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Original Article

Internal Medicine Section

Evaluation of Myocardial Injury using Standard Diagnostic Tools and Tissue Doppler Imaging in Blunt Trauma Chest

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ABSTRACT

Introduction: Myocardial contusion is an entity in chest trauma which is difficult to diagnose. Current practice relies more on cardiac-specific biochemical markers and standard echocardiography, but no gold standard test exists. The application of Tissue Doppler imaging is yet unexplored.

Aim: The present study was designed to evaluate cardiac injury in patients with blunt trauma chest using conventional transthoracic echocardiography parameters and Tissue Doppler imaging.

Materials and Methods: After ethical approval was taken from the Hospital and University and a written informed consent from all patients/attendants, this prospective study was conducted on a total of 30 patients in range of 15-60 years of age with blunt trauma chest. Patients with positive Trop-T and raised CPK (> 308 IU/L), raised CK-MB (> 24 IU/L) levels were suspected to have myocardial injury and were enrolled in the study. All patients fulfilling the inclusion criteria then underwent 2D-Echo and Tissue Doppler Imaging. Results of the observations were analysed using chi-square test.

Results: Out of the total of 30 patients, 63.3% showed ECG changes suggestive of cardiac injury. A 76.7% patients suffered systolic dysfunction and 36.6% patients suffered diastolic dysfunction irrespective of ECG changes. On comparison of early filling velocity wave i.e., E wave (measured by transthoracic echocardiography) and tricuspid annular velocity Em wave (measured by tissue Doppler echocardiography) at tricuspid valve, we found statistically significant difference among two techniques. (p = 0.04)

Conclusion: Echocardiography is very sensitive parameter for evaluation of myocardial contusion. Tissue Doppler imaging provides additional and reliable information.

Keywords: Cardiac enzymes, Chest trauma, Echocardiography

INTRODUCTION

Blunt Cardiac Injury (BCI) can present as asymptomatic myocardial injury to cardiac rupture to death [1]. The reported incidence of cardiac contusion in patients with blunt chest trauma ranges between 3% and 56% depending on the diagnostic methods [2]. To determine accurate prediction of BCI various diagnostic methods, such as ECG, biochemical cardiac markers, transthoracic and transoesophageal echocardiography and radionuclide imaging studies have been investigated. No gold standard test exists for the diagnosis of BCI. ECG changes being one of the sensitive, easy, quick and economical parameter have been widely used to predict myocardial contusion. Patients with suspected BCI can have ECG changes (80%). New cardiac markers, such as troponins T, I and C are subunits of the thin filament-associated troponin–tropomyosin complex are being used. Compared with CK-MB, the former 'gold standard' in diagnosing myocardial injury, troponin measurement offers substantially better sensitivity for the detection of myocardial injury. Release kinetics of troponins T and I are similar; both are released within 4–12 hours after myocardial necrosis, with a peak value 12–48 hours from the onset of symptoms. Currently most of the physicians rely on troponins, it being more cardiac-specific.

Echocardiography has been used to evaluate the heart for injury because it provides direct visualisation of cardiac structures and can assess the extent of myocardial injury. Continuous and pulse wave Doppler imaging has been routinely used to assess velocities across mitral and tricuspid valves to study functional anatomy of these valves. There is a bias in this technique as preload and sympathetic activity can affect the measurement. A new echocardiographic technique of tissue Doppler imaging, which uses tissue motion is being tried to evaluate myocardial injury. The velocity of myocardial motion is measured. Using doppler principles, TDI can quantify higher amplitude, low velocity signals of myocardial tissue motion. TDI can be performed in pulsed wave and color modes. Pulsed wave Tissue Doppler Signal (TDS) is used to measure peak myocardial velocities and is particularly well suited to measurement of long axis ventricular motion because the longitudinally oriented endocardial fibers are more parallel to ultrasound beam in apical view. As the apex remains relatively stationary throughout the cardiac cycle, mitral annular motion is a good surrogate measure of the overall long Left Ventricular (LV) contraction and relaxation. TDI has been used to evaluate systolic and diastolic function of left and right ventricle. The European Society of Cardiology proposed that evidence of abnormal relaxation, filling or diastolic stiffness is needed for the diagnosis of diastolic heart failure [3].

Thus, the present study was designed to detect cardiac injury in patients with blunt trauma chest using transthoracic echocardiography and tissue Doppler imaging and to compare their findings with previously used standard ECG and biochemical tools.

