Diagnostic and prognostic value of 2D-Strain in Non-ST Elevation Myocardial Infarction

Valeur diagnostique et pronostique du 2D-Strain dans l'infarctus du myocarde sans sus-décalage du segment ST

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RÉSUMÉ

Introduction : Le Strain a montré une valeur diagnostique et pronostique prometteuse dans les syndromes coronariens aigus avec cependant, moins de données dans l'infarctus du myocarde sans élévation de ST (NSEMI).

Objectif : évaluer, chez les patients avec NSTEMI, la capacité du Strain à prédire la gravité de la maladie, en évaluant les corrélations avec les paramètres pronostiques établis, et à prédire les artères coronaires coupables et occluses. Secondairement, déterminer les facteurs associés aux modifications du Strain au cours du suivi.

Méthodes : L'étude était prospective, les patients avec NSTEMI présentant une lésion coronaire significative et sans cardiopathie non ischémique significative ont été inclus. Une étude angiographique et échocardiographique, y compris du Strain longitudinal global (GLS) et territorial (TLS), ont été effectuées dans les 24 heures suivant l'admission. Le score de syntaxe I a été calculé. La maladie coronarienne sévère a été définie par une atteinte du tronc commun gauche ou tritronculaire.

Résultats : Soixante-dix patients âgés de 60,2 ± 10,1 ans ont été inclus ; 61% étaient fumeurs, 54% étaient diabétiques et 46% étaient hypertendus. 34% avaient une coronaropathie sévère, 7% une occlusion coronaire aiguë (OCA) et 14% une occlusion totale coronaire chronique (CTO).
Un GLS> -15,3% a prédit une fraction d'éjection ventriculaire gauche (FEVG) <50% avec une sensibilité (Se) de 80% et une spécificité (Sp) de 78%. Le GLS était associé à la complexité et à la gravité de la coronaropathie. Un GLS> -14,1% a détecté une coronaropathie sévère avec 83% de Se et 80% de Sp. Le TLS a déterminé l'artère coupable dans 74% des cas et le TLS> -9,2% a prédit une OCA avec 85% de Se et 85% de Sp. Le TLS était également associé aux CTO. Après un suivi médian de 10 mois [3-12 mois], le GLS s'est amélioré de manière significative. La FEVG, le GLS de base, le score index de mouvement pariétal et la revascularisation étaient les facteurs prédictifs de cette amélioration.

Conclusion : Chez les patients avec NSTEMI, le GLS a détecté une coronaropathie sévère et une fonction myocardique altérée. Le TLS prédit l'artère coupable et son occlusion. L'amélioration du GLS à moyen terme a été prédite par les paramètres de base de la fonction VG systolique et la revascularisation du myocarde.

Mots clés : 2D Strain longitudinal, infarctus du myocarde sans élévation du segment ST, facteur pronostique indépendant, occlusion coronaire aigue.

SUMMARY

Background: Strain has shown a promising diagnostic and prognostic value in acute coronary syndromes. With, however, less data in non-ST elevation myocardial infarction (NSEMI).

Aim: to evaluate in NSTEMI patients, the ability of strain to predict the severity of the disease, by assessing correlations to established prognostic parameters, and to predict culprit and occluded coronary arteries (CA). Secondary, to determine factors associated to strain changes during follow-up.

Methods: The study was prospective, NSTEMI patients with significant coronary lesion and without significant non-ischaemic disease were included. Angiographic and echocardiographic investigation including global (GLS) and territorial (TLS) longitudinal strain were performed within 24h from admission. Syntax I score was calculated. Severe coronary artery disease (CAD) was defined by left main of three-vessel disease.

