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.

VALORE INCREMENTALE DELLA VALUTAZIONE DELLA PERFORMANCE SISTOLICA VENTRICOLARE MEDIANTE STRAIN/STRAIN RATE NEL PREDIRE L’OUTCOME DI PAZIENTI CARDIOPATICI ISCHEMICI SOTTOPOSTI AD INTERVENTI DI CHIRURGIA VASCOLARE.

Dagianti A 1, Regna E 1, Laurito A 2, Malaj A 2, Gossetti B 2, Fedele F 1

1 Professorship of Cardiovascular Diseases, “Sapienza” University of Rome – Policlinico “Umberto I”, Italy
2 Professorship of Vascular surgery, “Sapienza” University of Rome – Policlinico “Umberto I”, Italy

1 Cattedra Malattie Apparato Cardiovascolare - Università "La Sapienza" di Roma - Policlinico "Umberto I"
2 Cattedra di Chirurgia Vascolare A - Università "La Sapienza" di Roma - Policlinico "Umberto I"

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Key words: strain-strain rate imaging, speckle tracking

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

Introduzione: 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 ($1 / s$), then $SR = (V_2 - V_1) / L$, less dependent on loading conditions and therefore best index of myocardial contractility. And possible to report the values of "regional strain" (SRI) as a "regional shortening fraction" in the long axis (longitudinal strain) and as "regional thickening fraction" in the short axis (radial strain), represented by curves $\varepsilon / SR$ with morphology opposite: 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 the "strain rate" 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. Were recorded three cardiac cycles in cineloop format for offline analysis. 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 was recorded the value of global strain (GS), expressed as mean ± standard deviation. 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 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. Just 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 most ‘half of the group of patients studied was seen after the implementation of appropriate therapeutic strategies such as (Coronaroventricolografia 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 also has seen a reduction by echocardiographic assessment of diastolic volumes (260 ± 90 ml to 205 ± 82 ml) and systolic (from 208 ± 85 ml to 140 ± 72 ml).

Discussion e 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 indication for patients with not cardiac 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 perciò migliore indice della contrattilità miocardica. E’ 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 $\varepsilon/\text{SR}$ 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 $\pm$ deviazione standard. Le variabili quantitative sono state comparate 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, II, 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 $\pm$ 2,8% vs -17,84 $\pm$ 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 (Coronaroventricolografa 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-speckle tracking è una metodica non invasiva valida per realizzare un’integrazione tra parametri regionali di funzione sistolica e indici 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.
Background

I) "The strain (\( \varepsilon \)) means "deformation" of fig. 6-7 and can be calculated as the change in length (L-L0) divided by the original length (L0), ie (Lagrangian strain \( \varepsilon = (L - L0) / L0 \)); 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. Lo strain rate reflects how fast the deformation occurs myocardial 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" ie it is load-dependent, so is not a perfect measure of myocardial contractility; on the other hand the strain-rate (SR) even if it is anc 'it depends on the load (load-dependeant) appears to be less "load-dependeant", and then it would be a more reliable index of myocardial contractility compared with strain. In fact 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) Is possible to report the values of "regional strain" (SRI) as: a) "regional shortening fraction" in the long axis (longitudinal strain) (fig. 2) and as b) "regional thickening fraction" in the short axis (radial strain) (fig. 1), represented by curves \( \varepsilon / SR \) morphology opposite: 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 "deformation" myocardial strain rate the "speed" of myocardial deformation.

**Fig. 1-2**

**Strain radiale :**
Parasternale asse corto(SAX) - in alto a sinistra è visualizzata la regione di interesse suddivisa i 6 segmenti. Il software estrae le curve di strain visualizzate a destra in alto. A destra in basso sono visualizzati i valori di strain per ogni segmento.

**Strain Longitudinale :**
Apicale 4 camere - dei 6 segmenti visualizzabili in sezione apicale 4 camere : in arancione è visualizzata la curva di strain globale.
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](image)

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

**Limiti S/SR (TDI) :**
Dipendenza dall’angolo di correzione

**Fig. 11**

![Telediastole, Systole, Protodiastole](image)

**Analisi con S/SR (Speckle Tracking)**
Twisting – Untwisting miocardico
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 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.14

Such as the absence of angle-dependence with the regional beam ultrasonor. 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 (what happens in systole in the radial function evaluation) and in yellow thinning (what 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, said diastase, between the rapid ventricular filling and atrial contraction each curve of the \( \varepsilon \) regional can be divided into components, each one representing the different phases of the cardiac cycle.

Speckle Tracking:
From two different kernels, the relative displacement and hence Strain as well as Strain rate can be derived.

