Original Article

Ultrasonic Tissue Characterization in Acute Coronary Syndromes

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Summary

Background: **Ultrasonic tissue characterization (UTC), as evaluated through integrated backscatter, has the potential to detect precocious structural damage to myocardial tissue. In acute coronary syndromes (ACS) this technique is attracting attention due to its potential to evaluate myocardial viability.**

Objective: **To evaluate the role of UTC in the emergency department.**

Methods: **We studied 28 individuals, classified in three groups: Group I (13; 52.2±15.5 years) with patients admitted with chest pain who have negative evaluation for acute coronary syndrome; Group II (9; 54.2±10.0 years) with acute myocardial infarction in right coronary artery territory; and Group III (6; 62.1±9.1 years) with acute myocardial infarction in the anterior descendent branch territory. For each individual, we analyzed four segments in the short axis view at the papillary muscle level (1 – anterior; 2 – anterior-lateral; 3 – inferior e 4 – septal), for the following parameters: corrected coefficient, amplitude, delay index and IBS pattern.**

Results: **The acute myocardial isquemic process in its initial phase was not detected by the corrected coefficient or by the IBS amplitude. The sincronicity parameters (delay index and IBS pattern), more sensible, were partially able to identify changes in more extension regions of myocardial infarction.**

Conclusion: **More studies should be conducted to evaluate these parameters in the early phase of acute coronary syndromes. (Arq Bras Cardiol 2007;89(2):107-112)**

Key words: **Coronary vessels/anormality; coronary arteriosclerosis; myocardium/ultrastructure; "integrated backscatter".**

Introduction

Ultrasonic tissue characterization (UTC) is a new ultrasound technique for non-invasive[1] tissue structure assessment. Different techniques are available, among them videodensitometry – the most frequently used for vascular studies[2,3]. For dynamic models as the myocardium, however, the technique most frequently used is the integrated backscatter (IBS)[1].

IBS has been used in different studies in literature. It has been proven the ability to identify changes in different models of chronic cardiopathy, and even the potential for subclinical detection of structural damage[4,5], such as diabetes mellitus-induced myocardiopathy[6,7].

IBS has also been studied in the acute coronary syndrome (ACS) scenario, where major interest is its potential to identify myocardial viability[8-10]. However, its technical evaluation in the emergency room scenario – the objective of the present study – is hardly ever explored.

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Methods

Individuals under study - Twenty-eight individuals were studied, divided into three groups: group I (13 individuals – 52.2±15.5 years of age, 5 [38.4%] males) made up of patients referred to the emergency room with clinical suspicion of ACS condition, which was ruled out through invasive (catheterization) and/or non-invasive (scintigram) assessment; group II (9 individuals – 54.2±10.0 years, 6 [66.6%] males) with acute inferior wall infarction and group III (6 individuals – 62.1±9.1 years, 3 [50.0%] males) with anterior myocardial infarction. Patients included in groups II and III had no records of previous ACS, echocardiographic evidence of previous ischemic condition, any other cardiopathy, or diabetes mellitus. Those patients also reported univascular injury, which is to say, the other coronary arteries not involved in the ischemic event were free of significant atherosclerosis, defined as the absence of injuries or smaller than 50% injuries on angiography.

All infarcted patients were submitted to chemical thrombolysis no later than four hours as of symptoms onset. All patients were submitted to invasive stratification while at hospital, complemented with functional assessment through myocardial scintigram. All patients were also submitted to percutaneous or surgical revascularization, following clinical indication. Approximately three months after the event the patients were submitted to doppler echocardiogram to check ventricular function and recovery of motility in the infarcted area.

Experimental protocol - The study was carried out with Hewlett-Packard (Andover, Massachusetts) ultrasound equipment, Sonos 5500 model, with an S4 multifrequency transducer (2-4 MHz), immediately upon patients' arrival to the emergency room. Patients' evaluation and procedures were carried out immediately for concurrent exam.

