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Research Article

The Acute Effects of Esmolol in Intact and Infarcted Myocardium–Experimental Study

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ARTICLE INFO

Article history:
Received: 15 July, 2020
Accepted: 27 July, 2020
Published: 20 August, 2020

Keywords:
Esmolol
acute myocardial infarction
speckle tracking echocardiography
twist
rotation

ABSTRACT

Aim: Early intravenous use of b-blockers within the first hours of STEMI is less firmly established. The aim of this study was to evaluate the effect of esmolol on left ventricular (LV) haemodynamic, rotational and strain parameters in intact myocardium and early post an experimental acute anterior myocardial infarction (MI).

Methods: In 20 healthy pigs LV torsional and strain parameters were calculated from basal and apical short axis epicardial planes with speckle tracking technique using EchoPAC platform. LV measurements at baseline and during esmolol infusion (0.5 mg/kg for 1 min, then 0.05 mg/kg/min for 5 min) were compared in intact myocardium and repeated without b-blocker and during esmolol infusion 2 hours post LAD ligation.

Results: LV function was highly dependent on the esmolol infusion, in the intact and even more in the infarcted myocardium. LV ejection fraction, LV dP/dt_{max} and LV end-systolic pressure decreased significantly, a deterioration produced by the administration of esmolol. Torsion-twist and untwisting rate also presented significant reduction in correlation with ejection fraction and cardiac output, appearing to affect especially the apex torsional and strain parameters.

Conclusion: Esmolol infusion significantly reduces LV haemodynamic, torsional and strain parameters in intact myocardium and early post MI. These results suggest that early intravenous use of esmolol in patients with STEMI is risky and it is prudent to wait for the patient to stabilize before starting esmolol.

Introduction

The emergency treatment of acute MI with intravenous β-blocker therapy has been studied in many trials [1-4]. However, substantial uncertainty has continued about the value of adding early β-blocker therapy to current standard interventions in acute MI and its use is limited and varies widely [5-7]. In the previous studies, mortality during the first day or two after acute MI seemed to be reduced with early β-blocker therapy and this has been attributed to the prevention of life threatening arrhythmias and cardiac rupture [4, 8]. Moreover, concerns have been raised about the potential hazards of intravenous β-blocker therapy in acute MI [6]. In ESC Guidelines for the management of acute MI, early administration of IV beta-blockers at the time of presentation followed by oral beta-blockers should be considered in haemodynamically stable patients undergoing primary PCI [9].

Esmolol is an ultrashort-acting cardio selective β-blocker, may prove useful in this setting because its short biological half-life would allow both rapid titration to a specific hemodynamic target and rapid reversal of drug effect should any untoward reaction occur [10]. In animal studies, esmolol appeared to reduce ischemic myocardial damage: it was effective in lowering the heart rate and blood pressure in patients with MI [11, 12].

Two-dimensional speckle tracking echocardiography (STE) allows detailed evaluation of LV mechanics, including LV strain and LV torsion [13, 14]. This technique provides important additional information for

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http://dx.doi.org/10.31487/j.JICOA.2020.04.09

the selection of the optimal pharmaceutical therapy in acute phase of MI. The role of STE in the assessment of the effects of esmolol before and after MI has been evaluated in few studies [15, 16]. Data based on STE comparing the effects of esmolol infusion in intact and infarcted myocardium, LV strain and LV torsion are still lacking.

The aim of this study was to evaluate the effect of esmolol on left ventricular (LV) haemodynamics, rotational and strain parameters in intact myocardium and early post an experimental acute anterior MI.

Materials and Methods

The protocol complied with the "Principles for the Care of Experimental Animals" and the "Guidelines for the Care and Use of Experimental Animals" issued by the US National Academy of Sciences and National Institute of Health (version 85- 23, revision 1996) and was approved by the Scientific Committee of the "Alexandra" university hospital.

