THE INCREMENTAL VALUE OF THE PERFORMANCE EVALUATION USING SYSTOLIC VENTRICULAR STRAIN / STRAIN RATE IN PREDICTING THE OUTCOME OF ISCHEMIC HEART DISEASE PATIENTS UNDERGOING MAJOR VASCULAR SURGERY.

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Key words: strain-strain rate imaging, speckle tracking

Parole chiave: strain-strain rate imaging, speckle tracking
Abstract

Introduction: The strain, or "deformation" can be calculated as the change in length compared to the original size (Lagrangian strain $\varepsilon = (L - L_0) / L_0$). The strain rate is calculated as the instantaneous spatial velocity gradient ($1 / \text{s}$), then $\text{SR} = (V2 - V1) / L$, less dependent on loading conditions and therefore best index of myocardial contractility. It is possible to plot the values of "regional strain" (SRI) as a "regional shortening fraction" on the long axis (longitudinal strain) and as "regional thickening fraction" on the short axis (radial strain), represented by curves $\varepsilon / \text{SR}$ with opposite morphology: negative in systole (shortening) and positive in diastole (elongation) for the longitudinal strain, positive in systole (thickening) and negative in diastole (thinning) for the radial strain. The strain measures the "deformation", the strain rate quantifies the "strain rate" of myocardial ischemia. The method of speckle tracking allows to overcome the limits of conventional Doppler techniques, such as the angle-dependency.

Objective: To demonstrate the prognostic value additional to the traditional economic parameters, derived from pre-operative assessment of left ventricular performance by SRI and speckle tracking in patients with vascular disease polidistrictual undergoing major vascular surgery.

Methods: We enrolled 54 patients (15 females and 39 males, mean age 73 years), hypertensive and ischemic heart disease (16 with single vessel coronary artery disease and 38 with multivessel coronary artery disease), polidistrictual with vascular disease, 24 of them diabetics. Each subject underwent a clinical examination and echocardiographic study pre-and post-operative MyLab30Gold echocardiograph (Esaote) according to the recommendations of the ESA, with high acquisition frame rates $> 200$ frames / s.

The FE method was calculated with Simpson. Three cardiac cycles in cineloop format for offline analysis were recorded. The left ventricular apical and parasternal projection 4 bedrooms short axis was divided into 6 segments evaluated individually with the software-Esaote X-Strain-Italy for the analysis of 2D SRI longitudinal (regional shortening fraction), radial (regional thickening fraction) and speckle tracking.

For all subjects the value of global strain (GS), expressed as mean ± standard deviation, was recorded. The quantitative variables were compared using Student’s t test. Correlations were performed with the study of the linear correlation. A p value $<0.05$ was considered statistically significant. Data were analyzed using SPSS 10.0 (SPSS, Chicago, IL, USA).

Results: In this study it was possible to find values of Peak Systolic Strain rate ($1$/sec.) Peak Systolic Strain (%) and global left ventricular strain significantly decreased in particular in the group of patients with diabetes and multivessel coronary artery disease compared with the average values of the sample (-14.8 ± 2.8% vs -17.84 ± 3.1%, P <0.05).

SRI has been able to detect early changes in myocardial contractility, even before a clear deterioration of the pump function evaluated as ejection fraction. Only for a small portion of these patients there was a higher occurrence of angina or electrocardiographic abnormalities (arrhythmias, abnormal ventricular repolarization phase) in the postoperative period. In more than half of the group of patients studied we assisted, after the implementation of appropriate therapeutic strategies such as (Coronary ventriculography with insertion of coronary stents, coronary bypass) and a variable period of time, to a significant improvement in clinical status of the patient with a reduction in NYHA functional class as well as to a reduction by echocardiographic assessment of diastolic (260 ± 90 ml to 205 ± 82 ml) and systolic (from 208 ± 85 ml to 140 ± 72 ml) volumes.

