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Comparison of left ventricular deformity and twist parameters during Speckle Tracking with Philips iE33 and Affiniti 70 scanners

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SOUHRN

Cíl: Cílem této studie bylo porovnat parametry napětí a zkroucení stěny levé komory měřené metodou speckle tracking echocardiography (STE) se skenery firmy Philips s různým softwarem.
Materiál a metody: V odstupu 30 minut bylo za stejných podmínek vyšetřeno 36 pacientů s akutním koronárním syndromem (AKS; nestabilní angina pectoris a infarkt myokardu) ultrazvukovými skenery Philips iE33 (Q-lab, verze 7.1, 2009) a Affiniti 70 (aCMQ, 2019). Skenování a měření primárních parametrů se provádělo ve stejných apikálních řezech a v řezech v krátké ose levé komory srdeční (LK). Měřenými parametry byly longitudinální napětí (longitudinal strain, LS), obvodové napětí (circumferential strain, CS), rotace a zkroucení LK. Opakovaná shoda výsledků byla hodnocena metodou podle Blanda–Altmana.
Výsledky: Největší pozitivní vztah LS byl nalezen v bazálním segmentu spodní stěny LK (r = 0,79; *p* < 0,001). U pacientů bez abnormální kinetiky stěn (wall motion abnormalities, WMA) LK při měření skenerem Affiniti 70 byly hodnoty podstatně nižší než hodnoty deformace naměřené přístrojem Philips (–9,1 [–12,5 až –8,0] pro přední stěnu a –10,7 [–13,4 až –7,8] pro spodní stěnu LK; r < 0,01). Posun hodnot LS u anteroseptální stěny činil 3,1 ± 3,6 % a u spodní stěny 1,46 ± 5,8 %. Analýza korelace hodnot CS naměřených různými skenery nezjistila statisticky významné vztahy. Mírně pozitivní vztah byl zaznamenán mezi zkroucením (r = 0,49; *p* < 0,01) a narovnáním (r = 0,38; *p* < 0,05) LK bez statisticky významného rozdílu v parametrech. Hodnoty posunu a narovnáním stěny LK byly 0,14 ± 0,52°/cm, respektive 0,09 ± 0,32°/cm.
Závěry: Nejshodnější výsledky při měření skenery Philips iE33 (Q-lab) a Affiniti 70 (aCMQ) byly nalezeny u LS bazálního segmentu spodní stěny a středního segmentu anteroseptálních stěn, zkroucení a narovnání stěny LK vyšetřených pacientů s AKS. Největší variabilita mezi hodnotiteli byla zaznamenána při posuzování výsledků ultrazvukového vyšetření na šedé stupnici v případě segmentálního CS při použití softwaru skenerů iE33 a Affiniti 70.

ABSTRACT

Aim: The purpose of this study was to compare the strain and twist parameters measured by Philips scanners with different software using the Speckle Tracking Echocardiography (STE) method.
Material and methods of the study: 36 patients with the acute coronary syndrome (ACS) (unstable angina pectoris and myocardial infarction) were investigated on the ultrasonic scanners Philips iE33 (Q-lab, version 7.1, 2009) and Affiniti 70 (aCMQ, 2019) under the same conditions with an interval of 30 min. Scanning and measurement of the primary parameters were performed from the same apical and short-axis sections of the left ventricle (LV). Longitudinal strain (LS), circumferential strain (CS), LV rotation and twist were measured. The consistency of the results was assessed using the Bland–Altman method.
Findings: The greatest positive LS relationship was found in the basal segment of the LV inferior wall (r = 0.79; *p* <0.001). For patients without wall motion abnormalities (WMA) LS when measured with Affiniti 70 scanner they proved to be substantially lower than the normal value for the Philips deformation (–9.1 [–12.5; –8.0] for the front wall and –10.7 [–13.4; –7.8] for the inferior wall LV, r <0.01). The shift in LS values for the anteroseptal wall was 3.1±3.6%, for the inferior wall 1.46±5.8%. Correlation analysis of CS values measured by different scanners did not reveal statistically significant relationships. A moderate positive relationship was found between twist (r = 0.49; *p* <0.01) and untwist (r = 0.38; *p* <0.05) of the LV without a statistically significant difference in parameters. The displacement of twist values is 0.14±0.52°/cm, and of untwist is 0.09±0.32°/cm.