Results: Seventy NSTEMI patients aged 60.2±10.1 years were enrolled; 61% were smokers, 54% diabetics and 46% hypertensive. 34% had a severe CAD, 7% had an acute coronary occlusion (ACO) and 14% a chronic coronary total occlusion (CTO). GLS >-15.3% predicted a left ventricular ejection fraction (LVEF) <50% with 80% Sensitivity (Se) and 78% Specificity (Sp). GLS was associated to CAD complexity and severity. GLS > -14.1% detected severe CAD with 83% Se and 80%Sp. TLS determined the culprit artery in 74% of cases and TLS > -9.2% predicted ACO with 85% Se and 85% Sp. TLS was also associated to CTO. At a 10 months median follow-up [3-12months], GLS significantly improved, baseline LVEF, GLS, wall motion score index and revascularization were the predictors of this improvement.

Conclusion: In NSTEMI patients, GLS detected severe CAD and poor myocardial function. TLS predicted the culprit vessel and its occlusion. GLS improvement at midterm was predicted by baseline systolic LV function parameters and myocardial revascularization.

Key-words: 2D Longitudinal Strain, 2D Strain Speckle Tracking, Non-ST Elevation Myocardial Infarction, Independent prognostic factor, Acute coronary occlusion.

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INTRODUCTION

Following acute coronary syndrome (ACS), ischemic myocardial segments have different outcomes from a total or a partial recovery to an irreversible injury. Many studies(1–4) have addressed this issue concluding to the importance kinetic abnormalities assessment usually by transthoracic echocardiography (TTE) (5). Among TTE parameters, the diagnostic and prognostic value of left ventricle ejection fraction (LVEF) and wall motion score (WMSI) has been validated (6). However, through a better understanding of myocardial deformations (7–9), bidimensional (2D) strain emerged in 2004 and widely spread in multiple clinical applications due to its reproducibility (10), thus overcoming the limits of conventional ultrasound parameters (11-13). Longitudinal strain better assess endocardial myocardium layers, has the highest reproducibility and was and the most used in clinical practice (14).

2D global (GLS) and territorial (TLS) longitudinal Strain had diagnostic and prognostic values in ACS studies (15,16). In ST segment Elevation Myocardial Infarction (STEMI) patients, 2D longitudinal strain allowed a more objective assessment of myocardial regional and global kinetic injuries and coronary artery disease (CAD) severity (17). However, due to the heterogeneity of non ST elevation myocardial infarction (NSTEMI) patients, this diagnostic value is still to be validated.

In this context we conducted this study which aimed to:

• Evaluate the ability of 2D GLS and TLS in NSTEMI patients to predict the severity of the disease by assessing correlations to main clinical, echocardiographic and angiographic established prognostic factors.

• Determine the ability of 2D GLS and TLS to determine the culprit artery and predict acute coronary occlusion in NSTEMI.

• Secondary to determine factors associated to GLS changes after NSTEMI.

METHODS

This study was an investigator-initiated clinical trial conducted in a single tertiary coronary care center for a period of 6 months (January to June 2018). A Cohort of consecutive patients, admitted in the intensive coronary care unit (ICU) for NSTEMI, was screened for enrollment.

The study was approved by the local ethics committee of la Rabta hospital

Study Population

All patients gave written informed consent. Inclusion criteria were age ≥ 18 years, a clinical diagnosis of recent NSTEMI either inaugural or recurrent or preceded by other manifestation of coronary artery disease, and a planned coronary angiography performed within 24 hours of admission. Non-inclusion criteria were: All moderate or severe valvular heart diseases including mitral stenosis with a mitral area inferior to 2cm², aortic stenosis with an aortic area inferior to 1.5cm², moderate or severe mitral or aortic regurgitation. Significant non-ischemic cardiomyopathy (NICM) which included all hypertrophied left ventricles with a parietal thickness exceededing 15mm, and cardiomyopathies that were not clearly related to the ischaemic disease with a LVEF ≤ 40% (hypertensive disease, rhythmic cardiomyopathy, primitive dilated cardiomyopathy, homogenous and diffuse systolic LV dysfunction of unknown origin..), atrial fibrillation rhythm during TTE, the absence of a significant coronary stenosis on the coronary angiography and coronary angiographies not performed or performed more than 24 hours after admission. Patients with poor acoustic window were excluded. All patients were examined upon admission and received medical and invasive treatment according to guidelines (18).