Discussion e Conclusions: SRI by 2D speckle-tracking analysis is a valid non-invasive method to achieve an integration of regional systolic function parameters and indices of global function, useful not only for the purpose of better diagnostic accuracy but also for the prognostic stratification of patients with indication of noncardiac vascular surgery.
Abstract

**Background:** Lo strain, ossia "deformazione", può essere calcolato come variazione in lunghezza rispetto alle dimensioni originarie (Lagrangian strain $\varepsilon = (L - L_0)/L_0$). Lo strain rate è calcolato come gradiente di velocità spaziale istantaneo (1/s), quindi $SR = (V_2 - V_1)/L$, meno dipendente dalle condizioni di carico e pertanto miglior indice della contrattilità miocardica. È possibile riportare i valori di "regional strain" (SRI) come "regional shortening fraction" in asse lungo (strain longitudinale) e come "regional thickening fraction" in asse corto (strain radiale), rappresentati da curve $\varepsilon$/SR con morfologia opposta: negativa in sistole (accorciamento) e positiva in diastole (allungamento) per lo strain longitudinale, positiva in sistole (ispessimento) e negativa in diastole (assottigliamento) per lo strain radiale. Lo strain misura la "deformazione", lo strain rate la "velocità di deformazione" miocardica. La metodica di speckle tracking permette di superare i limiti delle tecniche Doppler tradizionali, quali ad esempio l’angolo-dipendenza.

**Obiettivi:** Dimostrare il valore prognostico aggiuntivo rispetto ai parametri eco tradizionali, derivante dalla valutazione pre-operatoria della performance ventricolare sinistra mediante SRI e speckle tracking in pazienti con vasculopatia polidistrettuale sottoposti ad interventi di chirurgia vascolare.

**Metodi:** Sono stati arruolati 54 pazienti (15 femmine e 39 maschi, età media 73 anni), ipertesi e cardiopatici ischemici (16 con coronaropatia monovasale e 38 con coronaropatia multivasale), con vasculopatia polidistrettuale, 24 dei quali diabetici. Ogni soggetto è stato sottoposto ad esame clinico ed indagine ecocardiografica pre- e post-operatoria con ecocardiografo MyLab30Gold (Esaote) secondo le raccomandazioni dell’ASE, con acquisizione ad alto frame rate > 200 frame/s.

La FE è stata calcolata con metodo Simpson. Sono stati registrati tre cicli cardiaci in formato cineloop per le analisi offline. Il ventricolo sinistro in proiezione 4 camere apicale e parasternale asse corto è stato suddiviso in 6 segmenti valutati individualmente con il software X-Strain-Esaote-Italy per l’analisi 2D SRI longitudinale (regional shortening fraction), radiale (regional thickening fraction) e speckle tracking.

Per tutti i soggetti è stato registrato il valore di Global strain (GS) espresso come media ± deviazione standard. Le variabili quantitative sono state comparative mediante test T di Student. Le correlazioni sono state effettuate con lo studio della correlazione lineare. Un valore di $p < 0,05$ è stato considerato statisticamente significativo. I dati sono stati analizzati mediante software SPSS 10,0 (SPSS, Chicago, Illinois, USA).

**Risultati:** Nello studio effettuato è stato possibile riscontrare valori di Peak Systolic Strain rate(1/sec.) Peak Systolic Strain(%) e di Global strain ventricolare sinistro significativamente ridotto in particolare nel gruppo di pazienti diabetici e con coronaropatia multivasale rispetto alla media del campione esaminato (-14,8 ± 2,8% vs -17,84 ± 3,1%; $p < 0,05$). Lo SRI è stato in grado di rilevare precocemente alterazioni della contrattilità miocardica, ancor prima di un evidente deterioramento della funzione di pompa valutata come frazione d’eiezione. Proprio in una piccola parte di tali pazienti si è registrata una maggiore insorgenza di angina o anomalie elettrocardiografiche (aritmie, anomalie della fase di ripolarizzazione ventricolare) nel periodo post-operatorio. In più della metà del gruppo di pazienti studiati si è assistito dopo l’attuazione di adeguate strategie terapeutiche quali (Coronaroventricolografia con inserimento di stent coronarici, By-pass coronarici) ed un periodo di tempo variabile ad un significativo miglioramento dello stato clinico del paziente con una riduzione della Classe funzionale NYHA inoltre si è assistito tramite Valutazione Ecocardiografica ad una riduzione dei Volumi telediastolico(da 260±90 ml a 205±82 ml) e telesistolico(da 208±85 ml a 140±72 ml).

