Signature: © Pol J Radiol, 2017; 82: 798-805
DOI: 10.12659/PJR.904031

Polish Journal of Radiology
www.PolRadiol.com
ORIGINAL ARTICLE

Received: 2017.02.25
Accepted: 2017.03.06
Published: 2017.12.15

Echocardiography in the Evaluation of Chest Pain in the Emergency Department

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Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Summary

Background: A challenge for clinicians in emergency departments (EDs) is rapid identification of those patients with chest pain who require admission and urgent management and those with low clinical risk who can be discharged safely from the ED. This study was designed with an aim to evaluate the ability of two-dimensional transthoracic echocardiography (2D-TTE) to determine causes of acute chest pain in patients presenting to the ED in order to decide whether hospital admission and further investigations were needed.

Material/Methods: A total of 250 consecutive patients admitted with chest pain, were enrolled in this prospective study. Patients were divided into three groups: high risk, moderate risk, and low risk of cardiac events, according to cardiovascular risk factors. 2D-TTE was obtained using the HI vision Avius ultrasound unit (Hitachi). Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS), version 20.

Results: Ischemic and/or non-ischemic heart diseases (IHD and/or NIHD) were detected in 147 (86.5%), 13 (7.6%), and 10 (5.9%) patients with high, moderate, and low risk, respectively. 2D-TTE was characterized by sensitivity of 85.86%, specificity of 100%, and positive predictive value (PPV) of 100% for detecting causes of chest pain.

Conclusions: 2D-TTE increased specificity and sensitivity of detecting causes of chest pain, when compared to patient history, clinical findings, and electrocardiography (ECG). 2D-TTE can be used to help determine the need for hospital admission, to confirm or exclude diagnosis, and guide urgent therapy.

MeSH Keywords: **Echocardiography, Doppler • Electrocardiography • Myocardial Infarction**

PDF file: http://www.polradiol.com/abstract/index/idArt/904031

Background

Chest pain is one of the most frequent reasons for patient visits in emergency departments (EDs). Possible causes of chest pain are numerous and diverse, but importantly, several conditions, such as acute coronary syndrome, pulmonary embolism, and aortic dissection, require urgent management and, in some cases, may be life-threatening [1]. More than 8 million ED visits take place annually in the United States because of chest pain or related symptoms, which makes them the second most frequent cause of ED visits in adults [2]. A huge cost generated by patients with chest pain in the ED was recently confirmed in a retrospective study with 1000 patients, in which the mean cost per patient was almost €3,000 [3]. Therefore, a challenge for clinicians in EDs is rapid identification of those patients with chest pain who require urgent management and those with more benign entities who do not require admission [4,5]. To face this challenge, an increasing array of diagnostic strategies and modalities have been investigated during the past decades, including chest pain units (CPUs), new cardiac biomarkers, clinical risk scores, early stress testing, accelerated diagnostic protocols (ADPs), and noninvasive imaging of the myocardium and coronary arteries to provide a rapid and, cost-effective evaluation [6].

Two-dimensional transthoracic echocardiography (2D-TTE) is one of the most powerful diagnostic and monitoring tools available to critical care practitioners in EDs [7]. TTE is a safe, painless, and rapid diagnostic investigation that can be performed at bedside and contribute significantly to acute management of certain patients [8]. In addition, TTE can provide important information that can change management in 80% of patients, increase diagnostic accuracy and efficiency in EDs, and determine the cause of unexplained hypotension in 48% of intensive care units (ICUs). It can be used to monitor cardiac output, determine disorders of cardiac physiology, and provide anatomical information relevant to diagnosis [7].

Given its availability, rapidity, and additional information provided with regard to cardiac status, 2D-TTE may be used as the initial imaging modality when aortic dissection is clinically suspected in the emergency room. However, due to low negative predictive value (NPV), 2D-TTE does not permit to rule out dissection, and further tests will be required, if TTE is negative. The value of TTE is also limited in patients with abnormal chest wall configuration, obesity, pulmonary emphysema, and those on mechanical ventilation. These limitations may prevent adequate decision-making in some cases, but they can be overcome by transoesophageal echocardiography (TOE). In patients with acute chest pain, special attention should be paid during 2D-TTE examinations to aortic root dilatation, aortic regurgitation, and/or pericardial effusion, since these findings should raise the suspicion of acute aortic syndrome. If dissection cannot be directly visualized, other imaging techniques are mandatory [9].