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Conclusions: The most comparable results when working on the Philips iE33 (Q-lab) and Affiniti 70 (aCMQ) scanners were found for the LS of the basal segment of the inferior, middle segment of the anteroseptal walls, twist and untwist of the left ventricle of the examined patients with ACS. The greatest intra-operator variability in tracking ultrasound grayscale spots with the software of iE33 and Affiniti 70 scanners was found for segmental CS.

Keywords:
Deformation of left ventricle
Speckle tracking echocardiography

Introduction

Recently, the STE method has become more and more common in clinical practice, owing to the improvement of imaging algorithms, improvement of ultrasound technology, and introduction of reference values of deformity parameters and comparability with other methods of deformity assessment.[1,2] However, unlike magnetic resonance imaging (MRI), echocardiography is more operator-dependent. Image selection is currently required to obtain deformation values, which goes beyond the standard echocardiographic protocol.[3–5] Despite the attempts made to standardize the parameters of deformations, there are still substantial ranges of deformation measurements from various equipment manufacturers, which hampers direct comparison of results.[6–14] When comparing the reproducibility of the deformation parameters, the best result is obtained for the global parameters (global longitudinal deformation). The average absolute difference between repeated measurements of various parameters of longitudinal deformation is 1–14%.[4,8,9,15]

The purpose of this study was to compare the strain and twist parameters measured by Philips scanners with different software using the STE method.

Materials and methods of research

The study involved 36 patients with ACS (unstable angina pectoris, acute myocardial infarction). All patients underwent 12-lead ECG. The presence of Q or non-Q postinfarction focal changes in the myocardium was detected. Echocardiography (echo) was performed on the 7th day of hospitalization by one operator using Philips iE33 ultrasound scanners (software for ASSAY Q-lab version 7.1, 2009) with an S5-1 (1.7–3.5 MHz) transducer (Philips Vetra Sound) and Affiniti 70 (software for automatic ASSAY of heart movement aCMQ, 2019) with an S5-1 transducer (1.7–3.5 MHz). Thus, each patient was examined twice, first with the iE33 device, then with the Affiniti 70 scanner in a 30-minute interval. Scanning and measurement of the main parameters were performed from the same apical and short-axis sections of the left ventricle (LV). Apical sections are represented by two-chambered, four-chambered, and apical long-axis sections. Short-axis sections were scanned at the basal, middle, and apical levels. As a result of echocardiography, the following parameters were obtained: left atrial volume, course LV systolic volume, LV ejection fraction (Simpson), LV myocardium mass. WMA was diagnozed based on echo criterion - systolic thickening of the LV wall. Hypokinesia is a decrease in systolic thickening compared to adjacent segments (or thickening less than 20%), akinesia – the absence of systolic thickening of the studied LV segment.

A high-quality two-dimensional image of echocardiography was used to analyze the deformation of the myocardium. The anteroseptal wall was located in the apical long-axis section. The inferior wall of the left ventricle was examined in a two-chamber apical section. A prerequisite for the inferior wall localization was the absence of a right ventricle in the scanning sector. The frame rate for each pair of measurements was the same and varied from 60 to 80 per second. When working with the iE33 scanner, the resulting images were archived on a CD. Obtained data was processed on a personal computer (PC) with the off-line software package QLAB 7.1 (Philips). The Affiniti 70 scanner software made it possible to process and obtain data immediately upon completion of examination (within 10 minutes) without the use of additional programs and a PC. All poor-quality images with drift curves were discarded. In STE mode, the maximum systolic peaks of LS and CS deformity of LV segments (%) were determined. When examining short-axis sections at the level of the mitral valve (basal) and apical segments (apical) based on the rotation curve, the systolic (before the aortic valve closure) and diastolic rotation were determined. Twist was calculated as the difference between apical and basal rotation (°). The twist and untwist indices are the ratio of twist and the size of the long axis of the left ventricle in the apical section (°/centimeter).