**Discussione e Conclusioni:** L’analisi 2D SRI-specchle tracking è una metodica non invasiva valida per realizzare un’integrazione tra parametri regionali di funzione sistolica e indicì di funzione globale, utile non solo ai fini di una migliore accuratezza diagnostica ma anche per la stratificazione prognostica di pazienti con indicazione ad interventi di chirurgia vascolare non cardiaca.
The incremental value of the performance evaluation using systolic ventricular strain / strain rate in predicting the outcome of ischemic heart disease patients undergoing major vascular surgery.

Background

I. "The strain (ε) means "deformation" of fig. 6-7 and can be calculated as the change in length (L-L0) divided by the original length (L0), i.e. (Lagrangian strain ε = (L - L0) / L0); since the myocardial deformation or strain is caused by the contraction of the myocardial fibers, the strain / strain rate is a measure of the contractile myocardial function. The strain rate reflects how fast the myocardial deformation occurs and is calculated as a gradient of instantaneous space velocity (1 / s), then SR = (V2 - V1) / L. Similar to the FE% calculated for the left ventricle, the strain is load-dependent, so it is not a perfect measure of myocardial contractility; on the other hand the strain-rate (SR) even if it depends on the load (load-dependent) appears to be less "load-dependent", and then it would be a more reliable index of myocardial contractility compared with strain. Indeed, it emerges from a study by Weidemann et al. that the strain-rate (SR) is more closely related to (dp / dt) and thereby to the contractility, the strain (S) is more closely related to (stroke volume, FE%) as a consequence to the pump function.

II. It is possible to plot the values of "regional strain" (SRI) as: a) "regional shortening fraction" on the long axis (longitudinal strain) (fig. 2) and as b) "regional thickening fraction" on the short axis (radial strain) (fig. 1), represented by curves ε / SR opposite morphology: negative in systole (shortening) and positive in diastole (elongation) for the longitudinal strain b) positive in systole (thickening) and negative in diastole (thinning) for the radial strain. The strain measures the myocardial "deformation", the strain rate measures the "speed" of myocardial deformation.

Fig. 1-2

Radial Strain:
Short axis Parasternal (SAX) – A view of the relevant area, divided into 6 segments, is shown in the upper left part. The software identifies the strain curves shown in the upper right part. The strain values are described at the bottom right of the image.

Longitudinal strain:
Apical 4 chamber view – apical 4 chamber view of the 6 segments: in orange the global strain curve.
The method of speckle (fig. 11, 12, 13, 14, 15) tracking allows to overcome the limits of conventional Doppler techniques (fig. 10).

**Fig. 10**

![Angle Correction Diagram](image)

\[ V_1 = \frac{V_{\text{Beam}}}{\cos(\theta)} \]

**S/SR (TDI) Limits:**
Dependence on the correction angle

**Fig. 11**

![Telediastole, Systole, Protodiastole Diagrams](image)

**Analysis with S/SR (Speckle Tracking):**
Myocardic Twisting – Untwisting
The incremental value of the performance evaluation using systolic ventricular strain / strain rate in predicting the outcome of ischemic heart disease patients undergoing major vascular surgery.

**Fig. 12**

*S/SR (Speckle Tracking)*

**Fig. 13**

*Speckle Tracking: Kernel displacement*
The incremental value of the performance evaluation using systolic ventricular strain/strain rate in predicting the outcome of ischemic heart disease patients undergoing major vascular surgery.