I Surgical Preparation

Twenty healthy pigs, weighing 35±5 kg, were sedated with intramuscular administration of midazolam 5 mg/kg and ketamine potassium 5 mg/kg, anaesthetized with intravenous (IV) thiopental sodium 5 mg/kg, intubated and controlled by mechanical ventilation (Sulla 808V, Drager Medizintechnik GmbH, Germany). Anaesthesia was maintained with IV propofol 0.1–0.2 mg/kg. During the experiment, analgesia was maintained with the administration of opioid - fentanyl. Additional anaesthetic was administered during the experiment as needed. A 7F sheath was inserted into the right internal jugular vein for the delivery of drugs and fluids. Fluid loss was compensated for by continuous infusion of saline into the right jugular vein. Through a left external carotid artery, a 6F pigtail catheter was placed into the LV cavity and used for LV pressure monitoring. Lead II of the standard electrocardiogram (ECG), LV pressure, and hemoglobin oxygen saturation were monitored throughout the experiment. After catheter insertion, a 5000 IU heparin bolus was administered to avoid endovascular thrombus formation. Loading conditions were kept constant during the different maneuvers.

We used the same surgical procedure that we have developed in our previous experiments [17]. A regular median sternotomy was performed after thymic resection and a longitudinal pericardiotomy and a surgical exposure of the left descending coronary artery (LAD) was performed. Two stitches were placed afterwards, 3-0 prolene (Ethicon, Johnson & Johnson Co), just after the origin of the first diagonal branch, in order to be used for the following ligation of the LAD. The four edges of the two stitches were placed in a rigid plastic tube 5 cm in length. While the edges of the stitches were secured, the tube was pushed towards epicardium, till its proximal part of the tube has a distance of 3-5 mm from LAD. This way, a tying loop was created around the vessel that allowed the flow to be interrupted, during the next phase of the experiment without ligation.

II Standard Echocardiography

The echocardiographic study was performed using a Vivid *i* digital ultrasound system (GE Medical Systems Ultrasound Israel Ltd., Tirat Hacarmel, Israel) and a 3.5 MHz phased array transducer. Two-dimensional gray-scale echocardiographic images were obtained using 2nd harmonic imaging. Instrument settings were held constant for each experiment. At each stage of the experiment, the following parameters were measured: the LV end-diastolic (EDV) and end-systolic (ESV) volumes, the EF (modified Simpson's rule). Stroke volume (SV) and cardiac output (CO) were measured and calculated from a subxiphoid epicardial apical four-chamber view. Mitral early (E) diastolic flow velocity was measured and the early diastolic (e´) wave of the lateral mitral annulus was obtained by tissue Doppler imaging from the apical 4-chamber view. The ratio E/e´ was calculated. To determine the timing of cardiac events, mitral inflow and LV outflow were recorded using pulsed Doppler echocardiography. Three consecutive cardiac cycles were stored in cine loop format for off-line analysis. Averaged values were calculated for each parameter.

III Two-Dimensional Speckle Tracking Echocardiography

Assessment of LV rotation and twist were obtained by acquisition of specific short- axis planes with internal landmarks: the basal plane was acquired at the level of the mitral valve leaflets, while excluding the mitral annulus, and the apical plane was acquired distally to the papillary muscles. The frame rate range was 65 -80/s. In each phase, three consecutive cardiac cycles' cine loop images were stored for offline analysis with a dedicated platform EchoPac PC (version 7.0, GE Medical Systems). The software automatically defined the ventricular centroid for the mid myocardial line on a frame-by-frame basis and calculated the time domain LV strain (radial and circumferential), rotation and rotational velocity for each segment in both short-axis planes. Regional strain curves were then analysed and peak radial strain and peak circumferential strain were measured for each segment at both planes. The averaged LV rotation and rotational velocity profile were used for the calculation of LV twist and twist velocity. As viewed from the apex, counterclockwise rotation was expressed as a positive value, whereas a clockwise rotation was denoted as a negative value.