Methods of parametric and non-parametric statistics were used for statistical assessment of the obtained data. In the case of a normal distribution (the Kolmogorov–Smirnov test was used for the assessment), the Student's t-test was used to determine the significance of the difference between the mean values. In the absence of a normal distribution of the trait, a comparison was made using the Mann–Whitney U-test. When comparing several independent nonparametric features, the Kruskal–Wallis test was performed. The statistical relationship between random variables was studied when conducting correlation analysis (Spearman's rank correlation). The consistency of the results was assessed using the Bland–Altman method. The method makes it possible to compare the results of measurements performed in two different ways. The fact of the matter is that the difference and the average are calculated for each pair of measurements. The average difference, calculated for all pairs of signs in the data set being investigated, characterizes the systematic divergence of indices, which presence indicates the incomplete correspondence of the results, obtained by different methods, and the standard deviation of differences – the degree of scatter of the results. Differences were considered statistically significant at $p < 0.05$. The data in the tables are presented as (M±SD) or Me (25; 75 quartiles).

Results

As a result of the study, the following signs of the examined patients with ACS were obtained (Table 1).

As can be seen from Table 1, no predominance of WMA in anterior or inferior walls has been revealed. Male sex is a known risk factor for coronary heart disease. The size and contractility of the LV are within the normal values.[16]

Comparisons were made of peak LS measured by the software of Philips iE33 (Q-lab) and Affiniti 70 (aCMQ) ultrasonic scanners (Table 2).

As can be seen from Table 2, the greatest positive LS relationship was found in the basal segment of the LV inferior wall. Peak LS values as measured by the Affiniti 70 scanner are significantly lower. Moreover, the revealed dependence is characteristic in the segments with the highest sensitivity and specificity for the diagnosis of WMA of the corresponding LV wall.[17]

The LS value was analyzed depending on the presence of the WMA of the studied segment. In patients with ACS without WMA of the anterior wall, the LS peak of the anteroseptal wall of the LV when scanning with iE33 and Affiniti 70 differed significantly (–15.6 [–18.7; –11.7] and –9.1 [–12.5; –8.0], respectively, $p < 0.001$) (Fig. 1).

Consequently, the LS values of the anteroseptal wall of patients without WMA of the anterior LV wall obtained by the software of Affiniti 70 scanner are significantly lower than normal values.[16]

In the presence of WMA of the anterior LV wall (n = 16), the magnitude of the LS peak of the middle segment of the anteroseptal LV wall when scanned with iE33 and Affiniti 70 did not differ (–6.6 [–10.4; –3.8] and –4.3 [–9.2; –1.4], respectively, $p > 0.05$). Comparison of LS values of the anteroseptal wall in patients with WMA of the anterior LV wall using the Bland–Altman method revealed a shift in the mean value of the absolute error by 3.1% (95% CI: 1.16–5.0%) (Fig. 2).

The location of the values predominantly above the baseline indicates that the software of Affiniti 70 scanner underestimates the low LS values of the LV anteroseptal wall.

Comparison of LS of the LV inferior wall in patients without WMA of the inferior wall revealed lower deformity peak values when scanned with Affiniti 70 (–14.8 [–18.6; –9.7] and –10.7 [–13.4; –7.8], respectively, $p < 0.01$) (Fig. 3).

In patients with WMA (n = 15) of the inferior LV wall, no differences in LS of the basal segment of the inferior wall were revealed when scanned with iE33 and Affiniti 70 (–7.2 [–8.6; –5.1] and –5.1 [–7.6; –3.0], respectively, $p > 0.05$).

The bias in the mean value of the absolute error was 1.46% (95% CI: 4.7–1.8%) (Fig. 4).

As can be seen from Figure 4, for the inferior wall there is less, but still some underestimation of the low LS values of the basal segment of the LV inferior wall remaining when examined with the Affiniti 70 scanner.

Correlation analysis of CS values of the anteroseptal and inferior LV walls, measured by iE33 and Affiniti 70 scanners, did not reveal statistically significant relationships in the inferior and anteroseptal LV walls ($p > 0.05$).