Electrocardiogram

The ECG obtained at admission was used. Evidence of ischemia was defined as any ST deviation >0.5 mm or symmetric T-wave inversion in two or more contiguous leads.

Laboratory analysis

Laboratory testing, realized upon admission, included cardiac markers' measurement (high sensitive Troponin Ic), renal function markers' measurement (creatinine serum level), serum Hemoglobin level and serum C Reactive Protein (CRP) dosage.

Renal failure was defined by a glomerular filtration rate ≤ 60 ml/mn calculated using serum creatinine level and the Modified Diet in Renal Disease formula (MDRD) formula.

Based on laboratory results and clinical findings the GRACE risk score (The Global Registry of Acute Coronary Events) was calculated for each patient using the GRACE score calculator. http://www.gracescore.org/WebSite/default.aspx?ReturnUrl=%2f

Transthoracic echocardiography

Echocardiographic exam was performed, within 24 hours from admission, on Vivid E9 ultrasound scanner (General Electric Medical Systems, Horten, Norway) equipped with an M5S probe under electrocardiographic recording. All exams were realized by the same operator. A senior cardiologist repeated then, in a blind manner to the operator findings, the strain measures. Variability of strain measures between the operator and the senior cardiologist was calculated. When significant differences were found, the senior cardiologist had to repeated again the strain measures. In all cases, senior operator's final findings were considered the final patient's results.

For the assessment of regional Left Ventricle (LV) function, a 17-segment model was used. Segments were visually qualified as: 1 normokinetic; 2 hypokinetic; 3 akinetic, 4 dyskinetic. Segments were discarded when ultrasound quality was poor. WMSI was calculated the average score of the analyzed segments (14). Territorial wall motion score (WMSI t) was defined as the average score of segments belonging to a same coronary territory based on a theorotical anatomical distribution of coronary arteries.

LVEF was measured using the Simpson's biplane rule on the two-chamber and four chamber apical views. LVEF was described as preserved (≥ 50%) or impaired (< 50%) (19).

2D strain protocol

2D strain speckle tracking was applied to apical 2, 3and 4-chamber views. Analysis was performed directly on the echocardiographic system using AFI (Automatic Function Imaging) Segmental and Global longitudinal tele-systolic strain values were acquired and summarized as a bulls' eye. TLS was calculated by analogy to WMSI t by averaging strain values of a same coronary territory segments. A cut off -18% was defined to indicate the impairment of GLS and TLS (14).

Coronary angiography

Coronary angiographies were realized within 24 hours from admission and analyzed by an experienced interventional cardiologist, blinded to the results of the ultrasound exam, using stored cine loops with multiple angles. The culprit vessel was determined using ECG and angiographic findings (thrombus, dissection, and hematoma). Significant coronary stenosis was a ≥ 50% reduction of lumen diameter in the left main (LMA) and ≥70% at the other arteries ≥1.5 mm. Coronary occlusion was defined as TIMI (Thrombolysis in Myocardial Infarction) flow grade 0 or 1. Acute occlusions were differentiated from chronic total occlusions by angiographic pattern (thrombus, calcification) along with clinical and ECG findings. SYNTAX I Score (SS) for CAD complexity assessment was calculated using the SYNTAX I score calculator http://www.syntaxscore.com/calculator/start.htm. CAD was classified in low risk :SS≤ 22; medium risk: 22<SS<33 and high risk: SS≥ 33.

Statistical analysis

Analysis was performed on the SPSS software version 23. The Spearman test was used to for correlation between quantitative variables. The Mann-Whitney U-test was used to study the association of strain to qualitative variables. Receiver Operator Characteristics (ROC) curves identified cut-offs for best sensitivity (Se)- specificity (Sp) couples. ROC curves were compared using dedicated statistical software (MedCalc version 10.4, Mariakerke, Belgium).