LV twist was defined as the net difference between apical and basal rotation in degrees (°). Because the degree of rotation for the same amount of LV torque increases as the distance from the mid ventricular level increases, LV twist is expected to vary with the distance between the planes at which basal and apical short-axis images are obtained. LV torsion (°/mm) was calculated as LV twist /Ld longitudinal length (measured between the locations of the base and apex of the LV in the end-diastolic phase). The opposite rotation after LV twist was defined as LV untwist and the time derivative of LV untwist was designated as the LV untwisting rate (°/s). The following parameters were measured: (1) peak apical and basal rotations and rates; (2) peak LV twist, torsion, torsion rate and peak LV untwisting rate; and (3) peak apical and basal systolic radial and circumferential strains.

IV Experimental Protocol

After completion of the surgical preparations, a steady-state period of 15 minutes was allowed, for the animal to be stabilized. The measurements are performed initially before the LAD ligation in rest (control), and subsequently during the IV infusion of esmolol, with a bolus dosage of 0.5 mg/kg for one minute, and after that 0.05 mg/kg/min for 4 minutes, up to the maximum conservation dosage of 0.25 mg/kg/min. Later, the animal is left without any intervention for a period of 30 minutes. Acute myocardial infarction is been provoked through the ligation of LAD, with the pulling of the four edges of the two stitches that are placed

outside of the sternum. Subsequent measurements are performed 30 minutes after the ligation and at the end of de novo infusion of esmolol in the same as dosage before the provocation of infarction.

Ten animals were randomly selected to assess the reproducibility of apical circumferential strain and Bland-Altman analysis was performed to evaluate intraobserver and interobserver agreement. The mean difference ± 2sd for apical circumferential strain was 0.4±2.2% for intraobserver and 2.5±3.6% for interobserver agreement.

V Statistical Analysis

Results are presented as mean±sd. Statistical analysis was performed on absolute values and each experiment served as its own control. The normality of distributions was checked using the Kolmogorov–Smirnov test. The Bonferroni correction was used for post hoc comparisons. Pearson correlations were studied and linear regression analysis was performed to define the relationship between parameters. The level of significance was set at $p<0.05$. The statistical software package SPSS for Windows, version 23 was used for the analysis (SPSS Inc., Chicago, IL, USA).

Results

In intact myocardium, ejection fraction (EF) (51.60%±5.03%), cardiac output (3094.40±570.37 ml/min), dP/dt_{max} (1.36±0.31 mmHg/s), LV systolic pressure (95.35±11.96 mmHg) and peak APEX circumferential strain (-15.07±4.71%), decreased significantly after esmolol infusion [EF (38.15±8.80%, $p<0.001$), cardiac output (2171.85±515.25 ml/min, $p=0.001$), dP/dt_{max} (1.03±0.38 mmHg/s, $p=0.001$), LV systolic pressure (85.34±13.47 mmHg, $p=0.001$) and peak APEX circumferential strain (-12.38±2.43%, $p=0.020$)]. (Tables 1 & 4).

Table 1: Effect of esmolol on the hemodynamic and conventional variables in intact myocardium.

	Control	ESMOLOL	p
EDV (ml)	63.53 ± 9.01	61.08 ± 11.08	NS
ESV (ml)	30.25 ± 5.95	37.88 ± 8.97	p = 0.005
SV (ml)	33.30 ± 4.86	23.10 ± 6.40	p < 0,001
EF (%)	51.60 ± 5.03	38.15 ± 8.80	p < 0.001
CO (ml/min)	3094.40 ± 570.37	2171.85 ± 515.25	p < 0.001
LVSP (mmHg)	95.35 ± 11.96	85.34 ± 13.47	p < 0.001
LV dP/dt_{max} (mmHg/s)	1.36 ± 0.31	1.03 ± 0.38	p < 0.001
HR (beats/min)	94.08 ± 17.91	96.88 ± 17.78	NS
E/e´ ratio	8.15 ± 4.22	8.91 ± 3.00	NS

EDV: LV End-Diastolic Volume (ml), ESV: LV End-Systolic Volume (ml), SV: LV Stroke Volume (ml), EF: LV Ejection Fraction (%), CO: Cardiac Output (ml/min), LVSP: LV End-Systolic Pressure (mmHg), LV dP/dt_{max}: the maximal rate of rise of LV Pressure according to time (mmHg/s), HR: Heart rate (beats/min), E: mitral early filling velocity (m/s), e´: early diastolic mitral annulus velocity by tissue Doppler imaging, E/e´: ratio of two velocities.
The values are averages ± standard deviation.