The differences in the values of the apex rotation are considered, since the latter makes the main contribution to the twisting and untwisting of the LV (Table 3).[6,18]

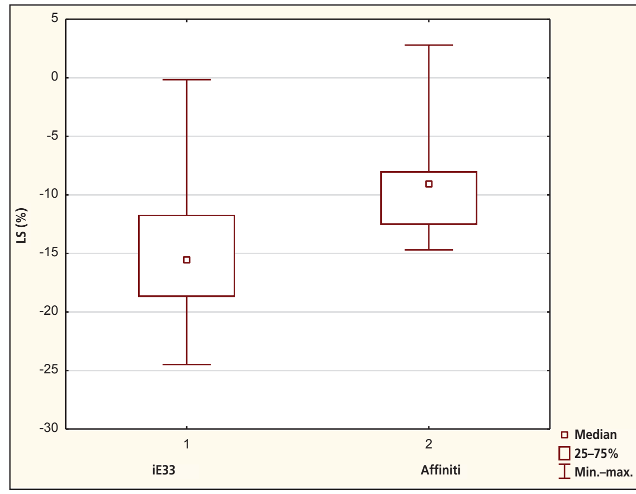

Fig. 1 – Comparison of LS peaks of the middle segment of the anteroseptal wall of the examined patients with ACS without WMA of the anterior LV wall (n = 20).

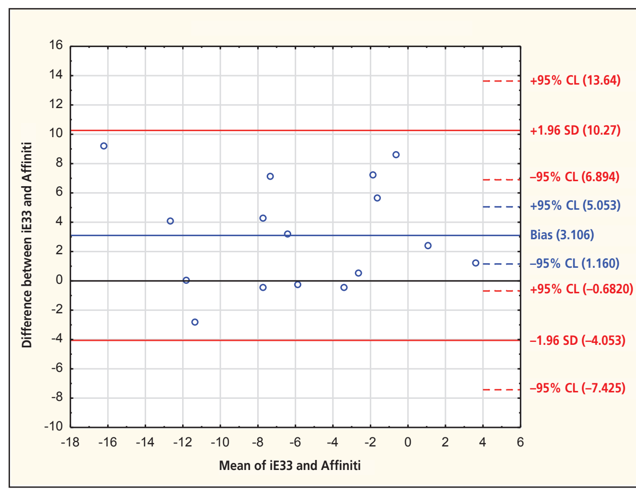

Fig. 2 – Bland–Altman diagram comparing the LS measurements of the middle segment of the anteroseptal wall from iE33 and Affiniti 70 scans of the examined patients with ACS with WMA of the anterior LV wall. Here and in Figures 4, 5 and 6 each marker displays a separate pair of data, each marker type corresponds to a separate patient. The solid horizontal line shows the average difference between LS iE33 and Affiniti. The dotted line shows the upper and lower 95% consistency limit. The abscissa axis is the average over a pair of measurements; the ordinate axis is the absolute error. Bias is an offset. SD is the root mean square (standard) deviation. Displacement = 3.1%; upper limit (95% = 5.0%); lower limit (–95% = 1.1%). Standard deviation = 3.6%; standard error = 0.91%.

A moderate positive relationship was found between the twist and untwist parameters, measured with the software of Philips iE33 and Affiniti 70 scanners. There was no statistically significant difference in the parameters.

Comparison of the twist index measured by Philips iE33 and Affiniti scanners using the Bland–Altman method revealed a relatively small bias (Fig. 5).

Figure 6 presents a Bland–Altman diagram showing a comparison of the results of measuring the untwist index of the examined patients when scanning with iE33 and Affiniti 70.

Table 1 – Clinical, instrumental, and nosological characteristics of the examined patients with ACS

Index			Value
Mean age, years			63.1±10.0
Gender	Male		28 (77.8%)
	Female		8 (22.2%)
Nosology	Unstable angina pectoris		14 (38.9%)
	Myocardial infarction	Anterior	14 (38.9%)
		Inferior	8 (22.2%)
Wall motion abnormalities Anterior Inferior		No	9 (25%)
		16 (44.4%)	
		11 (30.6%)	
Postinfarct changes on the ECG Anterior Inferior		No	13 (36.1%)
		13 (36.1%)	
		10 (27.8%)	
HR, beats per minute		69.4±11.0	
LA volume index, ml/m^2		33.6±11.6	
Index of MMLV, g/m^2		86.7 (73.3; 109.2)	
Index of ESVLV, мml/m^2		21.2 (14.7; 34.8)	
LVEF, %		55.9±11.8	

EF – ejection fraction; ESVLV – end-systolic volume of left ventricle; LA – left atrium; MMLV – mass of myocardial left ventricle.