The statistical significance was considered when $p < 0.05$.

Inter- and intra-observer variability were assessed by re-analyzing all included patients.

RESULTS

Between January and June 2018, 102 patients were hospitalized in our ICU for NSTEMI, 70 were eligible and were included in our study.

Demographic data and medical history

Mean age was 60.2±10.1 years. Cigarette smoking was the most common cardiovascular risk factor (CVRF) and 26% of patients had a known CAD (Table 1).

We did not find a significant relationship between GLS and age (r= 0.1, p=0.1) or gender. Among other CVRFs, GLS was associated only to diabetes (p=0.05)

Non-invasive and invasive findings

Clinical, electrocardiographic, echocardiographic and angiographic findings are summarized in Table 2. Patients with clinical heart failure signs represented 7%, 48.6% of patients had an impaired (<50%) LVEF, while 75.7% had an impaired (>-18%) GLS. Thus, 20 (37.7%) among the 53 patients who had an impaired GLS, had a normal

LVEF, while almost all patients (33/34; 97.1%) with an impaired LVEF had also an impaired GLS. Left anterior descending artery (LAD) was the culprit artery in 62% of patients. Severe CAD was observed in 34% and 16% of patients had a SS>33. Sixty-two patients (88.6%) had a revascularization most them by percutaneous coronary intervention (PCI).

Table 1. Demographic data and medical history

General characteristics	N=70
Age (years), mean ± SD	60.2 ± 10.1
Male gender, % (n)	87 (61)
Cigarette smoking, % (n)	61 (43)
Diabetes, % (n)	54 (38)
Hypertension, % (n)	46 (32)
Dyslipidemia, % (n)	31 (22)
Obesity, % (n)	18 (13)
Coronary artery disease, % (n)	26 (18)
Myocardial Infarction, % (n)	17 (12)
Percutaneous coronary intervention, % (n)	20 (14)
Coronary Artery Bypass Graft surgery, % (n)	3 (2)
Stroke, % (n)	4 (3)
Peripheral artery disease, % (n)	6 (4)
Chronic kidney disease, , % (n)	7 (5)
Dialysis, % (n)	1 (1)
Chronic obstructive pulmonary disease, % (n)	6 (4)

Table 2. Clinical, electrocardiographic, echocardiographic and angiographic findings, index hospitalization

Characteristics	N=70
clinical exam, admission	
Heart rate, mean ± SD	78.1 ± 9
Systolic blood pressure (mmHg), mean ± SD	130.6 ± 25
Heart failure, % (n)	7 (5)
Paroxysmal atrial fibrillation, % (n)	3 (2)
ECG findings, admission	
ST deviation ≥ 0.5 mm, % (n)	38 (26)
Negative symmetrical T wave, % (n)	48 (34)
Pre-existing bundle branch block, % (n)	7 (5)
Normal ECG, % (n)	7 (5)
Laboratory findings, admission	
Troponines Ic (ng/l), median [IQR]	7344 [41-71640]
CRP (mg/l), mean ± SD	19.1 ± 33
Hemoglobin (g/dl), mean ± SD	13.5 ± 2.6
Grace risk score, admission, mean ± SD	132.6 ± 29.7
Echocardiography findings, admission	
End diastolic LV volume (ml), mean ± SD	105 ± 33
End systolic LV volume (ml), mean ± SD	55 ± 29
LVEF (%), mean ± SD	49.5 ± 11.1
WMSI, mean ± SD	1.43 ± 0.39
GLS (%), mean ± SD	-14.9 ± 3.9
Coronary angiography data, admission	
Severe CAD, % (n)	34 (24)
CAD complexity	
Low risk CAD (SS≤22), % (n)	58 (41)
Medium risk CAD (22<SS<33), % (n)	26 (18)
High risk CAD (SS≥33), % (n)	16 (11)
SS, mean ± SD	16.3 ± 6.8
Culprit LAD, % (n)	62 (43)
Culprit CX, % (n)	27 (19)
Culprit RCA, % (n)	11 (8)
Acute coronary occlusion, % (n)	10 (7)
Revascularization	
Percutaneous coronary intervention (angioplasty) % (n)	78.6 (55)
Coronary artery bypass grafting % (n)	10 (7)

CAD: coronary artery disease, CX: Circumflex artery, IQR: interquartile range, LAD: left anterior descending artery, LV: left ventricle/left ventricular, LVEF: left ventricular ejection fraction, RCA: right coronary artery, SD: Standard deviation, SS: syntax score, WMSI: wall motion score index.