The SR can be displayed as a color map or as a profile of deformation. To study the longitudinal function (shortening in systole and diastole lengthening) (fig.18) the apical sections, the SR coding in yellow shortening (due to the rapprochement of the plan atrio-ventricular cardiac apex during systole) and blue lengthening (due to estrange the plan atrio-ventricular cardiac apex during diastole). In contrast, studying the radial function (thickening in systole, thinning in diastole) (fig.19) sections from parasternal, encoding the SR thickening in blue (which happens in systole in the radial function evaluation) and in yellow thinning (which happens in diastole for the radial function). In both cases, the green indicates the absence of deformation, which in physiological conditions occurs during diastole, and in that time interval, called diastase, between the rapid ventricular filling and atrial contraction each curve of the ε regional can be divided into components, each one representing the different phases of the cardiac cycle.
The incremental value of the performance evaluation using systolic ventricular strain / strain rate in predicting the outcome of ischemic heart disease patients undergoing major vascular surgery.
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III) This division is performed with dedicated software, aligning in the same image curves $\varepsilon$ and SR with global mechanical events such as opening and closing of the mitral and of aorta to the left ventricle or the tricuspid and pulmonary for the timing of the SR regional of right ventricle (Fig 4).

**Fig. 4**

**Radial Strain:**
- It refers to the systolic parietal thickening.
- It is therefore characterized by positive slopes.
- It results from short-axis projections (SAX).

**Fig. 5**

**Longitudinal Strain:**
- It will be **negative** (shortening) during systole and **positive** (lengthening) during diastole.
The incremental value of the performance evaluation using systolic ventricular strain / strain rate in predicting the outcome of ischemic heart disease patients undergoing major vascular surgery.

Three-dimension strain: all three-dimensional objects are likely to undergo three-dimensional deformations along the three main axes (x,y,z). This figure also shows the principle of incompressibility: a 3-D object is stretched along the x axis and is compressed along the y,z axes as described in the formula below:

Principle of Incompressibility:
for an incompressible object to keep its volume immodified it is required that compression along an axis is balance by expansion along the two other axes.
Normal values for $\varepsilon$ and SR, both in adults have recently been published (fig. 21).

**Fig. 21 - Table 1. Normal values of Strain/Strain rate**

<table>
<thead>
<tr>
<th></th>
<th>End – Systolic Strain(%) male</th>
<th>Peak – Systolic Strain – rate male</th>
<th>End – Systolic Strain(%) female</th>
<th>Peak – Systolic Strain – rate female</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>&lt; 40 yr.</strong></td>
<td>-17.9% (2.1)</td>
<td>-1.09s -1(o.12)</td>
<td>-18.8% (2.0)</td>
<td>-1.06s -1(o.13)</td>
</tr>
<tr>
<td><strong>40-60 yr.</strong></td>
<td>-17.6% (2.1)</td>
<td>-1.06s -1(o.13)</td>
<td>-16.8% (2.2)</td>
<td>-1.01s -1(o.12)</td>
</tr>
<tr>
<td><strong>&gt; 60 yr.</strong></td>
<td>-15.9% (2.4)</td>
<td>-0.97s -1(o.14)</td>
<td>-15.5% (2.4)</td>
<td>-0.97s -1(o.14)</td>
</tr>
</tbody>
</table>

Values are given as mean (SD)

**Fig. 22**

Strain/Strain rate Imaging- strain components :
- 3 normal components
- 6 shear components

A) One-, two- and three-dimensional representation of linear myocardial strains

B) One-dimensional strain obtained by TDI

C) Two-dimensional strain obtained by Speckle-tracking imaging

D) A hypothetical strain obtained by STI analysis of 3-dimensional
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**Fig. 23 - Table 2a**

<table>
<thead>
<tr>
<th>Results of Post – Operative Phase</th>
<th>mean value in patients &gt; 60 aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>End – systolic Strain(%) in monovasal pt.</td>
<td>-15.8% (2.4)</td>
</tr>
<tr>
<td>End – systolic Strain(%) in diabetic, plurivasal pt.</td>
<td>-14.8% (2.3)</td>
</tr>
</tbody>
</table>