Description of ischemic heart disease (IHD)

Acute myocardial infarction (AMI), occurs when part of the heart muscle is damaged by lack of blood flow. The most common symptom is chest pain or discomfort, which may radiate to the shoulder, arm, back, neck, or jaw [10]. A potential value of 2D echocardiography as a diagnostic tool in AMI was discovered very early, and a large number of studies reported its high sensitivity, both qualitatively and quantitatively. As a general rule, for the differentiation of normal from infarcted myocardium, wall thickening is preferred to wall motion. Moreover, 2D echocardiography is extremely accurate for localization of infarction. There is a significant relationship between infarction and contractile dysfunction; consequently, the absence of wall motion abnormality or wall thinning rules out a clinically significant infarction [11].

Angina pectoris, commonly known as angina, is a sensation of chest pain, pressure, or squeezing that is often due to insufficient blood flow to the heart muscle because of obstruction or spasm of the coronary arteries [12]. Stable angina refers to the classic type of angina related to myocardial ischemia. A typical presentation of stable angina is that of chest discomfort and associated symptoms precipitated by some activity (running, walking, etc.), with minimal or non-existent symptoms at rest or after administration of sublingual nitroglycerin. Unstable angina may occur unpredictably at rest, which may be a serious indicator of an impending heart attack. What differentiates stable angina from unstable angina is the pathophysiology of atherosclerosis. Unstable angina results from a reduction of coronary blood flow due to transient platelet aggregation on apparently normal endothelium, coronary artery spasms, or coronary thrombosis [13].

Description of non-ischemic heart disease (NIHD)

Hypertrophic cardiomyopathy (HCM) is a common, inherited cardiovascular disease with an incidence of 1 in 500 in the general population. It is caused by more than 1,400 mutations in 11 or more genes encoding proteins of the cardiac sarcomere. Clinical diagnosis is based on otherwise unexplained left-ventricular hypertrophy identified by echocardiography or cardiovascular magnetic resonance imaging (MRI) [14].

Restrictive cardiomyopathy is a specific group of heart muscle disorders characterized by inadequate ventricular relaxation during diastole. This leads to diastolic dysfunction with relative preservation of systolic function. Confirmation of diagnosis and information regarding the etiology, extent of myocardial damage, and response to treatment requires imaging. Echocardiography is the initial cardiac imaging technique, but it cannot reliably suggest a tissue diagnosis to differentiate restrictive cardiomyopathy from constrictive pericarditis. However, recent advances, such as tissue Doppler imaging and spectral tracking, have improved its ability to diagnose restrictive cardiomyopathy [15].

Heart murmurs due to valvular abnormalities are common in the general population. Many heart murmurs have no clinical relevancy and are therefore called innocent murmurs [16]. Echocardiography is the imaging modality of choice to help diagnose and estimate the severity of aortic stenosis. 2D echocardiography demonstrates morphology of the aortic valve and can often delineate if it is trileaflet or bicuspid. It also aids in detecting other associated valve lesions and in estimating pulmonary artery systolic pressure [17].

Pericardial effusion occurs in patients with pericarditic chest pain or in patients with underlying diseases that can cause pericardial involvement (renal failure, chest irradiation) and thoracic complaints. Echocardiography is the most available and reliable technique to verify the presence and the amount of pericardial effusion; in addition, echocardiography offers valuable data for evaluation of hemodynamic repercussion [18,19].

Classically, 2D-TTE has been considered to have a limited value for diagnosing aortic dissection. In older series, sensitivity of diagnosing ascending aorta dissection was 78–90%, but only 31–55% in descending aortic dissection. Specificity for type A aortic dissection was reported to range from 87 to 96% and for type B dissection from 60 to 83% [20]. However, these data are derived from old studies, when modern imaging technology, such as harmonic imaging, was not available. Recently, harmonic imaging and the use of contrast-enhanced imaging have been shown to improve sensitivity and specificity of 2D-TTE in diagnosing aortic dissection [21]. Contrast-enhanced 2D-TTE has