MATERIALS AND METHODS

This prospective study was conducted over a period from January 2014 to December 2014. Patients aged 5-60 years with blunt trauma chest, with suspected myocardial injury on the basis of ECG or positive biochemical cardiac markers from the emergency and intensive care units were enrolled. As this was a period study so after the patients qualified for the inclusion criteria, we had 30 patients in the study.

Patients were considered to have chest injury if they had either: significant contusion on the chest wall with or without respiratory distress, clavicle fracture, one or more rib fractures, pneumothorax,

haemothorax and surgical emphysema. Ethical approval was taken from the Hospital and University Ethical Committee. A written informed consent was obtained from all patients/attendants in the study.

Patients with positive Trop-T and raised CPK (> 308 IU/L), raised CK-MB (> 24 IU/L) levels were suspected to have myocardial injury and were enrolled in the study. Patients with known history of ischaemic heart disease, old infarction or on chronic drug therapy such as nitrates, antihypertensives, antianginals and digoxin were excluded from the study. Along with the routine investigations, the patients were evaluated for ECG, CPK, CPK- MB and Troponin T. All the above cited investigations were carried out within 72 hours of patient's arrival in the emergency.

All patients then underwent 2D-Echo and Tissue Doppler Imaging. The patients were assessed while lying in left lateral decubitus using standard echocardiographic sections. The study was carried out using the commercially available echocardiography equipment (Sonos 4500, Hewlett-Packard, Andover, MA Philips Ultrasound), equipped with a 2.5 MHz transducer and the cardiac dimensions were measured according to the recommendations of the American Society of Echocardiography [4].

Atleast five consecutive beats were obtained from the parasternal view, to obtain the internal diameters of the LV in the short axis of the LV. Cardiac dimensions: left atrium diameter (LA) and final diastolic (LVd) and systolic (LVs) diameters of the LV were measured using the M-mode. Using modified Simpson's method obtained from the 4- and 2-chamber apical views, the EF of the LV was determined. Using 4-chamber apical view and positioning the pulsed doppler cursor on the tip of the mitral leaflet, the mitral flow was obtained. By using this flow, the maximum LV filling velocity at early diastole (E) and during the Atrial (A) contraction, the corresponding E/A ratio and the E wave Deceleration Time (DT) were determined.

Similarly by using tissue doppler of mitral annulus, the maximum myocardium velocities were measured at early m (E') and late (A') diastole and the ratio E'/A' was calculated. The normal ranges for various systolic parameters using transthoracic echocardiography were: ejection fraction >55%, end systolic volume (LV) 22 to 58 ml and right ventricle area 7.5-16 cm^2.

The normal values of diastolic parameters were: early filling velocity (E WAVE) < 0.5 – >0.9 m/sec and E/A ratio < 0.9 – >1.5 m/sec. TDI measurements were done to record early filling velocity wave (Em wave) < 0.06 – >0.14 m/sec, E/Em ratio - 6.67-8.57 m/sec, End Diastolic Volume (EDV) 67-155 ml.

STATISTICAL ANALYSIS

All examinations were performed by an experienced dedicated cardiology technician using commercially available equipment. Digitally stored images were analysed by a single observer who was blinded to clinical and outcome data. Results of the following observations were analysed using statistical software SPSS 20.00 using chi-square test.

RESULTS

About 50% patients in the study fell between age group of 41-55 years whereas only 16.7% patients fell into each other age group i.e., <26 years, 26-40 years and >55 years [Table/Fig-1]. Out of total 30 patients, 63.3% showed ECG changes and 36.7% showed no ECG changes. It was seen that irrespective of any ECG change systolic dysfunction was found in 76.7%. A 40% of patients in our study had deranged end systolic volume and 20% had both deranged end systolic volume and right ventricle area. More than 13% of total patients were found to have both ejection fraction and systolic function derangement. On comparing patients based on their ECG and presence or absence of systolic dysfunction it was found that 50% of patients had both ECG changes and systolic dysfunction. It was also observed that 13.33% patients had ECG changes without any systolic dysfunction.10% patients had normal ECG and no systolic dysfunction [Table/Fig-2]. A 36.7% of patients had diastolic dysfunction. Both the groups i.e., patients with ECG changes and no ECG changes had systolic dysfunction and diastolic dysfunction. On comparing diastolic dysfunction 20% of patients had both ECG changes and diastolic dysfunction whereas 16.67% patients had diastolic dysfunction but no ECG change. It was also observed that 43.33% patients had ECG changes without any diastolic dysfunction. 20% patients had normal ECG and no diastolic dysfunction [Table/Fig-3].