Level of statistical significance p < 0.05

**Fig. 24 - Table 2b**

<table>
<thead>
<tr>
<th>Results of Post – Operative Phase</th>
<th>mean value in patients &gt; 60 aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Systolic Strain-rate(-1/s) in monovasal pt.</td>
<td>-0.98 (0.13)</td>
</tr>
<tr>
<td>Peak Systolic Strain-rate(-1/s) in diabetic, plurivasal pt.</td>
<td>-0.13 (0.13)</td>
</tr>
</tbody>
</table>

Level of statistical significance p < 0.05

NMR and M-mode echocardiography measures the $\epsilon$ Lagrangian in which the tele-diastolic dimension is used instead of resting length as the length standard. The derived from DTI measure the $\epsilon$ natural, which uses the length snapshot as reference length and is calculated as the time-integral the SR signal derived from the DTI. However, it was shown that for small $\epsilon$ and measured with acquisitions at high frame rates the $\epsilon$ lagrangian can be put into relation with the log of the $\epsilon$ natural Lagrangian $\epsilon = \log(-1)$.

Cardiac MRI has limited availability and should be contraindicated in patients who suffer from claustrophobia or have metal devices. Echocardiography acquisition with high frame rate, is able to calculate the SR-dimensional whereas, to assess the regional myocardial function, the regional myocardial deformation should be analyzed in all three dimensions. However, today, the three-dimensional $\epsilon$ can only be obtained with MRI, but the acquisition is not in real time and frame rate is too low to assess the SR. The $\epsilon$ obtained by MRI is not in real time, implies a long analysis and has a low temporal resolution (> 30 frames / sec) when compared with the SRI. The advantages include greater spatial resolution, better image quality and the ability to measure the $\epsilon$ three-dimensional. The $\epsilon$ derived from the MRI is usually expressed as $\epsilon$ main (maximum variation in length) in a particular direction and at a specific point of the myocardium.
Finally, the $\varepsilon$ derived from DTI measure variations in the distance between two points materials of the myocardium. The $\varepsilon / \text{SR}$ echocardiographically derived correlate closely with the values derived from RMN. In recent years there has been a progressive interest for the study of myocardial function, in large part due to the development of recent techniques such as ultrasonic Doppler tissue and the tracking Speckle Imaging, which have allowed to obtain new parameters in clinical practice global and regional myocardial function, through the study of myocardial deformation or strain / strain rate analyzed by Speckle Tracking and tissue Doppler, which were added to the classical methods for assessment of systolic function such as ejection fraction (EF%), stroke volume (SV), dP / dt..

In the myocardial wall (fig. 8) the presence of three layers can be identified: 1) subendocardium 2) intermediate layer 3) subepicardium, characterized by a different prevalence of groups of myofibers with specific course. Subendocardium in the fibers are oriented in the longitudinal direction - sideways from the base toward the apex, forming a (spiral time) in the middle layer are oriented in a circular direction. and finally in subepicardium the fibers form a spiral counterclockwise while the subendocardial form a spiral slot. Therefore, it passes by a propeller tending to the left in the subepicardium, a propeller inclining to the right in the subendocardium; hence the fibers rotate according to a counterclockwise direction from the epicardium to the endocardium with a gradient angle of approximately 120 ° (from -60 ° in correspondence of the epicardium to +60 ° in correspondence with the endocardium) (fig. 9). Shear strain is generated by a contraction of epicardial fibers oriented in a left-helix (Fig. red arrow). So, Fundamental is the concept that: "torsion" is proportional to shear strain and ventricular length and inversely proportional to short-axis radius.

![Architecture of myocardium](image_url)

**Orientation of myofibers groups**

**Architecture of myocardium:**
The myocardial wall presents three layers:

1) Subendocardium
2) Intermediate layer
3) Subepicardium
The incremental value of the performance evaluation using systolic ventricular strain / strain rate in predicting the outcome of ischemic heart disease patients undergoing major vascular surgery.

Fig. 9

Orientation of myocardial fibres:
A) Left-helix orientation of epicardial fibers (red) and right-helix orientation of endocardial fibres (green) within the myocardial shell

"Shear-Strain", during contraction, occurs in the direction of the epicardial fibres orientation

B) Relationship between shear strain(xy) and Torsion(θ):
Shear Strain is generated by a contraction of epicardial fibres oriented in left-helix (red arrow). So Torsion is proportional to shear strain and ventricular length and inversely proportional to short-axis radius.