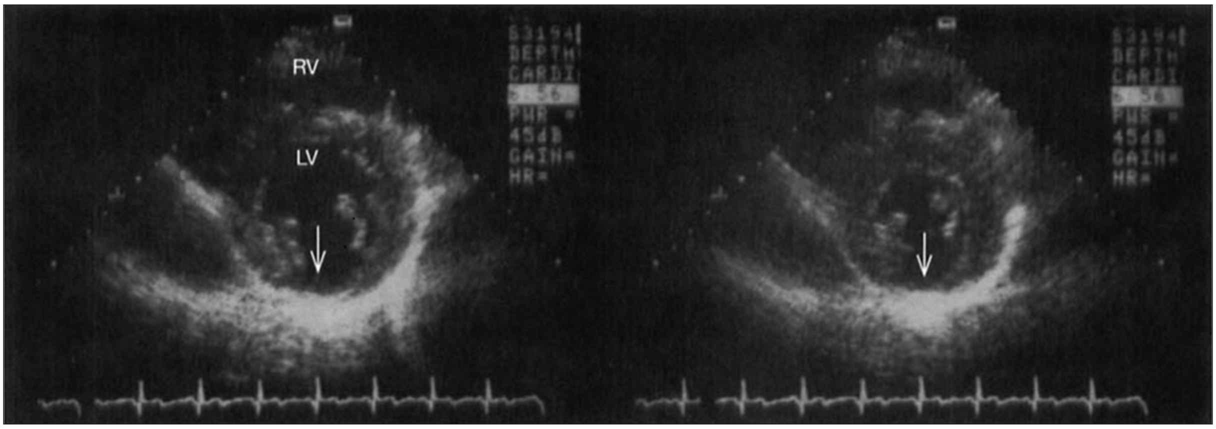

Figure 1. Parasternal short-axis view of the left ventricle (LV) at the level of the papillary muscles in a patient with an old inferior myocardial infarction (MI). The left panel was recorded at end-diastole and the right panel was recorded at end-systole. Thinning and lack of motion in the inferior wall can be noted (arrows).

similar accuracy to TOE in diagnosing type A aortic dissection (sensitivity, 93%; specificity, 97%), although it is lower in type B involvement (sensitivity, 84%; specificity, 94%), mainly in the presence of non-extended dissection, intramural hematoma, and aortic ulcers [21].

The aim of the current study was to evaluate the ability of 2D-TTE to determine the cause of acute chest pain and the hospitalization need in patients presenting to the ED.

Material and Methods

Between August 2014 and October 2016, a total of 250 consecutive patients admitted for chest pain, were enrolled in this prospective cohort study. All patients presented to the ED with chest pain or other symptoms suggestive of myocardial ischemia or infarction (MI) and underwent an evaluation by emergency physicians. The initial evaluation included patient history, physical examination, electrocardiography (ECG), and 2D-TTE. Patients with negative findings were discharged and scheduled for follow-up stress testing within 24–48 hours, whereas those with positive findings were admitted. Additional diagnostic evaluations were made at the discretion of the cardiac care unit (CCU) cardiologist.

The CCU cardiologist evaluated admitted patients with regard to demographic data and, the following cardiovascular risk factors: 1) family history, 2) high blood pressure (hypertension), 3) diabetes mellitus (DM), 4) smoking, 5) alcohol consumption, 6) unhealthy diet, 7) physical inactivity, 8) obesity, 9) history of contraceptive pill use, and 10) hormone replacement therapy (HRT). 2D-TTE findings, laboratory results, and exercise tests were also taken into account.

Also, it should be considered that patients who presented with chest pain were divided into three groups according to the above-mentioned risk factors: 1) patients at high risk; 2) moderate risk; and 3) low risk of cardiac events. High-risk patients were those with >3 cardiovascular risk factors, while moderate-risk patients were those with 3 of the above-mentioned risk factors. Patients with a low risk had <3 of the listed risk factors. Informed consent was

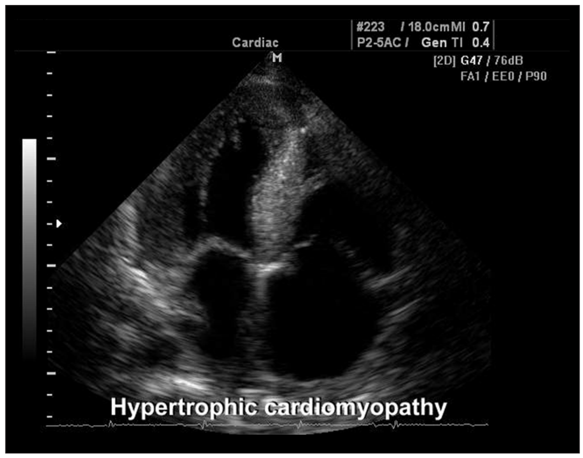

Figure 2. Echocardiography in a 68-year-old male with HCM.

obtained from all patients, and the study was reviewed and approved by the institutional review board.