After a full echocardiography baseline study was carried out and recorded in a Super-VHS tape for further analysis, the images were captured by the integrated backscatter (IBS) through acoustic densitometry software included in the ultrasound system. The software allows the visualization of real time, bidimensional images where the gray scale is proportional to IBS intensity. The software also allows the acquisition and the storage (in 512-byte optical disks per sector) of continuous frame sequences (up to 60 frames at fixed 30 Hz speed), thus forming a continuous loop of approximate two heart cycles at 60 beats per minute rate. The frames were captured synchronically to the ECG shown simultaneously on equipment screen and stored with the captured loop.

Short axis parasternal images were captured and stored in optical disk at the papillary muscle level (Fig. 1). The equipment was adjusted for optimal image definition before images were captured. No attempt was made for adjustment uniformization among patients. Study subjects were instructed to stop breathing at the moment of image capturing in order to limit attenuation effects. After each projection image was captured and recorded in optical disk – with no change in equipment parameters – a rubber phantom image was captured (ATS Laboratories, 15 x 15 x 5 cm, 15 decibels), also stored in an optical disk.

Data analysis - Tissue characterization study was carried out offline, following the same principles applied to protocols previously carried out in our service[11]. Stored images were retrieved from the optical disk and exhibited on the screen using the ultrasound system acoustic densitometry software. The region of interest (ROI) would be selected with shape and size adaptations for the largest region possible of segment under study, although limited to the myocardium, and not exceeding endocardial or epicardial borders. Initial measure was regulated for the first QRS complex peak in the loop; and the final measure for the third QRS complex peak so that two complete heart cycles would be measured. After those adjustments, integrated backscatter (IBS) sampling was initiated along the heart cycle, with IBS decibel values for each of the 60 frames that made up the stored loop. Along the cycle, the ROI was manually kept within myocardial limits.

After the samples were obtained, software analysis mode was used for IBS curve analysis. IBS values were displayed on ordinates axis, with corresponding frame number on abscissa axis.

Variables measured for analysis were: IBS cyclical variation amplitude, IBS intensity, interval between QRS and IBS cyclic variation nadir/peak (Fig. 2) and cyclic variation pattern (Fig. 3). Amplitude, intensity, and intervals were repeated three times for each segment. Means were used for statistical analysis. In addition to those objective variables, cyclic variation pattern was also studied (synchronicity of curve produced and ventricular contraction), classified as follows: S – curves presenting IBS value reduction at ventricular contraction; N – curves presenting IBS value increase at ventricular contraction and I – curves presenting no identifiable pattern or with straight line behavior. For the purpose of cyclic variation pattern analysis in segments (Fig. 1) S pattern was expected; for segments 2 and 3 (Fig. 1), N pattern was expected. All other patterns were considered non-expected, which is to say, N and I for 1 and 3, and S for 2 and 4 (Fig. 2).

After IBS analysis was concluded in each segment, with ROI position unchanged, the rubber phantom image corresponding to that projection was retrieved. That allowed the ROI sample to be positioned at the same site and depth in the phantom image. Just as carefully the same parameters were obtained for the phantom image for each of the four segments. Based on IBS intensity value obtained in the segment under study and on IBS intensity value obtained at the same site and depth on the phantom image, IBS corrected coefficient (CC) was build by dividing $\text{Intensity}_{\text{patient}}$ by $\text{Intensity}_{\text{phantom}}$.

Cyclic variation delay index was calculated by dividing the interval between QRS complex and cyclic variation nadir/peak by the interval between cyclic variation nadirs/peaks (Fig. 3).

Statistical analysis - In addition to demographic variables, the following IBS derived variables were considered for analysis: corrected coefficient, amplitude, delay interval and curve pattern.

Continuous variables are presented as means and SD; categoric variables are presented as ratio. Non-parametric Kruskal-Wallis test was used to compare continuous variables between groups. Chi-square test was used for categoric variables. Statistic significance was considered at 5%.