After acute MI, EF decreased to 34.08±6.40% ($p<0.001$), cardiac output to 2338.84±641.48 ml/min ($p=0.001$), dP/dt_{max} to 1.16±0.32 mmHg/s ($p=0.008$), LV systolic pressure to 84.41±11.39 mmHg ($p<0.001$), peak APEX circumferential strain to -9.38±3.87% ($p<0.001$), APEX rotation to 2.22 ± 1.69^0 ($p<0.001$) and untwisting rate to $-71.92\pm24.76\ ^0$/s. (Tables 2 & 5). The administration of esmolol produced even further deterioration of EF to 30.75±7.70%, ($p=0.014$), of dP/dt_{max} to 0.93±0.29 mmHg/s, ($p=0.011$), of LV systolic pressure to 76.28±15.09 mmHg, ($p=0.026$) and of untwisting rate to -46.59 ± 19.83^0/s, ($p=0.001$). Cardiac output did not change significantly. (Tables 3 & 6).

Table 2: Effect of infarction on the hemodynamic and conventional echocardiographic variables of LV.

	Control	MI	p
EDV (ml)	63.53±9.01	64.50±12.39	NS
ESV (ml)	30.25±5.95	42.47±8.88	p < 0.001
SV (ml)	33.30±4.86	22.09±5.78	p < 0.001
EF (%)	51.60±5.03	34.08±6.40	p < 0.001
CO (ml/min)	3094.40±570.37	2338.84±641.48	p = 0.001
LVSP (mmHg)	95.35±11.96	84.41±11.39	p < 0.001
LV dP/dt_{max} (mmHg/s)	1.36±0.31	1.16±0.32	p = 0.008
HR (beats/min)	94.08±17.91	106.88±17.64	p < 0.001
E/e´ ratio	8.15±4.22	9.92±4.46	NS

EDV: LV End-Diastolic Volume (ml), ESV: LV End-Systolic Volume (ml), SV: LV Stroke Volume (ml), EF: LV Ejection Fraction (%), CO: Cardiac Output (ml/min), LVSP: LV End-Systolic Pressure (mmHg), LV dP/dt_{max}: the maximal rate of rise of LV Pressure according to time (mmHg/s), HR: Heart rate (beats/min), E: mitral early filling velocity (m/s), e´: early diastolic mitral annulus velocity by tissue Doppler imaging, E/e´: ratio of two velocities.
The values are averages ± standard deviation.

Table 3: Effect of esmolol on the hemodynamic and conventional echocardiographic variables after acute myocardial infarction.

	MI	MI+ESMOLOL	p
EDV (ml)	64.50 ± 12.39	58.96 ± 13.63	NS
ESV (ml)	42.47 ± 8.88	41.04 ± 8.99	NS
SV (ml)	22.09 ± 5.78	17.92 ± 6.81	p = 0.001
EF (%)	34.08 ± 6.40	30.75 ± 7.70	p = 0.014
CO (ml/min)	2338.84 ± 641.48	1989.48 ± 893.88	NS
LVSP (mmHg)	84.41 ± 11.39	76.28 ± 15.09	p = 0.026
LV dP/dt_{max} (mmHg/s)	1.16±0.32	0.93 ± 0.29	p = 0.011
HR (beats/min)	106.88±17.64	112.72 ± 16.97	NS
E/e´ ratio	9.92±4.46	9.11 ± 4.54	NS

EDV: LV End-Diastolic Volume (ml), ESV: LV End-Systolic Volume (ml), SV: LV Stroke Volume (ml), EF: LV Ejection Fraction (%), CO: Cardiac Output (ml/min), LVSP: LV End-Systolic Pressure (mmHg), LV dP/dt_{max}: the maximal rate of rise of LV Pressure according to time (mmHg/s), HR: Heart rate (beats/min), E: mitral early filling velocity (m/s), e´: early diastolic mitral annulus velocity by tissue Doppler imaging, E/e´: ratio of two velocities.
The values are averages ± standard deviation.

