reference values."¹³

LEFT ATRIAL SPECKLE TRACKING:

Left atrium functions as a reservoir, conduit, and pump. It is tracked in apical four-chamber view so that the region of interest (ROI) covers the inter-atrial septum, superior wall and lateral wall.

Atrial strain is evaluated in various conditions, such as hypertension, diabetes, heart failure, ischemic and valvular heart disease, atrial fibrillation, including the facilitation of stroke risk calculation and for prognostic purposes. Faraz Pathan et al.¹⁴ have shown the normal strain values as shown in Table 4.

RIGHT ATRIAL SPECKLE TRACKING:

TABLE 4: NORMAL LEFT ATRIAL STRAIN VALUES

Reservoir Function		Conduit Function		Pump Function	
39.4%	(27.6% - 59.8%)	23%	(15.7% - 33.4%)	17.4%	(14% - 25%)

Right atrium is said to be a neglected chamber. An assessment of it by speckle tracking is particularly difficult because of its thin walls, contour, many structures fitted into a small space and it can be imaged only in one view i.e. four

chamber apical view. However, atrial mechanics involve the same three phases as in left atrium, i.e. reservoir, conduit and pump. Aitzaz Bin Sultan Rai et al.¹⁵, have emphasized the importance of right atrial strain assessment in the following conditions:

- Drug trials of right atrium
- Tricuspid valve abnormalities
- Congenital heart disease
- Patent foramen ovale closure surgeries
- CRT lead implantation
- Pulmonary hypertension

CLINICAL INDICATIONS FOR SPECKLE TRACKING ECHOCARDIOGRAPHY:

Speckle tracking echocardiography is gaining immense value in many clinical situations because of its robustness, ease of use and off-line assessment. Clinical indications are:

1. HYPERTENSION:

Hypertension being the most prevalent clinical entity in cardiology practice needs the most attention, as sub-clinical LV dysfunction ensues early on much before any decline in ejection fraction, as shown by Amal Ayoub et al¹⁶ in their study of 90 patients. Hypertensive patients with preserved ejection fraction when compared with a normal cohort showed sub-clinical dysfunction in a significantly higher number of patients, as shown in Table 5. In this regard it has been found that impairment of longitudinal and radial strain precedes the reduction of circumferential strain and torsion, thus, preserving the LVEF.

2. DIABETES MELLITUS:

Strain analyses can predict sub-clinical LV dysfunction

TABLE 5: 2D SPECKLE TRACKING DATA IN TWO GROUPS

	HTN GP	CONTROL GP	p-VALUE
GLS (%)	-19.5±2.43	-20.75 ± 1,56	0.015
Normal Systolic function	37 (61.7%)	27 (90%)	
Subclinical dysfunction	23 (38.3%)	3 (10%)	0.005

before overt Diabetic Cardiomyopathy by detecting reduced longitudinal strain, as shown by Nakai et al¹⁷ in their study of 60 diabetic patients compared with 25 age-matched controls. No significant differences in LVEF were noted between the two groups. However, GLS showed significant difference (-17.6% ± 2.6 vs. -20.8% ± 1.8; p< 0.001). They further found that the drop in GLS was associated with duration of diabetes as the segregation of diabetic group into those with >5 years of disease and <5 years of disease showed lower GLS values in the former group (-16.7% ± 3 vs. -18.2% ± 1.9 with p< 0.05).

3. HEART FAILURE:

Heart failure is a very common cause of hospital admissions. To see the reasons for these readmissions clinical, echo and strain parameters were compared. Causes of re-admission are heterogeneous. Clinical parameters for assessment of risk for re-admission are modest, echo parameters are promising but the most commonly used parameter, "EF", is inconsistent in this regard. GLS is associated with HF readmission, independent

of and incremental to clinical and basic echocardiographic parameters, as shown by Makoto Saioto et al¹⁸ in their study of 92 patients. Readmission within 30 days was associated with greater impairment of LV GLS (-8.6% vs -11.1%; $p < 0.01$).