Ethical considerations - The study was approved by the

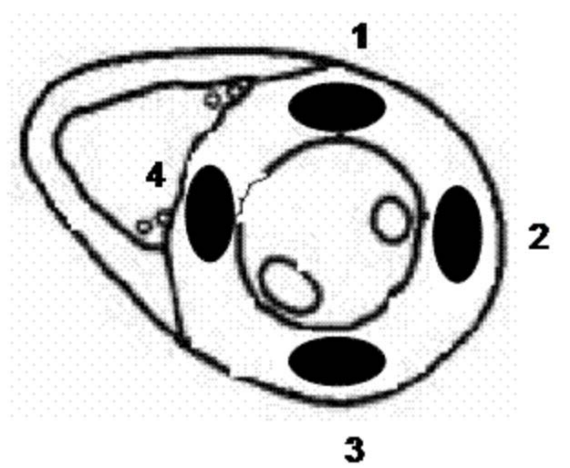

Fig. 1 - *Echocardiographic view of heart short axis at papillary muscles level. The numbers correspond to myocardial areas under analysis: 1 – mid-anterior segment; 2 – mid-antero-lateral segment; 3 – mid-inferior segment and 4 – mid-septal segment.*

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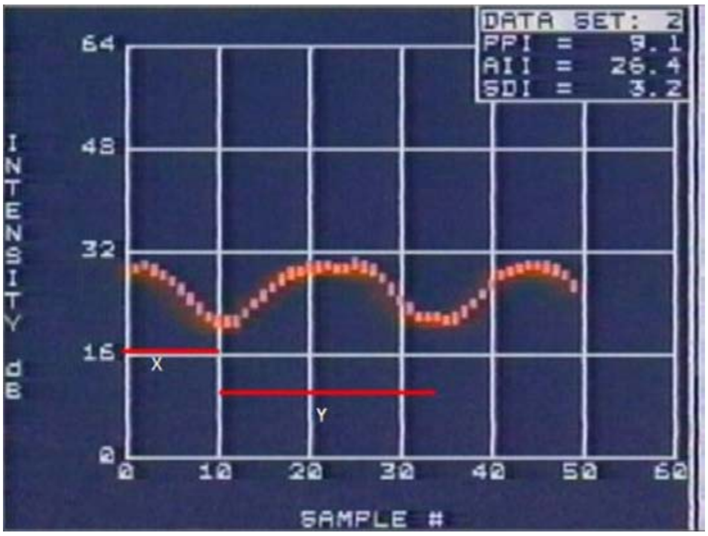

Fig. 2 - *An illustration of an IBS curve. As the beginning of the curve is always adjusted to be concurrent to QRS complex in ECG, X interval illustrated corresponds to the period from QRS complex to IBS curve nadir. Y interval was obtained for each patient enrolled in the study as the interval between the two nadirs. Delay index of cyclic variation was calculated by dividing X interval by Y interval.*