The changes of torsion–twist present a significant statistical correlation to the changes of EF ($r=0.20$, $p=0.004$) and the changes of untwisting rate have a significant statistical correlation with the changes of EF ($r=-0.19$, $p=0.007$) and of cardiac output ($r=-0.35$, $p<0.001$). Rotation of the LV apex shows a significant positive correlation with EF ($r=0.44$, $p<0.001$), (Figure 1). The accurate measurement of LV twist/untwist by

STE is contingent on high-quality recordings, high tracking quality, and the correct recognition of anatomic structures that identify the basal and apical short-axis levels. Our results were obtained using high frame rate that allows for accurate tracking and we also verified the tracking accuracy visually, retracing and repositioning the region of interest as needed. Nevertheless, good speckle tracking and reliable measurements of twist parameters were possible in 80%. Intraobserver variability for peak systolic circumferential strain was 4.5±1.5% and for twist 6.5±5.5%. The interobserver variability was 7.5±2.5% and 8.5±5.5% respectively. Infarct size ranged from 17% to 35% (mean 25±4%).

Table 4: Effect of esmolol on the torsional and strain variables of LV in intact myocardium.

	Control	ESMOLOL	p
LV torsion (º/mm)	0.12 ± 0.03	0.09 ± 0.04	p = 0.012
LV twist (º)	8.32 ± 2.36	6.04 ± 2.65	p = 0.008
LV systolic torsion rate (º/s)	58.84 ± 17.38	49.81 ± 15.76	p = 0.029
LV untwisting rate (º/s)	-80.44 ± 26.23	-58.34 ± 31.1	p = 0.040
BASE			
Rotation (º)	-5.25 ± 1.50	-4.14 ± 1.63	p = 0.040
Peak systolic rotation rate (º/s)	-43.08 ± 16.37	-38.57 ± 12.07	NS
Peak radial strain	40.33 ± 13.37	36.03 ± 12.03	NS
Peak systolic circumferential strain	-12.18 ± 3.77	-10.49 ± 2.75	p = 0.023
APEX			
Rotation (º)	3.71 ± 1.77	2.41 ± 2.73	NS
Peak systolic rotation rate (º/s)	30.63 ± 13.01	19.36 ± 23.61	NS
Peak radial strain	39.5 ± 10.77	27.81 ± 12.89	p = 0.005
Peak systolic circumferential strain	-15.07 ± 4.71	-12.38 ± 2.43	p = 0.020

LV Twist (^{0}): peak difference in systolic rotations of LV apex and base as viewed from the apex, LV Torsion (^{0}/cm): normalized twist: twist angle divided by the distance between the measured locations of base and apex, LV Systolic Torsion Rate (^{0}/s): peak velocity of LV Torsion, LV Untwisting Rate (^{0}/s): peak velocity of Untwisting, Rotation (^{0}): peak systolic Rotation of base or apex, Peak Systolic Rotation Rate (^{0}/s): peak velocity of basal or apical Rotation, Peak Radial Strain: peak radial deformation of base or apex, Peak Systolic Circumferential Strain: circumferential deformation of base or apex.
The values are averages ± standard deviation.

Table 5: Effect of MI on the torsional and strain variables of LV.