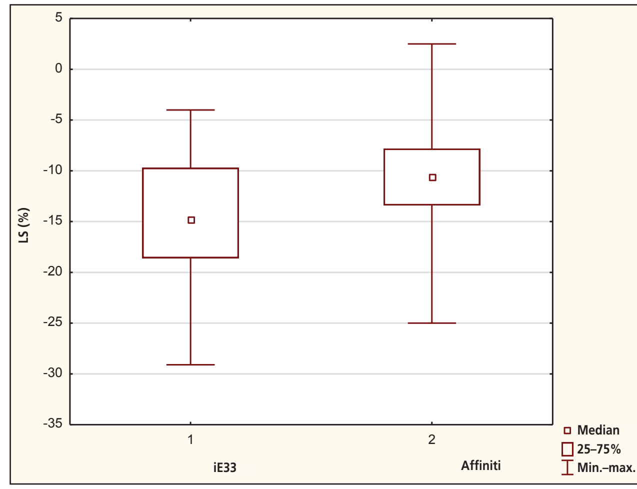

Fig. 3 – Comparison of LS peaks of the basal segment of the LV inferior wall in patients with ACS without WMA of the inferior wall (n = 21).

As can be seen in Figure 6, no significant displacement in the untwist index values was found.

Discussion

The purpose of this study was to investigate a type of intra-operator variability, where the software of the

Table 2 – Comparison of the LS sizes of ultrasonic scanners Philips iE33 and Affiniti 70 of the examined patients with ACS

Walls/segments of LV		iE33	Affiniti 70	*p*^{1}	r	*p*^{2}
Inferior	B	–10.4 (–16.5; –6.6)	–8.4 (–11.8; –4.6)	<0.01	0.79	<0.001
	M	–12.5 (–14.3; –8.4)	–10.0 (–13.4; –7.3)	>0.05	0.33	<0.05
	A	–13.0 (–18.6; –6.6)	–15.4 (–19.1; –7.5)	>0.05	0.69	<0.001
Antero septal	B	–5.2 (–9.7; –3.5)	–6.8 (–10.0; –4.3)	>0.05	0.25	>0.05
	M	–11.6 (–16.5; –6.6)	–8.3 (–11.6; –3.7)	<0.001	0.56	<0.001
	A	–15.5 (–20.7; –6.3)	–12.3 (–17.8; –8.4)	>0.05	0.43	<0.01

Note: here and in the Table 3 – *p*^{1} – statistical significance of the difference in LS of the indicated LV segments; *p*^{2} – statistical significance of Spearman's rank correlation coefficient; r – Spearman's rank correlation coefficient.
A – apical (apical segment); B – basal (basal segment); M – middle (middle segment).

Table 3 – Comparison of the values of twist and untwist of the studied examined patients with ACS, measured by the iE33 and Affiniti 70 scanners

Index	iE33	Affiniti 70	*p*^{1}	r	*p*^{2}
Systolic apex rotation, °	3.3 (1.3; 5.1)	3.5 (2.0; 5.0)	>0.05	0.47	<0.01
Twist index, °/cm	0.81 (0.43; 1.3)	0.9 (0.6; 1.2)	>0.05	0.49	<0.01
Diastolic apex rotation, °	0.7 (–0.16; 1.7)	0.5 (–0.3; 1.3)	>0.05	0.42	<0.05
Untwist index, °/cm	0.24 (0.11; 0.41)	0.37 (0.15; 0.53)	>0.05	0.38	<0.05