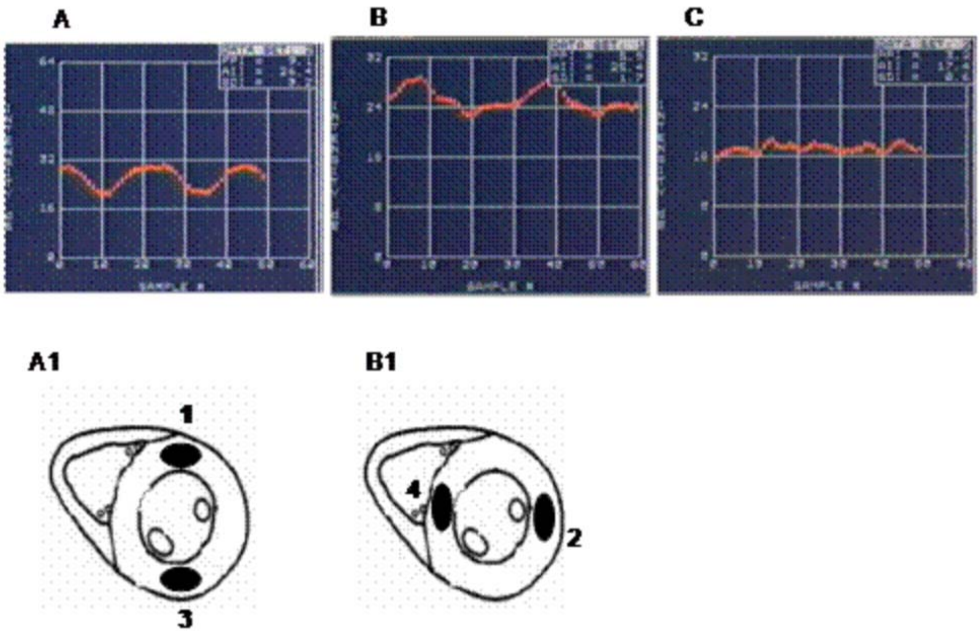

Fig. 3 - *IBS curve patterns. In A – IBS decreases with ventricular contractions perpendicular to the ultrasound beam (A1) - expected segment for those segments. In B, IBS is observed to increase with ventricular contraction in segments parallel to ultrasound beam (B1). C shows the absence of an organized pattern of response, classified as indeterminate, and not identified in the present work.*

Clinics Hospital Research Ethic Committee at the University of São Paulo Medical School at Ribeirão Preto, SP.

Results

Although patients with acute myocardial infarction in anterior descending branch of the left coronary were usually older than those in the other groups, no statistic difference was observed when patients' age was compared between groups. The same could be observed for gender and for the time elapsed between the onset of symptoms and the onset of thrombolysis in infarcted patients.

No statistic significance was observed when comparing corrected coefficient and IBS variation amplitude between the groups in the four segments under study (Table 1).

When studying IBS delay index, only segment 1 showed tendency to delay in the groups of patients with anterior descending branch, although with no statistic significance (Table 1). The same tendency was not observed for segment 3 of patients with right coronary infarction (Table 1).

IBS pattern variability pattern was the only parameter for statistically significant differences, although only for segment 1 in the groups of patients with left coronary descending branch infarction (Table 1). The same tendency could not be observed in the other segments.

Discussion

The corrected coefficient used in the present study is one of the techniques used to reduce the influence of a number of factors on ultrasonic tissue characterization. Major factors ruled out were ultrasound equipment adjustment, ultrasound coverage area to reach the transducer after myocardial tissue reflection – all of which varying from one individual to another[1]. Corrected coefficient is associated to the basic composition of tissue structure, and is most likely related to collagen level, although it is also affected by collagen tridimensional organization[1,11]. In nosologic models of chronic cardiopathy – as in previous infarctions scars[8,12] - in structural damage resulting from hypertension[5] and diabetes mellitus[13], as well as in dilated[14] and chagasic[11] cardiopathies – corrected coefficient is successful in identifying structural damage. In the present work, however, corrected coefficient was not successful in differentiating infarcted areas from healthy areas in myocardial tissue. A possible explanation is that infarcted areas were investigated early in condition course, when the technique would not be able to identify significant structural damage. Scar delimitation with deposition of collagen requires a time period longer than four weeks of delay between the onset of symptoms and assessment. Since inclusion criteria in the present study required the absence of previous ischemic events or of any other factors that would involve myocardial structural damage – such as diabetes mellitus – non-differentiation between the groups was not unexpected, and is in agreement with studies published elsewhere[8-10,15-17].

IBS variation amplitude changes are reported much earlier, and are more easily subject to documentation due to their ultrasonic tissue characterization. Studies that investigated that parameter in the percutaneous angioplasty setting reported the elimination of such variation during coronary occlusion by angioplasty balloon, with subsequent recovery with balloon deflation[18]. In the present study those changes were not reproduced in infarcted segments. Therefore, groups could not be differentiated through IBS amplitude variation. A possible explanation would be that injured artery occlusion might not have been complete at the moment the exam was carried out. Although occlusion extension was enough for electrocardiographic evidence and motility interruption, it would not change IBS amplitude. Since neither angiographic assessment was performed concurrently with the study, nor perfusion techniques used – such as contrast echocardiography – artery patency level at the point in time the study was carried out cannot be taken confidently. Another aspect to be considered is that although angiographic evidence showed