	Control	MI	p
LV torsion (º/mm)	0.12 ± 0.03	0.13 ± 0.37	p = 0.050
LV twist (º)	8.32 ± 2.36	7.21 ± 2.54	NS
LV systolic torsion rate (º/s)	58.84 ± 17.38	52.73 ± 13.42	NS
LV untwisting rate (º/s)	-80.44 ± 26.23	-71.92 ± 24.76	NS
BASE			
Rotation (º)	-5.25 ± 1.50	-5.79 ± 1.95	NS
Peak systolic rotation rate (º/s)	-43.08 ± 16.37	-49.04 ± 16.02	NS
Peak radial strain	40.33 ± 13.37	41.66 ± 13.95	NS
Peak systolic circumferential strain	-12.18 ± 3.77	-13.18 ± 2.46	NS
APEX			
Rotation (º)	3.71 ± 1.77	2.22 ± 1.69	p < 0.001
Peak systolic rotation rate (º/s)	30.63 ± 13.01	17.97 ± 19.09	NS
Peak radial strain	39.5 ± 10.77	18.77 ± 13.9	p < 0.001
Peak systolic circumferential strain	-15.07 ± 4.71	-9.38 ± 3.87	p < 0.001

LV Twist (^{0}): peak difference in systolic rotations of LV apex and base as viewed from the apex, LV Torsion (^{0}/cm): normalized twist: twist angle divided by the distance between the measured locations of base and apex, LV Systolic Torsion Rate (^{0}/s): peak velocity of LV Torsion, LV Untwisting Rate (^{0}/s): peak velocity of Untwisting, Rotation (^{0}): peak systolic Rotation of base or apex, Peak Systolic Rotation Rate (^{0}/s): peak velocity of basal or apical Rotation, Peak Radial Strain: peak radial deformation of base or apex, Peak Systolic Circumferential Strain: circumferential deformation of base or apex.
The values are averages ± standard deviation.

Table 6: Effect of esmolol on the torsional and strain variables of LV after MI.

	MI	MI + ESMOLOL	p
LV torsion (º/mm)	0.13 ± 0.37	0.08 ± 0.04	NS
LV twist (º)	7.21 ± 2.54	5.35 ± 2.39	p = 0.030
LV systolic torsion rate (º/s)	52.73 ± 13.42	42.13 ± 15.72	p = 0.040
LV untwisting rate (º/s)	-71.92 ± 24.76	-46.59 ± 19.83	p = 0.001
BASE			

Rotation (º)	-5.79 ± 1.95	-4.71 ± 2.03	p = 0.005
Peak systolic rotation rate (º/s)	-49.04 ± 16.02	-43.62 ± 20.85	NS
Peak radial strain	41.66 ± 13.95	34.19 ± 15.23	NS
Peak systolic circumferential strain	-13.18 ± 2.46	-10.39 ± 2.53	p < 0.001
APEX			
Rotation (º)	2.22 ± 1.69	1.54 ± 1.64	NS
Peak systolic rotation rate (º/s)	17.97 ± 19.09	12.02 ± 10.65	NS
Peak radial strain	18.77 ± 13.9	18.02 ± 9.02	NS
Peak systolic circumferential strain	-9.38 ± 3.87	-6.72 ± 3.32	p = 0.026

LV Twist (^{0}): peak difference in systolic rotations of LV apex and base as viewed from the apex, LV Torsion (^{0}/cm): normalized twist: twist angle divided by the distance between the measured locations of base and apex, LV Systolic Torsion Rate (^{0}/s): peak velocity of LV Torsion, LV Untwisting Rate (^{0}/s): peak velocity of Untwisting, Rotation (^{0}): peak systolic Rotation of base or apex, Peak Systolic Rotation Rate (^{0}/s): peak velocity of basal or apical Rotation, Peak Radial Strain: peak radial deformation of base or apex, Peak Systolic Circumferential Strain: circumferential deformation of base or apex.
The values are averages ± standard deviation.