Feasibility and reproducibility of longitudinal strain

No patients were excluded due to suboptimal image quality on echocardiography. Longitudinal strain was obtained in 1166 (97.9%) of 1190 analyzed LV segments. Following the validation of ultrasound data, inter-operator variability for the assessment of regional longitudinal strain was 3.2%.

Association between strain and conventional prognostic parameters in Non ST elevation myocardial infarction patients:

- Association to clinical findings, risk stratification scores and biomarkers

GLS was not associated to acute heart failure. We also did not find a significant correlation of GLS to high-sensitive Troponin I (r=0.66, p=0.6) and GRACE score (r=0.12, p=0.34). GLS was correlated however to hemoglobin level: (r=-0.3, p=0.01).

- Correlation between Global Longitudinal Strain and echocardiographic parameters

A negative correlation between GLS and LVEF was observed (r=-0.74, p<0.001) (figure1A). A cut-off of GLS=-15.3% predicted LVEF impairment with a Se=80% Sp=78%. A significant positive correlation was also found between GLS and WMSI (r=0.82, p<0.001) (figure 1B). Patients with normal WMSI (n=14) had impaired GLS in 14% of cases while 86% had normal GLS (p=0.09).

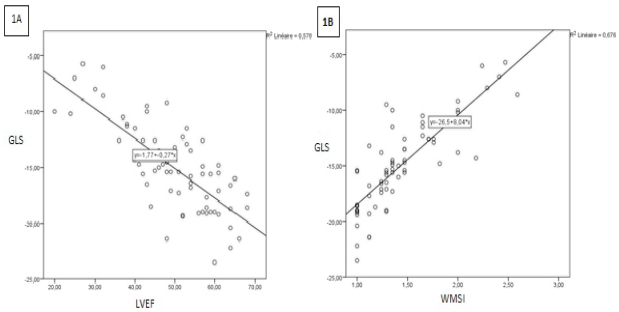
Correlation between longitudinal strain and angiographic data

- Association between Global Longitudinal Strain and coronary artery disease severity and lesions' complexity

GLS was higher in the group of patients with severe CAD; -12.8 ± 4.6% vs -16.0 ± 2.8%, p< 0.001. Among echocardiographic parameters (LVEF, WMSI and GLS), GLS had the strongest association to CAD severity with a slight advantage over WMSI and a larger one over LVEF (figure 2). GLS>-14.1% predicted severe CAD with a Se=80% and Sp=83%. We also found a correlation between GLS and coronary lesions complexity assessed by SS (r = 0.78, p=0.001), mean GLS was: -16.3 ± 2.4% in lower risk group, -14.1 ± 2.8% in medium risk group and -11.2 ± 5.1% in higher risk group (p=0.002).

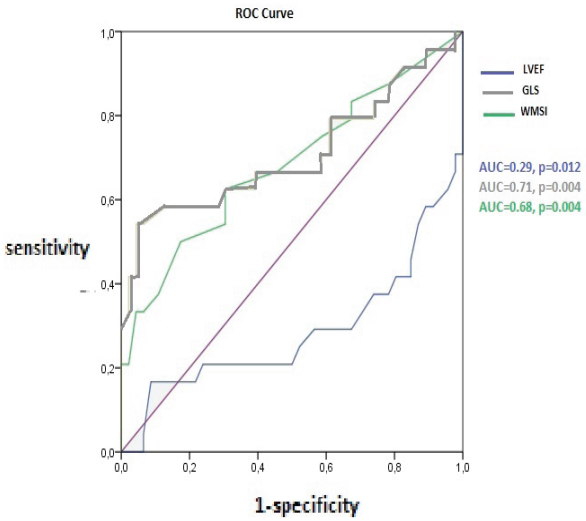
- Correlation between strain parameters, culprit vessel and vessel occlusion.