Fig. 3

Main directions (strain):
The three main components of myocardial deformation (strain) are:
1) Longitudinal
2) Radial
3) Circumferential

V) As a result of the particular type of myocardial architecture, the left ventricle, in systole undergoes various types of deformation that interact with each other in a complex manner, giving a varying contribution to the stroke volume. The main types of myocardial deformation that are created, according to the shortening of the muscle fibers are along the three orthogonal planes: 1) Longitudinal myocardial shortening 2) Myocardial circumferential shortening 3) Wall thickening or radial thickening 4) Torsion (fig. 3).
1) **Longitudinal Function:**

It is to be noted that, according to some authors, the longitudinal function, defined as the shortening of the longitudinal diameter of the ventricle, is the main determinant of the stroke volume. During systole, the apex is relatively fixed, while the plane of the ring mitral is lowered toward the tip, so most of the stroke volume would be provided by the longitudinal translation of the atrio-ventricular plan (atrio-ventricular plane displacement AvPD) that would act with a mechanism similar to that of a piston.

2) **Circumpherential Function:**

Some authors consider the circumpherential shortening decisive; 1) De Simone et al. have calculated that in normal subjects, 60% of FE depends on center-parietal (or circumpherential) shortening and that only 7% depends on longitudinal shortening, therefore, according to these authors, the left ventricular ejection, depends mainly on circumpherential shortening, and is also independently correlated to relativ thickening of the wall. The study of 2) Oki T. and coll. has however demonstrated that in healthy subjects, the shortening of the longitudinal fibers prevails over that of circumpherential fibers during the first phase of systole, while the shortening of circumpherential fibers prevails in the phase of ejection systole.

VI) **3) Wall thickening:**

Plays a key role in supporting the stroke volume. The myocardial fibers are oriented in a variable through the myocardial wall, and each is "stretched" by the interaction with the shortening of the other fibers. These interactions, are in such a way that the shortening occurs both in the fiber direction is perpendicular to them. Such "cross-fiber shortening" does so, the myocardial wall to shorten and thicken along two directions in the third.

4) **Twist (or Torsion):**

The twist is an important mechanism for both ejecting systole and the ventricular filling. The twisting that takes place during ejecting systole is counterclockwise (counter clockwise twisting) and occurs in the direction of subepicardial fibers, which have a greater radius than the subendocardial and perpendicular to the fibers of the subendocardial layer.

The twisting of the apex is greater than the torsion of the average of other segments, while that of the base is minimal. The rewind (untwisting) is implemented for the most part during the phase of isovolumic relaxation, before the opening of the mitral valve. Alterations of the rewinding of the left ventricle were observed in numerous pathologies such as ischemia and myocardial infarction, suggesting therefore, the importance of this deformation for normal cardiac function. From the velocity gradient between two points of myocardial veins calculated the strain rate represents the rate at which the deformation occurs and the latter strain, which represents the amount or rate of deformation with respect to the initial length (planar strain = (L-L0) / L0) (1).

VII) **Strain / Strain Rate - Limitations TDI (Strain Analysis) are:**

1) Dependence on angle correction

2) Analysis of right ventricular function: Difficulty in obtaining an optimal alignment between the structure and the ultrasound beam

3) Analysis twisting-untwisting Inability to measure the rotational components of the cardiac movements

Strain rate Imaging 2D-based (Speckle Tracking),the advantage of this method is that it tracks in two dimensions, along the direction of the wall, not along the ultrasound beam, and thus is considered angle independent (fig. 12, 13, 14, 15, 16, 17). The system uses an advanced tracking algorithm to estimate myocardial velocities starting from a set of reference points selected by the physician. "Speckle tracking” refers to the idea of a system that follows the "speckels” during the cardiac cycle. The "speckels” are the black and white pixels , randomly positioned, which represent the "texture" of 2D echo and result from the interaction of ultrasounds with myocardial tissue. From two different kernels, the relative displacement and hence strain as well as strain rate, can be derived. Kernel "displacement”. Following the kernel through a whole heart cycle it will be possible to identify a “ displacement
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Temporal derivation (displacement per time, or frame by frame displacement divided by the time between frames) results in the derived velocity curve. If kernels are placed at the segmental borders, the result will be segmental strain and strain rate in six segments per plane.

