中文題目：運用牛眼圖形變影像分析 Dobutamine 負荷式超音波以診斷冠狀動脈疾病之探討

英文題目： Strain Imaging with Bull’s eye map for Detecting Significant Coronary Stenosis During Dobutamine Stress Echocardiography

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Background:

Dobutamine stress echocardiography (DSE) is the best modality for CAD detection in patients who cannot exercise adequately. The visual estimation of stress-induced transient regional wall motion abnormalities are subjective and requires expertise to achieve high accuracy. Disagreement in expert diagnostic results has been reported in an inter-institutional study. Following the advent of tissue Doppler and 2-dimensional (2D) speckle tracking analysis, several investigators have attempted to apply deformation imaging to obtain quantitative information to enhance diagnostic accuracy. There is currently no consensus regarding which parameter and which cut-off value of strain and/or strain rate is most appropriate for high diagnostic accuracy. Although the bull’s eye map of longitudinal strain (LS) provides one-look recognition of the severity and extent of longitudinal dysfunction, no studies have determined its potential utility during DSE. Furthermore, the effect of expertise on the diagnostic accuracy has not been determined. Accordingly, the aim of this study was 1) to compare diagnostic accuracy between visual analysis and strain assessment using a bull’s eye map for detecting significant CAD, and 2) to investigate the effect of expertise (expert and fellow physicians) on the diagnostic accuracy of strain analysis against visual assessment during DSE.

Methods:

We retrospectively enrolled 37 patients who undergone both DSE and coronary angiography within 6 months (**Table 1**). Two investigators individually performed both the visual assessment and 2D strain analysis with speckle tracking software during DSE: one with more than 20 years of experience in stress echocardiography and 10 years of experience in 2D strain analysis (expert physician); the other had 1 year experience in both techniques (fellow physician). 2D speckle tracking analysis with use of vendor-dependent (GE) and vendor-independent (Epsilon and TomTec) software was performed on three apical views. Bull's eye map of longitudinal strain (LS) was generated at baseline and peak stress. Significant CAD was defined by the following criteria: at least 2 contiguous segments in the specific coronary artery territory at peak stress had (1) > 1% reduction in LS with an increase in the post-systolic shortening (GE), or (2) > 3% reduction in LS (Epsilon and TomTec) when being compared with baseline.

Table 1. Baseline characteristics of study participants

Variables	N = 37
Age, years	73.4±10.9
Female	16 (43)
Body surface area, m^2	1.55±0.19
Hyperlipidemia	19 (51)
Hypertension	24 (65)
Diabetes Mellitus	16 (43)
Current or previous smoking	9 (24)
Old myocardial infarction	10 (27)
LV hypertrophy	23 (62)
Beta-blocker	12 (32)
Calcium channel blocker	7 (19)
Nitrates	2 (5)
LVEF, %	68 (52.5－76.5)
LV mass index, g/m2	117.9 (92.8－135.2)
Baseline wall motion abnormality	14 (38)
Coronary angiography	
Coronary artery disease	25 (68)
No significant stenosis	12 (24)
One-vessel disease	10 (27)
Multi-vessel disease	15 (41)
Left anterior descending artery affected	17 (46)
Hemodynamics	
Baseline systolic blood pressure, mmHg	155.6±25.7
Peak systolic blood pressure, mmHg	162.4±37.2
Baseline heart rate, beat per minute, mmHg	67.6±13.3
Peak heart rate, beat per minute, mmHg	119.6±25.5
% predicted heart rate achieved, %	86.1±14

Values are mean ± standard deviation (SD) or n (%).

Results:

Twenty-five patients had significant CAD, including 17 with left anterior descending coronary artery (LAD) stenosis and 19 with non-LAD stenosis. Strain imaging provides a marginal increase in diagnostic accuracy over visual assessment on a patient basis; however, no diagnostic benefit was observed in detecting significant stenosis in LAD versus non-LAD by the expert (**Table 2**). The same trend was also observed for the fellow. However, strain analysis by the fellow had a significantly higher sensitivity but lower specificity compared with the expert.

Table 2: Diagnostic accuracy by visual and strain imaging assessment for detecting > 50% coronary stenosis