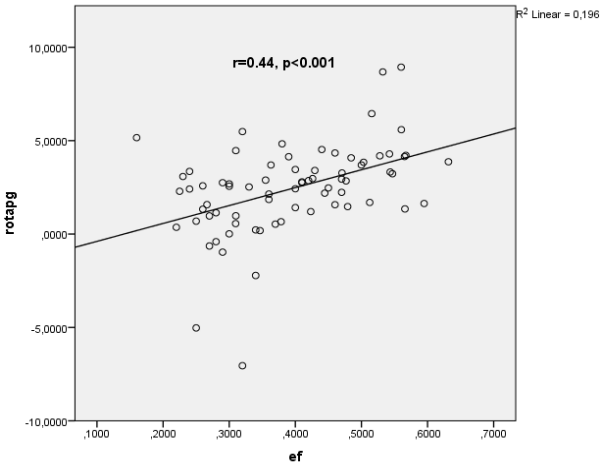

Figure 1: Rotation of the LV apex shows a significant positive correlation with ejection fraction.

Discussion

This experimental study is acute and refers to the first 30 minutes after acute myocardial infarction. In this chronic period LV torsion, rotation of the apex, as well as radial and circumferential strain of the apex are decreased significantly. The important reduction of the strain and the rotation of the apex are major determinant factors for the global twist of the left ventricle. Radial and circumferential strain and rotation of the base, along with torsion rate and untwisting rate of left ventricle did not change importantly after acute anterior myocardial infarction. These findings are accompanied by increase of end-systolic volume of the left ventricle and heart rate and at the same time decrease of stroke volume, ejection fraction, cardiac output, systolic pressure and dP/dt_{max}. In this study of acute phase, the coupling of functional geometry of the left ventricle with its performance is obvious.

Torsion of left ventricle is sensible in changes of segmental such as of global functioning of left ventricle, so that the quantitation of torsion can be used for the evaluation of left ventricle systolic function. The non-interventional measurement of LV torsion through speckle tracking by 2-dimension echocardiographic or magnetic tomography imaging seems to be a very promising method.

Enough studies have proven important correlation between LV torsion and ejection fraction, a widely used marker of LV systolic function. However, the relative accuracy of LV torsion in relation to ejection fraction under a wide range of contractility or segmental abnormalities of wall motion has not been yet totally studied. It has been also proven by studies that the rotation of the apex of left ventricle, and not of the base, demonstrated dose-dependent changes as an answer to the pharmacological formation of inotropic state. The rotation of the apex directly correlates to dP/dt_{max} under a variety of inotropic conditions of left ventricle, independently of the ligated coronary artery or its occluded segments or the development of segmental abnormalities of wall motion. Through torsion of the LV or of the apex separately, a more accurate measurement of LV contractility is provided, especially global rather than segmental, in relation to ejection fraction.

LV torsion constitutes the moving power of the heart combined with the contraction of its transverse spiral fibers. Torsion is developed during ejection, but untwisting is a deformation that occurs widely during isovolumic relaxation before the opening of mitral valve. The untwisting correlates with the release of powers that are being concentrated during systole and is considered that contributes to diastolic relaxation. The extent of torsion correlates the cavity pressure so that the velocity of its untwisting can be related to the rhythm of pressure fall. This deformation can be quantified by the use of magnetic resonance of tagged images, a non-interventional method for marking and sequencing of specific myocardial segments.

Given that not only structural anisotropy but also segmental heterogeneity of mechanical sequences of shortening and lengthening of the LV wall, lead to an efficient global function of normal heart, it is supported that simple contraction of transverse or circumferential muscles cannot totally explain all forms of LV functioning. Studies by MRI have confirmed that the more dominant motions of the heart during normal cardiac function also include the rotation of the oblique orientated fibers of LV, fact that increases ejection fraction from 30% (15% only by shortening, reaching up to 30% after contraction of transverse or horizontal orientated fibers) to 60% by the contraction of oblique fibers. This fact of mechanical shortening of different myocardial segments proves the significance of LV torsion in the production of sufficient power for cardiac function.