Fig. 16

VIII) What has changed today is that the speckels, rather than in a single line (M-mode), can be recognized in a whole region (the so-called Kernel) and followed throughout the cardiac cycle. Today this is possible because also with the two-dimensional echo, high resolution can be achieved through Dual Harmonic, with the need to use a high frame rate.

Fig. 17
rate. To overcome the limitations of the Strain (TDI) has developed a new method that allows to extract the information of strain rate and strain from the images obtained in 2D mode to grayscale. This was made possible by the improvement obtained in the resolution of 2D images with the use of a) second harmonic and b) the increase in frame rate.

The technique (Speckle tracking) is based on the recognition of groups of pixels within the myocardial wall with specific acoustic characteristics according to which, as already mentioned in the previous slide about the kernels followed frame by frame during the cardiac cycle.

From the displacement calculated in this way it is possible to extract both the information rate and speed both of Strain Strain. With the software currently on the market endocardial border in systole is manually traced. Based on this track the software performs an automatic tracking and identifies the segments of interest. After approval by the operator, which, if appropriate, can change the region of interest based on the quality of the tracking for all the regions of interest, the values of the parameters of deformation, which represent the average values calculated within individual regions of interest, are displayed (graphically and numerically).

IX) Strain-Strain rate: assessment of left ventricular systolic deformation based on the use of Speckle Tracking -

Features and Benefits:
1. The data quality depends on the quality of 2D images and correct positioning of the region of interest
2. Unlike the Doppler areas of interest (typically 12x6 mm) are selected within the myocardial wall, with the Speckle tracking are automatically selected myocardial segments. Strain values obtained are average values within the segment
3. The absence of angle-dependence with the ultrasound beam makes it possible to measure in all myocardial segments (apical long-axis and parasternal short axis): longitudinal, radial and circumferential deformation. In particular, for each segment analyzed it is possible to obtain simultaneously in two orthogonal directions (2D Strain) the information of deformation
4. The ability to automatically calculate the global Strain as the average of all segments
5. The execution speed of the calculation
6. Increased automaticity which reduces the intra and inter operator

Objective
To demonstrate that the $\varepsilon$/SR parameter is the best way of measuring left ventricular function compared with conventional echocardiographic parameters, using a pre-operative echocardiographic evaluation of the "performance" with the VS method (SRI) which can precisely predict the outcomes in cardiac patients with ischemic vascular disease polidistrectual, undergoing major vascular surgery. In fact, the $\varepsilon$/SR can detect early myocardial dysfunction of myocardial contractility long before you create a loss of pump function (estimated by ejection fraction or stroke volume FE%) in order to take appropriate therapeutic strategies; which is precisely the concept on which our study is based (2).