Park et al¹⁹ in their study of 4172 patients, demonstrated the greater prognostic value of LV GLS when compared with LVEF. Patients were divided according to current classification of HF [HF with reduced LVEF (HFrEF), mildly reduced LVEF (HFmrEF), and preserved LVEF (HFpEF)] and tertiles of LV GLS (severely reduced GLS $> -8\%$), moderately reduced LV GLS (-8.1% to -12.5%), and mildly reduced LV GLS ($< -12.6\%$). Patients with HFrEF had slightly higher mortality than those with HFmrEF or HFpEF (41%, 38%, and 39%, respectively; $P=0.031$), whereas patients with severely reduced LV GLS had significantly higher mortality rates at 5 years of follow-up when compared with the other tertiles (49% vs. 38% for moderately reduced LV GLS and 34% for mildly reduced LV GLS; $P<0.001$). They concluded patients with moderate and severe GLS reductions had higher mortality but LVEF was not associated with mortality.

4. VALVULAR HEART DISEASES:

Strain analysis has been found to be of value in this group of patients as it detects sub-clinical LV dysfunction in patients who have not yet developed symptoms or have dropped their ejection fractions. An earlier intervention will ensure better post intervention results. Aortic Stenosis leads to maladaptive LV remodeling that includes sub-endocardial ischemia and fibrosis. Sub-endocardial myofiber function dictates LV longitudinal contraction. Therefore, with advanced AS, it is not surprising that longitudinal strain is impaired.

Joanna Luszczak et al.²⁰ in the study of 49 patients demonstrated that while LVEF does not differentiate AS patients from control, GPLS was significantly decreased in the AS group ($-15.3 \pm 3.25\%$ versus $-19.6 \pm 2.46\%$; $p < 0.001$). GPLS was significantly reduced in symptomatic AS patients as compared to the asymptomatic AS group, -15.5% (11.8-16.8) versus -17.5% (14.7-18.9), $p=0.02$.

GLS differs significantly depending on the severity of valve stenosis, with values of 17.1%, 16.4%, and 14.5% LV systolic shortening for mild, moderate, and severe stenosis respectively, despite a maintained LVEF. In addition to GLS, endocardial radial strain is also found to be reduced in proportion to severity of disease; however, epicardial radial strain and circumferential strain is preserved in asymptomatic AS.²¹

In Low-flow Low-gradient severe AS, longitudinal strain is found to decrease even further compared with that in

individuals with high-gradient AS (11.6% vs. 14.8% LV shortening), suggesting that progressive longitudinal dysfunction may be a contributing factor to the low-flow AS phenomenon. These observations suggest that in patients with asymptomatic severe AS, decreases in longitudinal strain can identify high-risk candidates for aortic valve replacement (AVR).

At present, there is no clear consensus regarding minimum changes or absolute GLS that should warrant earlier intervention for AS treatment. However, it has been shown that in patients with normal or depressed LVEF undergoing trans-catheter AVR or surgical AVR, those with impaired GLS had a significantly higher risk of cardiac morbidity and death.

Following definitive procedural intervention, significant reductions in trans-aortic gradients are observed with associated improvements in LV strain patterns. Following either surgical or trans-catheter AVR, significant increases in longitudinal strain have been observed.

The prognostic value of LV GLS was also demonstrated by Arnold C. et al. in 294 patients with severe aortic stenosis. Patients were divided according to a cut-off value of LV GLS of -14% . Patients with more preserved LV GLS ($< -14\%$) had better survival when compared with patients with more impaired LV GLS ($> -14\%$). Among patients with more impaired LV GLS, there was no significant difference in survival when patients were subdivided according to LVEF ($> 55\%$ vs. $< 55\%$). Each 1% impairment in LV GLS was independently associated with 17% increased risk of all-cause mortality.²²

The range of cutoffs observed for GLS that appear to show improved outcome after AVR in normal LVEF patients are broad, and range from 12.1% to 17.8% LV shortening. These observations suggest that in patients with severe AS and a declining GLS, early AVR should be considered.²³

Similar to Aortic stenosis, STE helps in Mitral regurgitation to select patients for surgery and predict post-operative results. As after-load is reduced in this condition, ejection fraction as a marker of LV function is very deceptive. Lancellotti P et al²⁴ have shown in their study that in patients with severe MR and normal LVEF, those who required surgery during the follow-up had a lower GLS.