Patient	**Sensitivity**		**Specificity**		**Diagnostic accuracy**		**Positive predictive value**		**Negative predictive value**	
	expert	fellow	expert	fellow	expert	fellow	expert	fellow	expert	fellow
Visual analysis	56% (14/25)	56% (14/25)	83% (10/12)	58% (7/12)	65% (24/37)	57% (21/37)	88% (14/16)	74% (14/19)	48% (10/21)	39% (7/18)
GE	78% (18/23)	83% (19/23)[§]	55% (6/11)	10% (1/10)[¶§]	71% (24/34)	61% (20/33)	78% (18/23)	68% (19/28)	55% (6/11)	20% (1/5)
Epsilon	68% (17/25)	96% (24/25)	42% (5/12)	0% (0/12)[§]	59% (22/37)	65% (24/37)	71% (17/24)	67% (24/36)	38% (5/13)	0% (0/1)
TomTec	84% (21/25)	84% (21/25)	33% (4/12)[§]	42% (5/12)	68% (25/37)	70% (26/37)	72% (21/29)	75% (21/28)	50% (4/8)	56% (5/9)
LAD	**Sensitivity**		**Specificity**		**Diagnostic accuracy**		**Positive predictive value**		**Negative predictive value**	
	expert	fellow	expert	Fellow	expert	fellow	expert	fellow	expert	fellow
Visual analysis	47% (8/17)	41% (7/17)	95% (19/20)	85% (17/20)	73% (27/37)	65% (24/37)	89% (8/9)	70% (7/10)	68% (19/28)	63% (17/27)
GE	41% (7/17)	75% (12/16)	76% (13/17)	47% (8/17)[§]	59% (20/34)	61% (20/33)	64% (7/11)	57% (12/21)	43% (10/23)	67% (8/12)
Epsilon	53% (9/17)	94% (16/17)[¶§]	55% (11/20)[§]	20% (4/20)[¶§]	54% (20/37)	54% (20/37)	50% (9/18)	50% (16/32)	58% (11/19)	80% (4/5)
TomTec	47% (8/17)	82% (14/17)[§]	45% (9/20)[§]	50% (10/20)[§]	46% (17/37)[§]	65% (24/37)	42% (8/19)	58% (14/24)	50% (9/18)	77% (10/13)
RCA/LCX	**Sensitivity**		**Specificity**		**Diagnostic accuracy**		**Positive predictive value**		**Negative predictive value**	
	expert	fellow	expert	fellow	expert	fellow	expert	fellow	expert	fellow
Visual analysis	37% (7/19)	42% (8/19)	89% (16/18)	67% (12/18)	62% (23/37)	54% (20/37)	78% (7/9)	57% (8/14)	57% (16/28)	52% (12/23)
GE	65% (11/17)	82% (14/17)[§]	53% (9/17)[§]	19% (3/16)[§]	59% (20/34)	52% (17/33)	58% (11/19)	52% (14/27)	60% (9/15)	50% (3/6)
Epsilon	68% (13/19)	89% (17/19)[§]	56% (10/18)	11% (2/18)[¶§]	62% (23/37)	51% (19/37)	62% (13/21)	52% (17/33)	63% (10/16)	50% (2/4)
TomTec	84% (16/19)[§]	63% (12/19)	50% (9/18)[§]	44% (8/18)	68% (25/37)	54% (20/37)	64% (16/43)	55% (12/22)	75% (9/12)	53% (8/15)

LAD, left anterior descending artery; LCX: left circumflex artery; RCA: right coronary artery.
¶ $p < 0.05$ between the expert and the fellow.
§ $p < 0.05$ between visual assessment and strain analysis.

As for inter-vendor variability of GLS, an excellent correlation with GLS was noted for each comparison of the two software at baseline (r=0.85 to 0.87) as well as at peak stress (r=0.81 to 0.84, Figure 1).