On comparing early filling velocity measured by 2D echocardiography at tricuspid valve and tricuspid annular velocity measured by Tissue Doppler imaging, it was found out to be significant with a p-value of 0.04 [Table/Fig-4].

DISCUSSION

Myocardial contusion is histologically described as cellular injury,

Age Group (Yrs)	Frequency	Percentage
<26	5	16.7
26 – 40	5	16.7
41 – 55	15	50.0
>55	5	16.7
Total	30	100.0

[Table/Fig-1]: Based on age, patients were divided into four groups.

SYS DYS (P/n) * ECG Cross tabulation					
			ECG		Total
			N	P	
SYS DYS (P/n)	N	Count	3	4	7
		% of patients	10.0%	13.33%	23.3%
	P	Count	8	15	23
		% of patients	26.67%	50%	76.7%
Total		Count	11	19	30
		% of patients	36.67%	63.33%	100.0%

[Table/Fig-2]: Comparison of systolic dysfunction with ECG.
N= negative, P= positive

Diastolic Dysfunction * ECG Cross tabulation					
			ECG		Total
			N	P	
Diastolic Dysfunction	N	Count	6	13	19
		% of patients	20.0%	43.33%	63.3%
	P	Count	5	6	11
		% of patients	16.67%	20.0%	36.7%
Total		Count	11	19	30
		% of patients	36.67%	63.33%	100.0%

[Table/Fig-3]: Comparison of diastolic dysfunction with ECG.
N= negative, P= positive

Diastolic Dysfunction * ECG Cross tabulation							
			Em Wave			Total	p-value
			Supra Normal	Normal	Sub Normal		
E Wave	Supra Normal	Count	2	0	0	2	0.04
		% of patients	6.7%	0%	0%	6.7%	
	Normal	Count	4	17	0	21	
		% of patients	13.3%	56.7%	0%	70.0%	
	Sub Normal	Count	2	4	1	7	
		% of patients	6.7%	13.3%	3.3%	23.3%	
Total		Count	8	21	1	30	
		% of patients	26.7%	70.0%	3.3%	100%	

[Table/Fig-4]: E wave tricuspid vs EM wave tricuspid.

extravasation of red blood cells between myocardial muscle fibres, occasional necrosis and polymorphonuclear leukocytic infiltration. Myocardial contusion leads to cellular membrane disruption and release of cytoplasmic and membranous enzymes in the plasma [5]. Lesser cardiac injury without cellular disruption and sparing changes in biochemical markers can cause functional impairment. This can be picked up by echocardiography [6]. However, a definitive diagnosis of cardiac contusion can be made only on gross or histological examination of heart. The incidence of BCI depends on the diagnostic tool employed to make the diagnosis. Continuous Electrocardiogram, radionuclide perfusion scan, echocardiography, and creatine phoshokinase (CK-MB) fractions have been employed to detect myocardial contusion [7]. Unfortunately, none of these studies has demonstrated a good correlation in accurately defining patients at risk for cardiac complications after blunt chest wall trauma.

There are other confounding factors such as preload, other associated injuries and SIRS which bias the results of study. It is difficult to detect myocardial contusion. Cost benefit ratio of using large number of presently available diagnostic imagings is less. Recently the introduction of tissue doppler imaging to echocardiography has improved the reliability of echocardiography in studies diagnosing ventricular systolic and diastolic function.

In our study, we found that patients in age group of 41-55 years suffered blunt trauma chest the most as the patients in this age group constituted 50% of patients in our study. 63.3% patients in our study of blunt cardiac trauma had ECG changes, sinus tachycardia being the most frequent (52.6%). In our study, 76.7% patients suffered systolic dysfunction and 36.6% patients suffered diastolic dysfunction irrespective of ECG changes. On comparison of early filling velocity wave i.e E wave (measured by transthoracic echocardiography) and tricuspid annular velocity Em wave (measured by tissue Doppler echocardiography) at tricuspid valve, we found statistically significant difference among two techniques ($p = 0.04$).