Magne et al²⁵ in their study have shown that in patients with mitral regurgitation who fail to improve their GLS by 2%, on exercise, will have adverse cardiac events.

5. ISCHEMIC HEART DISEASE:

To evaluate ischemia, many parameters have been elaborated and compared with traditional methods like stress echocardiography, perfusion imaging and coronary

angiography with good correlation in various studies. The parameters of STE found to indicate ischemia are:

- Global peak longitudinal strain
- Dispersion of longitudinal strain in various segments
- Post-systolic stress (PSS) and PSS index
- Early systolic lengthening

Wei Chaun et al²⁶, in their study of 152 pts for the assessment of CAD by GLS found that GLS was decreased in CAD, LSD (difference between segment with highest and that with lowest strain) was increased, whereas, the ratio of these two was also higher in CAD patients. Characterization of severe CAD (LM/3VD) and less severe disease (2VD/1VD) by STE has also been reported.

Ischemic segments show the features of post systolic shortening in which the myocardial segment continues to

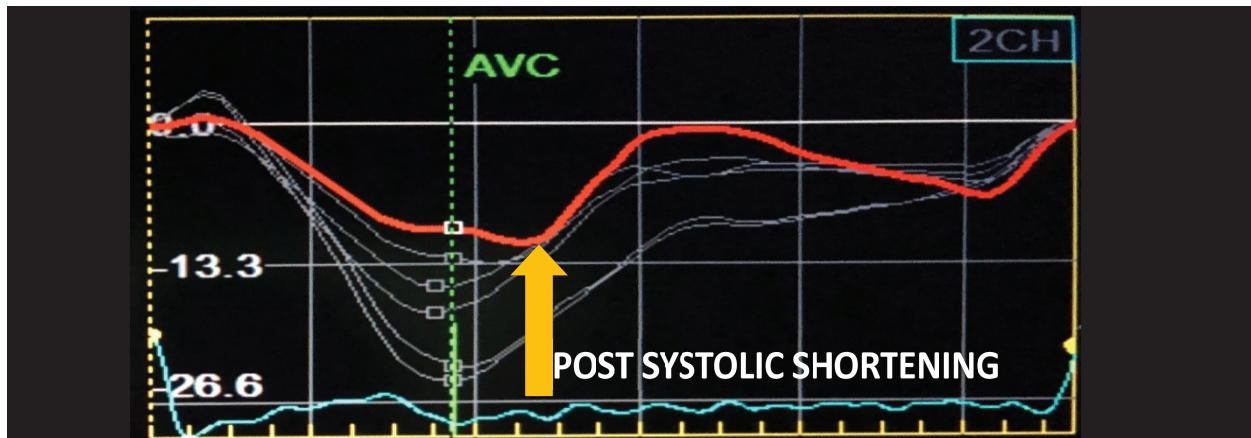
its significance in their article.²⁷

Early systolic lengthening, figure 13, is a feature of ischemic myocardium in which the contraction in ischemic segments lag behind the electrical events so that the pressure build-up by contraction of the normal segment increases the length of ischemic segments resulting in early systolic lengthening noted on STE. The duration of this corresponds with the extent of ischemia, as exemplified by Marit et al in their study.²⁸

Kristina and colleagues have demonstrated that patients who have sustained an MI can be predicted to have arrhythmia on the basis of mechanical dispersion, i.e. the difference in time required for the segmental graphs to reach peak strain²⁹, a value of 75 msec is indicative of high propensity of ventricular arrhythmias in this patient group, making them candidates for ICD.