No statistical difference was observed on GLS depending on the culprit vessel was LAD (GLS:-14.5 ± 3.4%) versus circumflex (Cx) or right coronary artery (RCA) (GLS: -15.4 ± 4.1%), p=0.5. The territory with the most impaired TLS corresponded to the territory of the culprit vessel in 74% of cases; 80% in case of single or two-vessel disease versus 67% in case of three-vessel disease (p=0.04) and it was as high as 89% in patients with no history of CAD versus 56% in case or previous known CAD (p= 0.01).



GLS: Global longitudinal strain, LVEF: Left ventricular ejection fraction, WMSI: Wall motion score index

Figure 1: Scatter plots showing linear correlations of global longitudinal strain with 1A: left ventricular ejection fraction, and 1B: wall motion score index



AUC: Area under the curve

Figure 2. Receiver Operator Characteristic Curves; prediction of severe coronary artery disease by global longitudinal strain, left ventricular ejection fraction and wall motion score Index

Table 3 shows differences in parameters between patients with and without ACO. TLS in the territory of the culprit vessel had the best ability to predict its acute occlusion. The cut off value of -9.2% had a Se=85% and Sp=85%. WMSIt (p=, GLS, and troponin level, were also predictive of ACO, while the GRACE score and LVEF were not.

Table 3. Comparison between clinical, echocardiographic parameters and troponin levels between patients with and without acute occlusion of the culprit vessel.

Parameters	AOC N=7	No AOC N=63	P
Heart rate (beats / mn), mean ± SD	79 ± 8	78 ± 13	p=0.8
Systolic Pressure (mmhg), mean ± SD	128 ± 25	131 ± 25	p=0.8
Serum Troponines Ic (ng/l), mean ± SD	22271 ± 9165	6726 ± 1092	P= 0.001
GRACE risk score, mean ± SD	133 ± 28	125 ± 29	p= 0.06
TLS culprit vessel (%), mean ± SD	-7.4 ± 5.1	-14.1 ± 6.0	p<0.001
GLS (%), mean ± SD	-13.6 ± 1.8	-15.0 ± 4.0	P=0.07
LVEF (%), mean ± SD	46.9 ± 5.2	49.7 ± 11.6	p= 0.05
WMSt culprit vessel (%), mean ± SD	1.81 ± 0.36	1.39 ± 0.39	p= 0.008

AOC: acute occlusion of the culprit artery, GLS: global longitudinal strain, LVEF: left ventricular ejection fraction, TLS: culprit artery territory's longitudinal strain, WMSIt: culprit artery territory's wall motion score index

Global strain evolution and its associated factors

Median follow-up was 10 [3-12] months, during which enhancement of GLS was significant from -14.9 ± 3.8% to -17.7 ± 3.1%, (p=0.001). Patients with impaired baseline LVEF and GLS showed a greater improvement of GLS, (respectively: -3.6 ± 0.46 vs -2.0 ± 0.28 (p = 0.006) and -3.0 ± 2.3 versus -0.8 ± 1.2. (p =0.001)). Univariate analysis showed that baseline LVEF (p=0.009), WMSI (p=0.001) and GLS (p=0.001), culprit LAD (0.02) and myocardial revascularization (p=0.001) were associated to GLS improvement, while age, CVRF, GRACE score, Troponin level, and AOC did not show a significant association. In multivariate analysis only myocardial revascularization (p=0.02) and baseline GLS (p=0.001) were associated to GLS improvement.