ECG has been used to diagnose patients for cardiac injury although no single ECG finding is pathognomonic for BCI. The ECG mainly reflects the electrical activity of the left ventricle because of its greater mass and is relatively insensitive to right ventricular electrical activity. Studies done earlier have shown similar incidence of ECG changes in patients of suspected blunt trauma chest (63.33%) [8]. However, nonspecific changes, including sinus tachycardia, are present in up to 80% of the ECGs obtained in patients with suspected BCI.

In a study, conducted on 118 chests trauma patients, out of 35 abnormal ECGs 18 patients had supraventricular arrhythmias [9]. Using any ECG changes (sinus tachycardia, bradycardia, conduction delays or atrial or ventricular dysrhythmias) a sensitivity of 100%, a specificity of 47% and a negative predictive value of 90% is present in the detection of BCI-related complications that require treatment [9]. Thus relying on ECG for myocardial contusion is difficult despite being very sensitive.

Different troponins like T, I and C which are subunits of the thin filament associated troponin–tropomyosin complex have been studied [10]. We included patients with positive troponin T as a marker for cardiac dysfunction. This goes well in consensus with a study of 388 patients with myocardial injury which showed 100% sensitivity and 93% specificity for a first generation troponin T assay [11]. However, a sensitivity of only 33-49% is seen if troponin sampling is done early after onset of symptoms (<4 hours) [12]. Thus, serial sampling atleast 12 hours after onset of symptoms is recommended in order to achieve optimal sensitivity. Echocardiography is non-invasive investigation but at times difficult in chest trauma due to surgical emphysema and pain. Ejection fraction has been shown to be an independent predictor of cardiac events in patients with left ventricular dysfunction [13]. In our study, 13.3% patients had both decreased ejection fraction and increased end systolic volume, 40% patients had only increased end systolic volume. In a retrospective study [13], it was found that decrease in ejection fraction and increased end diastolic volume on Doppler echocardiography are associated with poor prognosis. In our study, we observed that 23 (76.7%) patients had systolic dysfunction out of which only 19 (82.6%) had abnormal ECG and rest 4 patients had normal ECG. In a study done on 243 patients referred for echocardiography, it was observed that left ventricular systolic dysfunction is unlikely to be present if the ECG is normal or shows only minor abnormalities and there is usually a major ECG abnormality in the presence of left ventricular systolic dysfunction [14]. An abnormal ECG had a low specificity in the prediction of left ventricular systolic dysfunction. TDI is an echocardiographic technique that measures myocardial velocities, which are low frequency, high-amplitude signals filtered from conventional doppler imaging. The peak early diastolic mitral annular velocity (Em), as measured using TDI, is a relatively preload insensitive assessment of left ventricular relaxation [15]. Although, this variable is not independent of large, acute changes in preload for example, during dialysis or vena caval occlusion, it appears to be less influenced by preload in the critically ill [16]. Also, it does not pseudo-normalise in the same way that transmitral flow does [17]. The influence of changes in ventricular loading on Em in critically ill remains incompletely defined [18]. Peak early diastolic transmitral velocity (E) is dependent on left ventricular filling pressure, as well as the rate and extent of left ventricular relaxation [19]. The ratio of E to Em (E/Em) has been proposed as an estimate of left ventricular filling pressure that corrects E velocity for the influence of myocardial relaxation [20]. In a previous study, TDI evidence of diastolic dysfunction as Em below 9.6 cm/sec (myocardial relaxation below the lower 95% confidence limit of normal individuals [21] was taken which is in consensus with our study where we took Em values of below 6.0 cm/sec [22]. We found in our study that E wave and Em wave at tricuspid had a statistically significant difference with p-value of 0.04. Ozdemir O et al., studied asthmatic paediatric patients for assessment of ventricular function using conventional echocardiography and Tissue Doppler echocardiography and found that the deterioration of the electrophysiological properties of the right atrium may result in a risk of atrial fibrillation in patients with asthma [23]. This study showed that although the findings of clinical and conventional echocardiography were apparently normal in children with asthma, tissue Doppler echocardiography showed subclinical dysfunction of the right ventricle.

LIMITATION

Our study is limited by small sample size. As this was a study done over a fixed time period, the power of the study was less (60%). Serial echocardiography evaluations would have added to the accuracy of tool. We would have studied clinical corelationship with diagnostic tools to find out the validity of diagnostic tool. Further studies with more patients can be done to assess the role of tissue Doppler imaging.

CONCLUSION

Adding tissue Doppler imaging to standard echocardiography improves sensitivity and specificity of echocardiography to diagnose myocardial injury in blunt trauma chest patients.

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