Methods
We enrolled 54 patients (15 females and 39 males, mean age 73 years) hospitalized at the Department of Vascular Surgery, hypertensive and ischemic heart disease (16 with single vessel coronary artery disease and 38 with multivessel coronary artery disease), polidistrectual with vascular disease, 24 of which diabetics. Exclusion criteria were considered as follows: atrial fibrillation or significant valvular disease, COPD, high acoustic impedance of the thorax, prior mediastinal irradiation or chemotherapy. Each subject underwent a cardiological examination, ECG and echocardiography with SRI and standard (pre-and post-operative). For this analysis, echocardiography was used echocardiograph generation Esaote MyLab 30 Gold Package Software with X-Strain (Speckle Tracking) for the acquisition of SRI and offline analysis, as recommended by the ESA, with acquisition to high frame rate> 200 frames / sec. The acquisition of echocardiographic images was carried out at high frame rates (> 200 frames / sec.) to solve all high-speed events that occur during a normal cardiac cycle; The high frame rate acquisition also has the advantage of improving the "signal to noise ratio" with better inter-and intra-observer. The quality of the signal thus obtained, together with the use of
sophisticated analysis software Esaote X-Strain explains the shorter time required for "post-processing" (about 20 minutes per patient) than previous studies. In fact, X-Strain is the new method of imaging the ultrasound-associated Esaote My Lab 30 Gold which, as already mentioned, was used in our study, to evaluate the deformation of the heart and analyze the functionality of the myocardium through the study of the strain / strain rate (SRI) equipped with a modern software for analysis off-line for the executable 'high quality images in a short time for each patient examined. The 'X-Strain (fig. 16, 17, 20) is based on a 2D image (Speckle Tracking) and is therefore independent of the angle, although it uses a sophisticated algorithm. 2D-tracking patented XStrain™ is surprisingly easy to learn and use, integrates seamlessly into the platform of MyLab™ Esaote and was developed on a "one window user interface ". The FE method was calculated with Simpson. Three cardiac cycles in cineloop format were recorded for offline analysis. The quantitative variables were compared using Student’s t test. Correlations were performed with the study of the linear correlation. A p value <0.05 was considered statistically significant. Data were analyzed using SPSS 10.0 (SPSS, Chicago, Il, USA). For the study of regional 2D SRI longitudinal function (regional shortening fraction) of the left ventricle, we studied: interventricular septum, lateral wall (in 4 projection rooms) and the lower wall (in 2 projection rooms) and for the study of left ventricular radial function SRI 2D radial (regional thickening fraction), we examined the parasternal short axis. For each wall, we analyzed 3 regions: Baseline, Mid, Apical. Results: the study was noted at a value of global left ventricular strain significantly reduced in the group of patients with diabetes and multivessel coronary artery disease compared with the average of the sample (-14.8 ± 2.8% vs -17.84 ± 3.1%, P <0.05). SRI has been able to detect early changes in myocardial contractility, even before a clear deterioration of the pump function evaluated as ejection fraction. In these patients there was a higher occurrence of angina or electrocardiographic abnormalities (arrhythmias, abnormal ventricular repolarization phase) in the postoperative period (3).

**Results**

In the study it was possible to find values of Peak Systolic Strain rate (1/sec.), Peak Systolic Strain (%) and Global left ventricular strain significantly decreased in particular in the group of patients with diabetes and multivessel coronary artery disease compared with the average of the sample examined (-14.8 ± 2.8% vs -17.84 ± 3.1%, P <0.05). SRI has been able to detect early changes in myocardial contractility, even before a clear deterioration of the pump function evaluated as ejection fraction. Just a small portion of these patients manifested a higher occurrence of angina or electrocardiographic abnormalities (arrhythmias, abnormal ventricular repolarization phase) in the postoperative period. In more than half of the group of patients studied it was possible to observe, after the implementation of appropriate therapeutic strategies such as (Coronary ventriculography with insertion of coronary stents) and a variable period of time, a significant improvement in clinical status of the patient with a reduction in NYHA functional class (3.0 ± 0.5 to 2.1 ± 0.7, P <0.001 as well as a reduction by echocardiographic assessment of diastolic (260 ± 90 ml to 205 ± 82 ml) and systolic (from 208 ± 85 ml to 140 ± 72 ml) volumes (4).

**Discussion**

Our Study has highlighted the limitations of the S / SR (TDI) such as: a) dependence on the angle of the ultrasound beam b) analysis of right ventricular function (difficulty in obtaining the optimal alignment between the structure and the
ultrasound beam c) inability analysis of "untwisting-twisting" (inability to evaluate the rotational components of the cardiac movements). To overcome the limits of such echocardiographic method, a new echocardiographic method of S / SR through "Speckle Tracking" was introduced (5).

Conclusions
SRI analysis 2D speckle-tracking is a valid non-invasive method to achieve an integration of regional systolic function parameters and indices of global function, useful not only for the purpose of better diagnostic accuracy but also for the prognostic stratification of patients with indication of noncardiac vascular surgery.

References

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