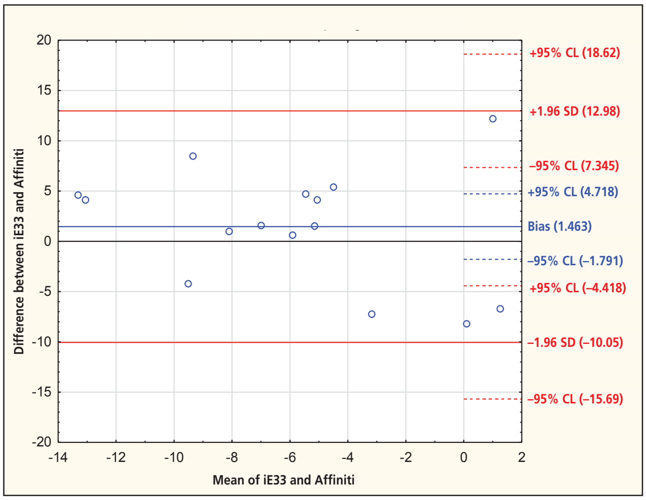

Fig. 4 – Bland–Altman diagram comparing the LS measurements of the basal segment of the inferior wall from iE33 and Affiniti 70 scans of the examined patients with ACS with WMA of the inferior LV wall. Displacement = 1.46%; the upper limit (95% = 4.7%); the lower limit (–95% = –1.8%). Standard deviation = 5.8%; standard error = 1.5%.

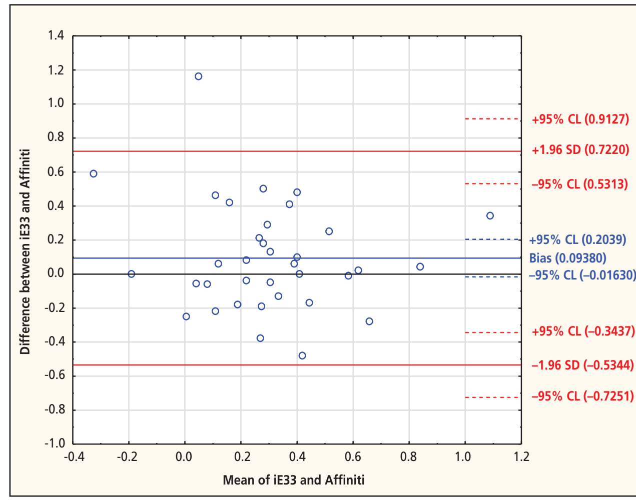

Fig. 6 – Bland–Altman diagram comparing the untwist index measurements from iE33 and Affiniti 70 scans of examined patients with ACS. Displacement = 0.09°/cm; upper limit (95% = 0.2°/cm); lower limit (–95% = 0.02°/cm). Standard deviation = 0.32°/cm; standard error = 0.05°/cm.

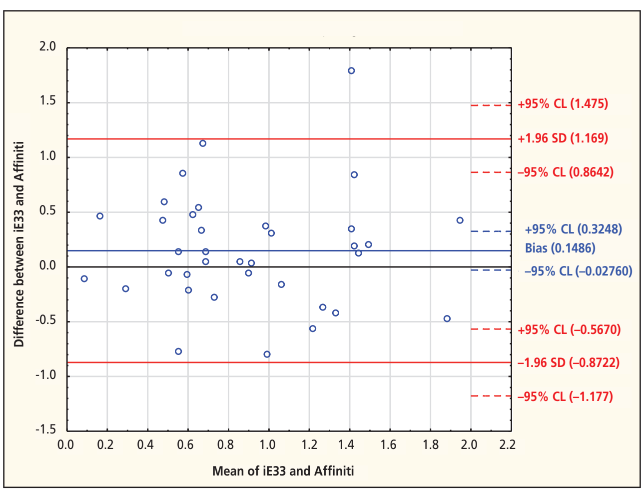

Fig. 5 – Bland–Altman diagram comparing the results of the twist index measurement in the iE33 and Affiniti 70 scans of examined patients with ACS. Displacement = 0.14°/cm; upper limit (95% = 0.32°/cm); lower limit (–95% = 0.03°/cm). Standard deviation = 0.52°/cm; standard error = 0.09°/cm.