Fig.15

Speckle Tracking:
If kernels are placed at the segmental borders, the result will be the segmental strain and strain-rate in six segments for plane.
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. 18

Fig. 19

Strain Rate Longitudinale

Strain Rate Radiale
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.

III) This division is performed with dedicated software, that align in the same image curves ε 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 Å \ SR regional of right ventricle (Fig 4).

**Fig. 4**

**Strain radiale:** indica l’inspessimento parietale in sistole ed è quindi rappresentato da curve con andamento positivo. Si ottiene dalle proiezioni in asse corto(SAX).

**Fig. 5**

**Strain Longitudinale:** sarà negativo(shortening) durante la sistole e positivo(allungamento) durante la 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.

**Strain in tre dimensioni:**

Tutti gli oggetti tridimensionali possono subire una

**deformazione in tre dimensioni lungo i tre assi principali** (x,y,z), Tale figura mostra anche il **principio dell’incompressibilità**:

Per cui un’oggetto tridimensionale subisce uno

**stiramento** (stretched) lungo l’asse x e viene **compresso** lungo gli assi y,z come mostrato dalla seguente **formula**

\[
\varepsilon_x = \frac{\Delta x}{x}, \quad \varepsilon_{xy} = \frac{\Delta x}{y}, \quad \varepsilon_{xz} = \frac{\Delta x}{z}
\]

**Principio Incompressibilità**

Per cui per un’oggetto incompressibile per mantenere il volume immodificato la

**compressione** lungo un’asse deve essere bilanciata dall’**espansione** lungo gli altri due assi
Normal values for  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>&lt; 40 yr.</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>40-60 yr.</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>&gt; 60 yr.</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)

Strain/Strain rate Imaging- Componenti dello strain :
- 3 componenti normali
- 6 componenti di shear

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
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.

Table 2a

<table>
<thead>
<tr>
<th>Risultati Fase Post – Operatoria</th>
<th>Valore medio in pazienti &gt; 60 aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>End – systolic Strain(%) in pt. monovasali</td>
<td>-15.8% (2.4)</td>
</tr>
<tr>
<td>End – systolic Strain(%) in pt. diabetici, plurivasali</td>
<td>-14.8% (2.3)</td>
</tr>
</tbody>
</table>

Valore di significatività statistica p < 0.05

Table 2b

<table>
<thead>
<tr>
<th>Risultati Fase Post – Operatoria</th>
<th>Valore medio in pazienti &gt; 60 aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Systolic Strain-rate(-1/s) in pt. monovasali</td>
<td>-0.98 (0.13)</td>
</tr>
<tr>
<td>Peak Systolic Strain-rate(-1/s) in pt. diabetici, plurivasali</td>
<td>-0.13 (0.13)</td>
</tr>
</tbody>
</table>

Valore di significatività statistica p < 0.05

NMR and M-mode echocardiography measure the $\varepsilon$ Lagrangian in which the tele-diastolic dimension is used instead of resting length as the length standard. The derived from DTI measure the $\varepsilon$ 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 $\varepsilon$ and measured with acquisitions at high frame rates the $\varepsilon$ lagrangian can be put into relation with the log of the $\varepsilon$ natural Lagrangian $\varepsilon = \log(1 - \varepsilon)$.

Cardiac MRI has limited availability and should be contraindicated in patients who suffer claustrophobic or have metal devices. Echocardiography acquisition with high frame rate, is able to calculate the SR-dimensional; instead, to assess the regional myocardial function, the regional myocardial deformation should be analyzed in all three dimensions. However, today, the three-dimensional $\varepsilon$ can only be obtained with MRI, but the acquisition is not in real time and frame rate is too low to assess the SR16. The $\varepsilon$ 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 $\varepsilon$ three-dimensional. The $\varepsilon$ derived from the MRI is usually expressed as $\varepsilon$ 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 $\varepsilon /$ 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
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.

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) can be identified the presence of three layers: 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 subepicardiche 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; for which the fibers, rotate according to a counterclockwise direction dall’epicardio endocardium with a gradient angle of approximately 120 ° (from -60 ° to +60 ° in correspondence of the epicardium in correspondence with the endocardium) (fig. 9). Shear strain is generated by a contraction of epicardial fibers oriented in at left-helix (Fig. of red arrow). So, Fundamental is the concept that: the "torsion" is proportional to shear strain and ventricular length and inversely proportional to short-axis radius.

**Fig. 8**

Decorso ed orientamento dei gruppi di miofibre

Architettura del miocardio:
E’possibile individuare nella parete miocardica la presenza di tre strati:

1) Subendocardio
2) Strato intermedio
3) Subepicardio
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

Orientamento delle fibre miocardiche:
A) Left-helix orientation of epicardial fibers (red) and right-helix orientation of endocardial fibers (green) within the myocardial shell. “Shear-Strain”, during contraction, occurs in the direction of the epicardial fibers orientation.