DISCUSSION

In this prospective monocentric study carried in NSTEMI patients aged 60.2±10.1 years and having a baseline mean LVEF= 49.5 ± 11.1% and GLS = -14.9 ± 3.9%, longitudinal strain parameters were highly feasible and reproducible. GLS associated significantly associated to diabetes, it was strongly correlated to conventional TTE systolic parameters; LVEF and WMSI. GLS was, in addition, highly predictive of severe CAD, indeed, a cut off value =-14.1% had a Se=80% and Sp=83% to predict three-vessel of LMA significant lesions. GLA was also predictive of lesion complexity assessed by SS. TLS had a good diagnostic value to identify the culprit lesion especially in patients without a history of CAD. TLS > -9.2% was highly predictive of total acute occlusion of the culprit vessel (Se=85%, Sp=85%). Finally, factors associated to GLS improvement at mid-term were high baseline GLS and myocardial revascularization.

Correlation of global longitudinal strain to conventional systolic echocardiographic parameters and its association to the coronary status.

Various studies demonstrated the diagnostic value of 2D GLS in ACS (48,52) and its correlation to conventional TTE parameters.

In their study, R. Ryczek et al.(20) evaluated the correlation between GLS and other conventional ultrasound parameters in 44 patients with NSTEMI. They demonstrated a significant correlation between GLS, LVEF and WMSI (r = -0.86, p < 0.001, r = 0.8, p < 0.001, respectively) congruent to our findings. Eek et al.(21) confirmed the same results in their cohort including 61 NSTEMI patients (respectively for GLS correlation to LVEF ad WMSI; r=0.73, p<0.001; r=0.69, p<0.001). In addition, this study reported a statistically strong association between GLS and infarct size assessed accurately by magnetic resonance imaging. A cut-off value of -13.8 was prdicted with 85 % Se and 96% Sp a large infract size (>12% of LV mass), the authors suggested that value should indicate urgent coronary angiography and revascularization.

Compared to LVEF, GLS seemed more sensitive to assess ischemia in our study; 75.7% of patients had an impaired GLS while only 48.6% had an impaired LVEF. Longitudinal strain explores deformation of longitudinal sub-endocardial myocardial layers and is less load-

dependent, for these reasons it was described as a more precocious and accurate tool to assess myocardial consequences of ischemia.

In agreement with our results, earlier detection of systolic dysfunction was reported by Hubbard et al.(22); GLS detected subclinical and rest echocardiographic ischemia in 74% of cases in patients with normal LVEF. Their trial included 70 patients, with normal LVEF, divided an into two groups depending on the presence or not of CAD. Mean GLS was significantly higher in CAD group: −14.3 versus−17.2, p < .001. A cut-off value of -15.9% had 71% Se and 74% Sp to differentiate CAD group from control group. In our study all patients had at least one significant coronary artery stenosis, we did not investigate the ability of strain to detect the presence of a CAD but we confirmed its high diagnostic value to detect patients with severe CAD and we identified a cut-off value of -14.1% as predictive of severe CAD.

Hoshi and al.(23)included 50 NSTEMI patients, divided as in our study into high-risk group, with three vessel CAD or left main disease, and a low-risk group having one or two vessel CAD. They found a significant association between GLS and the severity of CAD. They identified a cut-off value lower than ours; -19.5% to predict severe CAD with, however a lower Sp (62%) than in our study and a Se of 86%.

Jin-Oh Choi et al.(24)evaluated longitudinal deformation in 108 patients with either severe CAD, moderate CAD or normal coronary arteries. They similarly to the previous described study identified a threshold value of GLS = -19.4% to predict severe CAD with a Se=76% and Sp=74%. A comparison of basic ultrasound characteristics with the previous two studies is summarized in table 4.

Table 4. Studies' comparison: baseline data.