Table 1 – Corrected coefficient (CC), amplitude (A), cyclic variation delay index (I) and pattern (P) of IBS curve for myocardial segments under study. Values for continuous variables are expressed as means ± SD; P categoric values are expressed percentually. Segments 1 to 4 are the same as in Figure 1

		Segment studied			
		1	2	3	4
Corrected Coefficient (CC)	Control (13)	0.84±0.13	0.56±0.13	0.86±0.23	0.55±0.22
	AMI RC (9)	0.97±0.37	0.62±0.22	0.87±0.20	0.59±0.28
	AMI AD (6)	1,08±0.40	0.64±0.18	0.88±0.24	0.61±0.25
	p	0.3393	0.6537	0.9922	0.8800
Amplitude (A)	Control (13)	3,55±0.96	2,75±1,03	5,37±2,49	2,81±1,37
	AMI RC (9)	3,59±1,39	3,01±1,33	5,21±1,56	2,43±0.97
	AMI AD (6)	3,94±1,73	3,94±1,39	4,75±1,08	4,33±1,73
	p	0.7971	0.2729	0.9399	0.1949
Delay Index (I)	Control (13)	0.44±0.15	0.50±0.29	0.41±0.09	0.47±0.27
	AMI RC (9)	0.38±0.16	0.40±0.11	0.38±0.09	0.50±0.15
	AMI AD (6)	0.59±0.25	0.28±0.16	0.36±0.16	0.31±0.18
	p	0.1506	0.1963	0.7834	0.1422
Pattern (P)	Control (13)	1 (7,7%)	4 (30.7%)	0 (0.0%)	4 (30.7%)
	AMI RC (9)	1 (11.1%)	2 (22.2%)	1 (11.1%)	4 (44,4%)
	AMI AD (6)	4 (66.7%)	2 (33.3%)	2 (33.3%)	3 (50.0%)
	p	0.009	0.871	0.092	0.676

all injuries were proximal in infarcted patients, one cannot rule out that distal embolization of material may not affected terminal segments of coronary irrigation. Since only mid-ventricular segments were studied, such hypothesis could not be probed for confirmation.

It is a known fact that amplitude changes may not fully reflect the changes triggered by the ischemic process. In addition to IBS variability, changes in pattern or delay are documented and considered more sensitive, and stand as a possibility for the purpose of predicting the viability of injured myocardial tissue[9,10,12,15-21]. Such phenomenon has been investigated through techniques that are not available in the equipment used in the present study. In an attempt to make up for that, the authors tried to use delay index and IBS variability pattern.

When analyzing delay index segment 1 showed a tendency – although not statistically significant – to be more prolonged in infarcted patients. When analyzing expected pattern the same segment showed significant change. Those two findings suggest that the technique does have the potential to detect such change. The fact that it occurred only once may be related to infarction extension: a territory irrigated by anterior descending branch. Due to study rigid inclusion criteria, the limited number of patients enrolled in the study should also be taken into account. On the other hand, that could sponsor a more detailed study of delay index: easily obtained, it could be used in commercially available tools.

The analysis of synchronicity parameters (delay index and pattern) has been attractive from its potential to identify myocardial viability[9,10,12,15-21]. In the present study such analysis was limited to echocardiographic assessment of ventricular segmental motility recovery at rest. From all patients under study, only one patient with right coronary infarction showed full recovery of parietal motility. However, one must not disconsider the fact that other patients may not have had viable tissue associated to fibrosis, although insufficient for motility, which would require a more sophisticated analysis for the presence of myocardial viability – not performed in the present investigation.

In summary, IBS study in the ACS condition has demonstrated that changes resulting from early ischemic processes have not been detected by corrected coefficient or by IBS amplitude variation change. Synchronicity parameters, however, were partially successful – since more sensitive – in more extensive infarction areas. Further studies on the behavior of those indexes are necessary to more precisely define the usefulness of that non-invasive methodology in the acute syndrome scenario at emergency settings.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any graduation program.

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