Evaluation of chest pain being ischemic or otherwise keeps most of the hospital ER busy and packed with patients, as

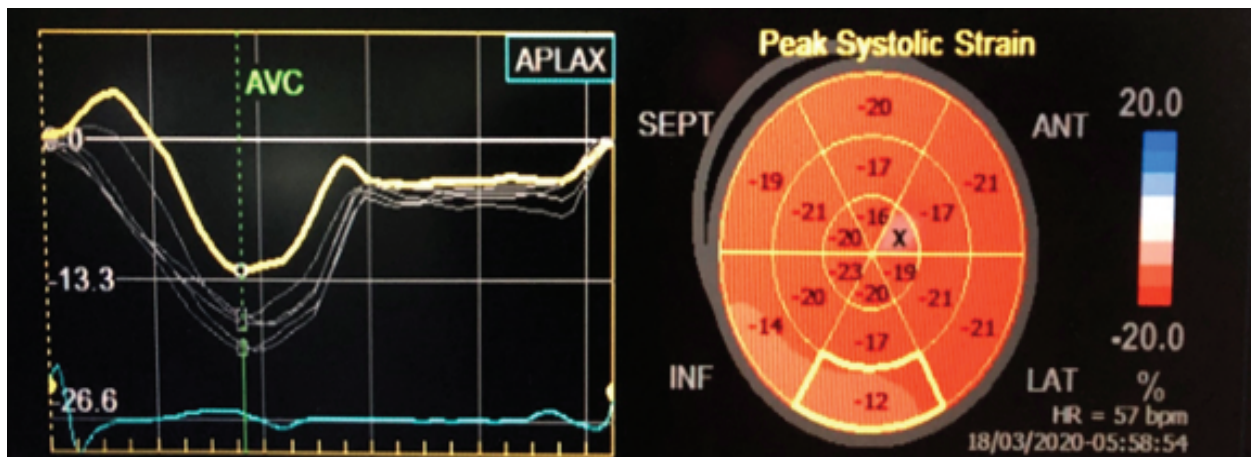
FIG. 12 POST SYSTOLIC SHORTENING TO DIAGNOSE CAD AND PREDICT FUTURE CV EVENTS IN STABLE ANGINA PECTORIS



shorten even when systole has ended and this goes on into diastole as PSS figure 12. Philip Brainan group has reported

this requires a lot of investigations as shown in Table 6.

FIG. 13 EARLY SYSTOLIC LENGTHENING IN ISCHEMIA



To assess the role of STE in this setting, Thomas Dahlslett et al. who show marked heterogeneity on Speckle Tracking

TABLE 6: PARAMETERS USED FOR ASSESSMENT OF CHEST PAIN	
PARAMETER	REMARKS
Risk factor assessment	Done once
ECG	Repeatedly
Troponin estimation	At least twice
Echocardiography	Done once
CT angiography	Expensive, involves X-rays, not easily available
Coronary Angiography	Final measure, requires expertise and expense

al.³⁰, in their study of 64 patients, found that 55% (35) did not have coronary artery obstruction whereas 45% (29) did. GPLS, territorial LS, LVEF, and WMSI differ significantly amongst the two groups. In an ROC analysis, GPLS out-powered the other variables in detection of ischemia.

On comparing the two groups (with and without significant CAD), they found that GPLS had sensitivity 0.93, specificity 0.78, positive predictive value (PPV) 0.74, negative predictive value (NPV) 0.92, and an accuracy of 0.78.

GPLS analysis is also helpful in patients undergoing Dobutamine stress echo for ischemia workup. Hai-Jyeong Hwang et al., in their study of 44 patients, found that in those who had CAD, the post-stress GPLS was lower than in those who had no CAD (-18 ± 3.4% vs -21 ± 1.9%; p=0.003).³¹

6. CARDIAC RESYNCHRONIZATION THERAPY:

STE has an excellent role in patients who are candidates for resynchronization therapy. It has been found that 1/3rd of CRT recipients don't respond; this is due to the reason elaborated by STE that LBBB as shown by these patients is not of the same type, figure 14, with responders are those

(typical LBBB patients) as compared to those who do have LBBB on resting ECG but no heterogeneity is noted on Speckle tracking, as demonstrated by Niels Risum et al. in their study.³²

The TARGET³³ and STARTER³⁴ studies have shown that radial strain assessment helps in locating scar tissue and selection of optimal place for lead placement.