Studies	Population	CAD history	LVEF (%), mean ± SD	GLS (%), mean ± SD	WMSI, mean ± SD
Hoshi and al	NSTEMI	None	60 ± 5	-19.2 ± 2.8	1.1 ± 0.2
Choi and al	Stable CAD	None	67 ± 5	-19.6 ± 2.7	1
Our study	NSTEMI	26%	49 ± 11	-14.9 ± 3.8	1.43 ± 0.39

CAD: coronary artery disease, GLS: Global longitudinal strain, LVEF: left ventricular ejection fraction, NSTEMI: non ST elevation myocardial infarction, WMSI: Wall motion score index.

Zang and al.(25)assessed the correlation between ultrasound parameters, risk stratification scores and the severity of CAD. This study included 139 patients without any coronary history admitted in the ICU unit for NSTEMI. They demonstrated the superiority of GLS and TLS over WMSI and LVEF in predicting CAD severity and complexity. Like in our study, the authors did not identify a significant correlation between GLS, TLS and GRACE risk score (p=0.2).

Concerning the prediction of lesion complexity of CAD by SS, Vrettos and al.(26) led a study in stable CAD cohort and found a significant correlation between GLS and the SS (r = -0.75, p <0.001). A cut-off value of GLS at -13.9% predicted a SS >22 with a Se = 71% and Sp = 90%.

These findings corroborate ours and confirm that GLS is a powerful tool to anticipate CAD severity and complexity, two major prognostic invasive factors.

Prediction of the culprit artery

In Thibault and al.(27) cohort study in 58 NSTEMI patients with preserved LVEF and normal WMSI, a high concordance was found between the presumed culprit vessel according to TLS and that determined by the coronary angiography. In our study the ability of TLS to detect the culprit artery dependent on the severity and diffusion of their lesions, and importantly to the presence of not of previous CAD events.

Association between longitudinal strain parameters and acute coronary occlusion

NSTEMI patients are a heterogeneous population, management strategy depends on a number of clinical, electrical and biological markers (28). Nearly one-quarter of these patients had acute total occlusion of the culprit vessel. This entity shares with STEMI this pathophysiological characteristic, in two-thirds of cases (but not all of them), however, the vessel is already collateralized at the time of coronarography (29,30). Among other factors, ACO is in favor of an early invasive. ECG has limited sensitivity (< 70%) to detect ACO (31,32). One-third of patients with ACO do not develop ST elevation, and are diagnosed as NSTEMI (33). The other clinical and biomarker also have limited sensitivity to identify ACO. These patients did not fulfill criteria for immediate reperfusion therapy but were at high risk of extensive transmural myocardial damage (28). In this context, the use of strain seemed promising giving

its simplicity, rapidity and accuracy to assess the ischemic risk area (34,35)

TLS > -9.2% predicted in our study ACO and indicated urgent invasive strategy. Only myocardial revascularization in these patients with important strain impairment could limit infarct damage and predict myocardial recovery and GLS improvement Grenne et al.(36) found a greater impairment of LV systolic function TTE parameters in 111 NSTEMI patients with ACO . The correlation was markedly significant with strain (r = 0.79, p = 0.001). Eek and al.(37) confirmed the utility of strain to predict ACO in NSTEMI and identified a cut off value of GLS= -16.3% (Se=67%, Sp=71%). A functional risk area by strain of minimum four segments yielded a Se=85% and Sp=70% to predict ACO. In our study GLS could not predict ACO and TLS was the best parameter to detect ACO with higher threshold value than Eek et al GLS cut-off value. This could be explained by an insufficient power of our study to detect significant association between GLS and ACO, the presence of a history of previous CAD in 26% of patients could also limited GLS diagnostic value.

Limits of the study

The monocentric character and the number of patients limited the power of this study, some negative results could be explained by this factor. Previous coronary events in one quarter of patients could alter diagnostic properties of strain. Finally, the long-term prognostic value of strain was not assessed,

CONCLUSION

2D strain parameters showed interesting diagnostic and prognostic value in NSTEMI, we suggest their routine measurement in the early hours, to assess the diffusion of ischemic risk area, to predict the culprit artery, the severity and complexity of CAD and to detect AOC. All of these data should better shape the management strategy to the individual patient.

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