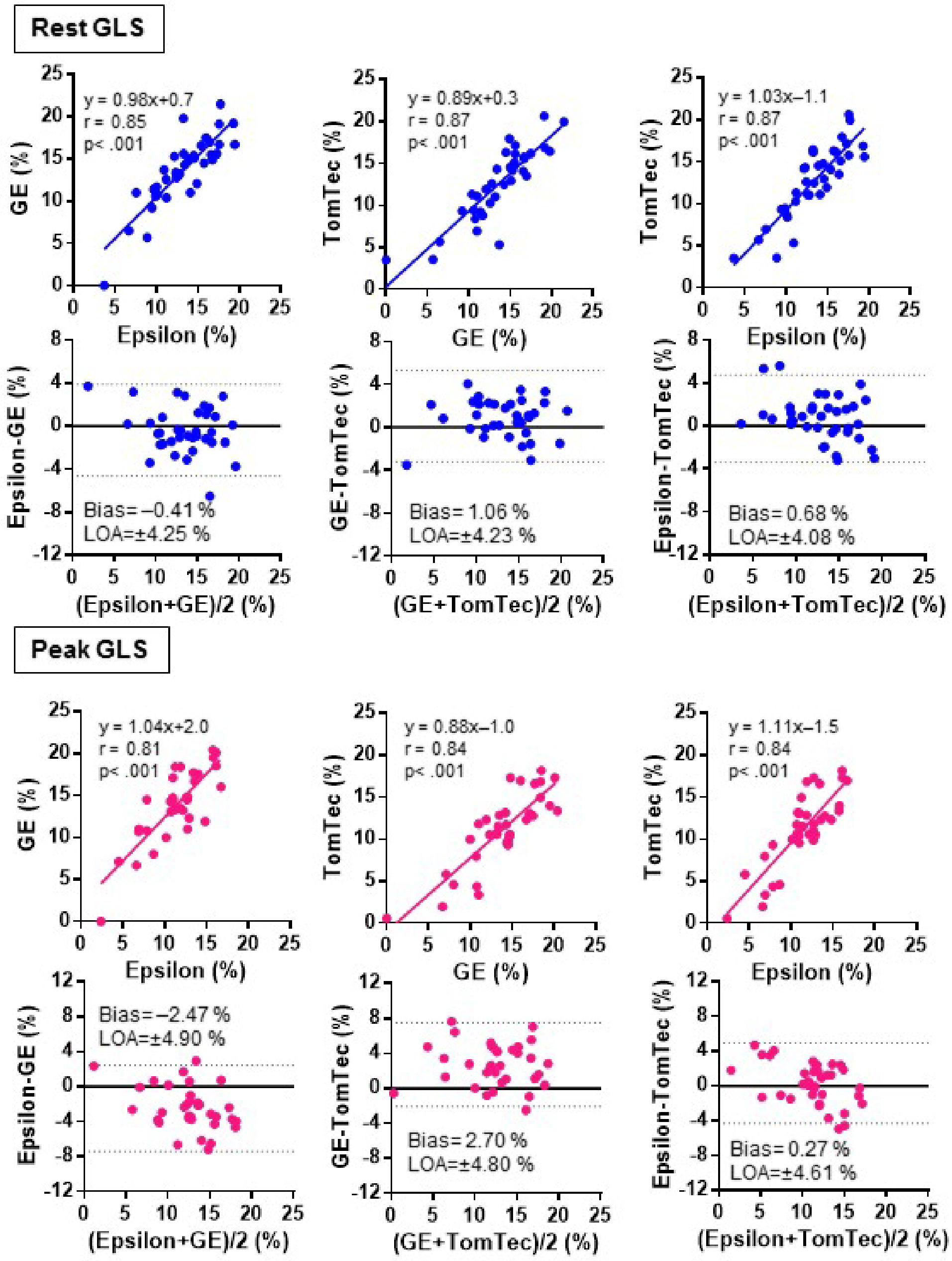

Figure 1: Linear correlation and Bland-Altman analysis of global longitudinal strain between three speckle tracking software used by the expert. Panel A shows a correlation at baseline, and panel B shows a correlation at peak stress. The 95% limit of agreement (LOA) is presented as 1.96 standard deviations (SDs).

A representative case with discordant results is shown in Figures 2.

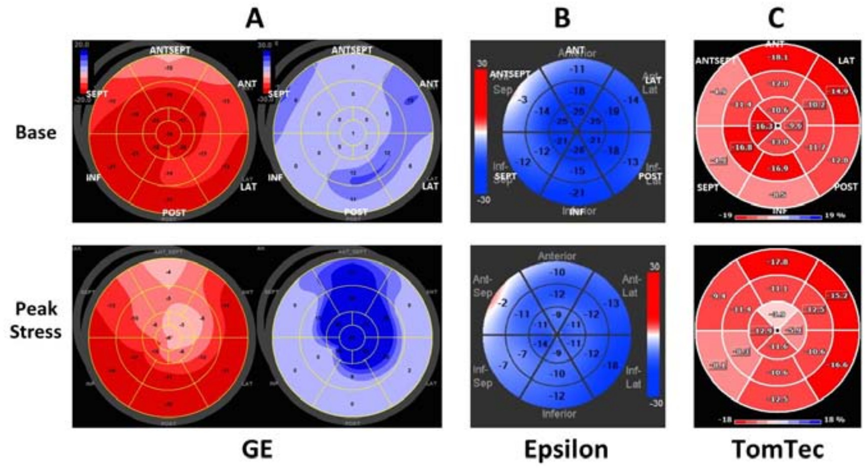

Figure 2: A representative case with concordant results.
The upper panel shows a baseline bull's eye map generated using GE (A), Epsilon (B) and TomTec (C) software, and the lower panel shows the corresponding map at peak stress. GE provides both the peak systolic longitudinal strain (LS) map and post-systolic shortening (PSS) map.
At baseline, all LS maps show some reduction in the strain values at the basal region of the myocardium.
A: At peak stress, there are reductions in LS and the development of PSS in the left anterior descending coronary (LAD) territory according to GE software.
B: >3% reduction in LS are observed in 3 major coronary artery territories using Epsilon software at peak stress.
C: >3% reduction in LS are shown in the right coronary artery (RCA) and LAD territories using TomTec software.
Stress-induced apical wall motion abnormalities are clearly diagnosed via visual assessment (see movie 1). Coronary angiography revealed 3-vessel disease.
Ant, anterior segments; ant sept, anteroseptal segments; inf sept, inferior segments; lat, lateral segments; post, posterior segments; sept, septal segments.

Conclusions

Strain analysis with a bull's eye map had no obvious benefits over visual analysis for CAD diagnosis during DSE. Expertise affects not only visual wall motion estimation but also deformation analysis for detecting significant CAD.