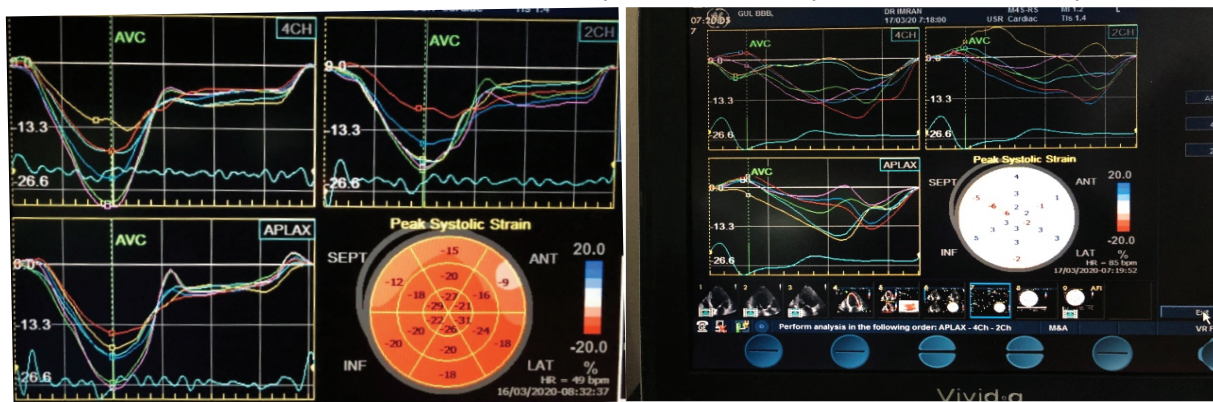
The parameters used for dys-synchrony assessment are:

- A. Maximum time delay between peak systolic strain of two segments (usually between the antero-septal and postero-lateral walls, DT)
- B. Dys-synchrony index of LV³⁵, taken from the standard deviation of time to peak systolic strain.

7. CARDIO-ONCOLOGY:

This is a rapidly growing field for the application of STE as most chemotherapeutic agents cause myocardial dysfunction by various mechanisms. Knowledge of sub-clinical dysfunction in these patients helps in altering the regimen which is more toxic and institution of cardiac drugs which can ameliorate the detrimental effect of these

FIG. 14 TYPICAL AND ATYPICAL LBBB SYNCHRONOUS (NON-RESPONDERS) AND ASYNCHRONOUS (RESPONDERS)



A. LBBB, SYNCHRONOUS PATTERN B. LBBB, MARKED DYS-SYNCHRONY

agents. There is a growing institution of clinics in hospitals which deal with oncology patients where cardiac and oncology consultations go side by side.

A King et al³⁶ have demonstrated the utility of GLS in their study of 43 patients of breast cancer (HER 2 positive) on Herceptin treatment. They showed that GLS assessment is better than 2D EF assessment in such patients as it has more intra and inter-observer variation, which results in a reduced assessment of EF rather than a real clinical change. They concluded that analysis by direct comparison, intra class correlation (ICC) and co-efficient of variation (CV) and Bland-Altman plots demonstrated that GLS is a more reproducible measurement than 2D EF.

Isaac B Rhea et al³⁷ in their study of 120 cancer patients (of various types) with normal ejection fraction analyzed 17 clinical and 6 echocardiographic parameters along with GLS for prognostic assessment with regard to mortality. They found that only ECOGP (Eastern Co-operative group oncology performance), male sex and GLS were significantly associated with mortality. Adding GLS to significant clinical variables provided incremental prognostic information.

CAVEATS:

Being an evolving modality, it has many caveats which need to be covered up with further research. Some are:

- Sinus rhythm is mandatory, non-sinus rhythms like atrial fibrillation, frequent ventricular ectopics and paced patients cannot be analyzed.
- Imaging needs to be of good quality.
- Vendor differences have not been sorted out completely.
- No guidelines from any agency have yet defined the clear limits of normal and abnormal.

CONCLUSION:

With the sophistication of Speckle tracking echocardiography sub-clinical cardiac dysfunction (both global and regional) can be detected by utilizing 2-D images (not needing Doppler) much before conventional parameters show any deterioration. Furthermore STE helps in the assessment of rotational and torsional dynamics, and thus has huge potential in numerous fields of cardiology.

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