In segmental analysis by MRI it has been referred that ischemia of anterior and posterior wall led to reduction of LV torsion of anterior segments, but not of the posterior too. Possible explanation to this finding was the uniqueness of fiber configuration of the global shape

distortion due to the ischemia. This proves that rotation of LV apex can be used as a marker of global but not of segmental contractility of the left ventricle. LV apex rotation has shown comparable accuracy by the evaluation of LV contractility, as there is no need of trying to measure the rotation of the base, which is difficult and includes many technical problems. Several limitations exist regarding the evaluation of data provided by MRI. The algorithms of automatic marking-sequencing and the improved velocity and analysis of images by newer MRI systems are expected to reduce these problems in the future. Higher chronicle analysis is now available using the MR scanners and future studies will try to achieve better results. However, cardiac MR is recognized as an excellent tool of research and has an increasing popularity and accessibility in clinical use.

Previous clinical studies have shown that in patients with anterior myocardial infarction, maximum circumferential strain of the apex is diminished in those who have systolic dysfunction with reduced ejection fraction, whereas this does not occur in patients with preserved ejection fraction. Patients with small area infarction and preserved ejection fraction had reduced radial and longitudinal strain, but circumferential strain and torsion did not change significantly. LV torsion is seriously affected in cases where ejection fraction is reduced and this happens mostly because of the reduction of the apex twist.

The effect of torsion in LV contractility is shown in studies whereby positive inotrope intervention, such as dobutamine infusion, an increase of torsion is provoked. On the other hand, the degree of reduction of LV torsion constitutes a prognostic marker of the remodeling size 6 months after acute myocardial infarction. An experimental study showed that acute ischemia (10 s after ligation) affects the dynamic of LV twist. Nevertheless, there are no studies evaluating of what happens immediately after acute myocardial infarction, taking into account of the parameters that form globally the complex architecture of left ventricle. The effect of esmolol after its infusion in intact and even more in infarcted myocardium seems to decrease importantly torsion, dP/dt_{max}, ejection fraction, cardiac output and end-systolic pressure of left ventricle.

Study Limitations

Owing to the setup of the study, only the acute effects of esmolol were assessed. The long-term effects in a chronic model of ischemia and cardiac decompensation may be different. The impact of esmolol infusion in patients with chronic ischemia is more clinically relevant and needs to be further investigated. Moreover, the ideal timing of esmolol infusion for non-LAD lesions (or for global injury) is not addressed in this study.

Clinical Implications

Assessment of LV systolic and diastolic pump properties is fundamental to advancing the understanding of cardiovascular pathophysiology and therapeutics. Despite widespread use of echocardiography to evaluate systolic and diastolic function, conventional echo parameters, such as ejection fraction, are limited in accuracy and practicality, Recent developments in STE have received much attention due to its clinical availability and feasibility. In this article, we have demonstrated that the LV torsion-twist correlates well with pressure-volume measurements of systolic function, under the condition of acute myocardial ischemia. Clinically, because strain imaging incorporates several aspects of the complex nature of myocardial contraction, use of this imaging technique has been shown to have advantages over LVEF assessment in certain circumstances, such as myocardial infarction. Because it is sensitive to beat to beat disturbance in myocardial performance, strain has been found to afford unique information compared with LVEF for detecting and quantifying myocardial ischemia and may be useful for myocardial viability prediction in patients with coronary artery disease.

Acute myocardial infarction is one of the common critical clinical situations where heart rate and contractility feature important variations. In the present study we showed that in the onset of this dangerous and health-threatening state, the use of an adrenergic blocking factor such as esmolol appears to have burdening effect over myocardium contractility. The quantitative evaluation of the velocity of deformation (strain rate) might be of clinical value for the acute quantitation of changes in the contractile function during a negative inotropic stimulation.

Conclusion

By the echocardiographic, hemodynamic and torsional-twisting parameters of the left ventricle after acute myocardial infarction, esmolol appears to worsen LV torsion, ejection fraction, cardiac output, end-systolic pressure, stroke volume and dP/dt_{max}, that's for use of esmolol should be avoided during the acute phase of infarction in hemodynamically unstable patients.

Conflicts of Interest

None.

Acknowledgments

Supported in part by the special account for research grants of Athens University and Hellenic Cardiological Society.

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