ultrasound scanner was the only variable. The study compared the software of Philips: iE33 (Q-lab) systems – a premium device (2009) and the more modern Philips Affiniti 70 (aCMQ) (2019) – an expert class device. With a similar principle of myocardial spots tracking in gray scale, the spatial resolution of the ultrasound image is the main reason for the difference in measured values. The STE method is based on the analysis of the spatial displacement of a spot or point in a grey-scale ultrasound image generated by the interaction between the ultrasound beam and myocardial fibers. Located speckles are the result of the interference of scattered ultrasound from structures smaller than the ultrasound wavelength. With this technology, random noise is filtered out, keeping small, specific and temporarily stable areas of the myocardium. Blocks (speckle kernels) can be recorded frame by frame (simultaneously in several zones within the image plane), which gives information about the local displacement, from which the parameters of myocardial function can be obtained.[1,2]

The most expected result of comparing the deformation of the segments was to obtain similar data. However, as a result of the study, significant differences were revealed. Correlation analysis revealed a significant positive relationship of predominantly LS values, more pronounced in the basal segment of the LV inferior wall. The CS values measured by the software of Q-lab and aCMQ scanners are not related. Despite the satisfactory visualization quality and comparable study conditions, the absence of a relationship between the parameters may indicate difficulties in the assessment and a poor accuracy of measurement of CS. Consequently, the magnitude of segmental CS may have low diagnostic accuracy. Some authors believe that measurement of segmental deformity in the clinical setting should be used with care. This is related to inter-operator variability and imperfection of the current generation STE.[1,4,9,19–21] Despite the fact that the contraction of circular fibers is the main cause of myocardial rotation, the values of twist and untwist characterize more global deformation processes. This may result in a more comparable twist and unwind result obtained with the software of Q-lab and aCMQ scanners.

The difference in deformity was revealed in the most informative diagnostic segments: the basal inferior and middle anteroseptal. Moreover, the differences are detected only in patients without WMA. LS calculated by the software of iE33 is more specific for patients without WMA (mean anteroseptal –15.6% and basal inferior –14.8%), which is consistent with the recommended normal value. For Affiniti 70, the same parameters are far below normal (–9.1% and –10.7%, respectively), which is inconsistent with the amount of deformity in the absence of WMA in the studied segment. Based on the data from previous studies, this may indicate a more accurate segmental value obtained when examining with the software of Q-lab scanner.[16,17]

The most comparable results of deformity when scanning with iE33 and Affiniti 70 were obtained in patients with WMA. It can be assumed that in the presence of fibrotic changes in the myocardium, the proportion of the "gray, hypoechoic zone" decreases, which contributes to an improvement in spatial resolution in STE. Therefore, in terms of tracking the altered myocardium, software of both systems shows similar results of LS and torsion parameters. This result is not the purpose of this study and may be the subject of future studies.

The revealed scatter of the difference between indicators and mean values are within 2SD, which indicates the consistency of measurements with each other.

The average difference between measurements is insignificant, which acknowledges that there is no systematic discrepancy and indicates that the spread of differences may be due to random measurement errors and method errors.

Conclusion

The most comparable results when working on the Philips iE33 (Q-lab) and Affiniti 70 (aCMQ) scanners were found for the LS of the basal segment of the inferior, middle segment of the anteroseptal walls, twist and untwist of the left ventricle of the studied patients with ACS. The greatest intra-operator variability in tracking ultrasound grayscale spots with the software of iE33 and Affiniti 70 scanners was found for segmental CS.

Limitations of the study

The results obtained may have limitations due to the relatively small number of patients involved in the study.

It is not out of the question that the more durable use of iE33 transducer could change the quality of the myocardial imaging in comparison with the more modern Affiniti 70. Besides, the dispersion of deformation values must be the same for LS and CS that is not proved in this study.

The limitation of this study is the lack of randomization when analyzing 2D images of one and the same patient acquired by different scanners. The difficulty of this approach lays in different principles of data-extraction when working with iE33 (Q-lab) and Affiniti 70 (aCMQ).

Conflict of interest
None declared.

Funding body
None.

Ethical statement
Authors state that the research was conducted according to ethical standards.

Informed consent
I declare, on behalf of all authors, that informed consent was obtained from all patients participating in the study.

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