B) Relationship between shear strain (xy) and Torsion (θ):

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

V) In following 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 shortening circumferenziale 3) Thickening of the wall thickening or radial 4) Torsione (fig. 3).

Fig. 3

Direzioni principali (strain):
I tre principali componenti della deformazione miocardica (strain):
1) Longitudinale 2) Radiale(o transmurale) 3) Circumferenziale.
1) **Longitudinal Function:**
Is to be noted, as, 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, it would be provided by the longitudinal translation of the plan atrio-ventricular (atrio-ventricular plane displacement AvPD) that would act with a mechanism similar to that of a piston.

2) **Circumpherential Function:**
Some authors consider the decisive shortening circumferenziale; 1) De Simone et al. have calculated that in normal subjects, 60% of FE depends from shortening center-parietal (or circumferenziale) and that only 7% longitudinal dall’accorciamento depends, therefore, according to these authors, the left ventricular ejection, depends mainly from ‘circumferenziale shortening, and is also correlated independently 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 the fibers circumferenziali during the first phase of systole, while the shortening of the fibers circumferenziali prevails in the phase of ejecting 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 for both the ventricular filling. The twisting that takes place during ejecting systole is counterclockwise (counter clockwise twisting) occurs in the fiber direction subepicardial, 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 segments average, 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 valve mitrale. 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, 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" esprime il concetto di un sistema che segue gli "speckels" durante il ciclo cardiaco. Gli “speckel ” sono quei puntini bianchi e neri, situati in modo del tutto casuale, essi costituiscono la "texture" dell’eco bidimensionale e sono il frutto dell’interazione degli ultrasuoni con il tessuto miocardico. 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, will lead to a “displacement curve” shown to the right. Temporal derivation (displacement per time, or frame by frame displacement divided by the
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.

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

Fig. 17

VIII) What has changed today is that the speckles, rather than in a single line (M-mode) can be recognized in a whole region (the so-called Kernel) and followed throughout the cycle cardiac. Today this is possible because also with the two-dimensional high resolution can be achieved through Dual Harmonic, with the need to use a high frame 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 are 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 is manually traced endocardial border in systole. Based on this track the software performs an automatic tracking and identifies the segments of interest. After approval by the operator, which, if it is considered appropriate can change the region of interest based on the quality of the tracking, for all the regions of interest, are displayed (graphically and numerically) the values of the parameters of deformation, which represent the average values calculated within individual regions of interest.

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 they are selected areas of interest (typically 12x6 mm) 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 measurable in all myocardial segments (apical long-axis and parasternal short axis) deformation: longitudinal, radial and circumferential. In particular, for each segment analyzed is possible to derive the information of deformation simultaneously in two orthogonal directions (2D Strain)
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 parameter \( \varepsilon / SR \) 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) 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 the ns. Studio (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 the echocardiographic images was carried out precisely at high frame rates (> 200 frames / sec.) To solve the same time all high-speed events that occur during a normal cardiac cycle; The acquisition also high frame rate-also has the advantage of improving the "signal to noise ratio" with better inter-and intra-observer. The quality of the signal thus
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.

obtained, together with the use of sophisticated analysis software Esaote X-Strain says the shorter time to "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 alluded 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 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 user interface “one window”. The FE method was calculated with Simpson. Were recorded three cardiac cycles in cineloop format 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 projection 2 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 there was a higher occurrence of angina or electrocardiographic abnormalities (arrhythmias, abnormal ventricular repolarization phase) in the postoperative period. In most ‘half of the group of patients studied was seen after the implementation of appropriate therapeutic strategies such as (Coronaroventriculography stent with insertion of coronary bypass coronary) and a variable period of time to 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). has also witnessed a reduction by echocardiographic assessment of diastolic volumes (260 ± 90 ml to 205 ± 82 ml) and systolic (from 208 ± 85 ml to 140 ± 72 ml) (4).
Discussion
The ns. 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). then to overcome the limits of such echocardiographic method, has introduced a new echocardiographic method of S / SR through "Speckle Tracking" (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 indication for patients with not-cardiac vascular surgery.

References

Corresponding Author: Alessandra Dagianti
Professorship of Cardiovascular Diseases, "Sapienza" University of Rome – Policlinico "Umberto I", Italy
e-mail: info@preventionandresearch.com

Autore di riferimento: Alessandra Dagianti
Cattedra Malattie Apparato Cardiovascolare - Università "La Sapienza" di Roma - Policlinico "Umberto I"
e-mail: info@preventionandresearch.com