2D-TTE was obtained using the HI vision Avius ultrasound unit (Hitachi), immediately on arrival to the ED. The study was conducted by one expert sonologist, who was blinded to the patient's status. An optimal phased array transducer with a frequency range of 1–5 MHz was used to perform scanning. 2D-TTE scanning included the apical four chamber and two chamber views; para-sternal short and long axis, thoracic aorta, upper abdominal aorta, and inferior vena cava (IVC) were also visualized. Intra-cardiac shunting and valvular regurgitation were evaluated with color Doppler imaging. Motion mode (M-mode) was used to test the blood flow measures in cardiac chambers, cardiac valves, pulmonary veins, and thoracic aorta. Each 2D-TTE exam was recorded on a compact disc (CD) to be interpreted later. In this research, 2D-TTE scanning guidelines and protocols were in line with Paventi et al., 2001 [22], and Levit and Jan, 2002 [23].

2D-TTE results were considered positive, when they documented IHD and/or NIHD (Figures 1 and 2). Sonographic features of abnormal wall movement, including akinesis or hypokinesis of one or more segments that presented in two different orientations, and a generalized hypokinesis

Table 1. Demographic data and cardiovascular risk factors in the studied patients.

Demographic data	(Years, n,%)
Age range	18 to 80 years
Mean age	67±2.4 years
Gender distribution	110 (44%) males and 140 (56%) females
Cardiovascular risk factors	**(n,%)**
Family history of cardiac disorders	(38, 15.2%)
High blood pressure (Hypertension)	(150, 60%)
Diabetes mellitus (DM)	(128, 51.2%)
Smoking	(65, 26%)
Alcohol consumption	(48, 19.2%)
Unhealthy diet	(118, 47.2%)
Physical inactivity	(93, 37.2%)
Obesity	(55, 22%)
History of contraceptive pill use	(18, 7.2%)
Hormone replacement therapy (HRT)	(10, 4%)

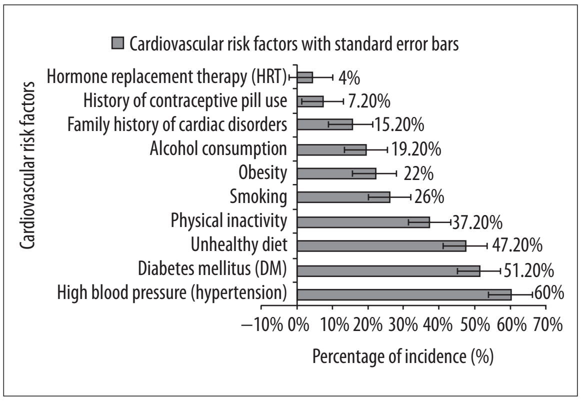

Figure 3. Cardiovascular risk factors in patients presenting with chest pain.

with an ejection fraction lower than 40% were used to diagnose an ischemic cardiac event. The echocardiographic diagnostic criteria for HCM were established with M-mode imaging, and they included asymmetrical septal hypertrophy, systolic anterior motion (SAM) of the mitral valve, a small LV cavity, septal immobility, and premature closure of the aortic valve [24,25]. On 2D echocardiography, HCM is characterized by an increased left atrial diameter due to obstruction and/or diastolic dysfunction. Left atrial diameter gives information on the risk of atrial fibrillation, heart failure development, and cardiac mortality, which is particularly high in patients with left atrial diameters >48 mm. Finally, left atrial fractional shortening, determined with the following formula: ([maximal diameter-minimum diameter]/maximal diameter×100), is an estimate of end-diastolic pressure in HCM. This parameter is directly related to exercise tolerance, and its reduction (i.e. <16%) represents an independent risk factor for atrial fibrillation [26].

Normal ventricular size and systolic function are usually evident in restrictive cardiomyopathy. Findings that have been described as helpful in diagnosing restrictive cardiomyopathy include mid-diastolic reversal of flow across the mitral and tricuspid valves. Atrial enlargement with normal left ventricular end-diastolic dimensions may also be seen [27]. As regards valvular abnormalities, aortic sclerosis on echocardiography is characterized by focal areas of valve thickening, typically located in the leaflet center with commissural sparing, and normal leaflet mobility. Diffuse leaflet thickening is not characteristic for aortic sclerosis; instead, it suggests normal aging changes, a different valvular pathology, or an imaging artifact. With aortic sclerosis, valvular hemodynamics is within normal limits, with an aortic valve velocity of less than 2.5 m/s. In patients with aortic stenosis, the aortic valve is usually thickened and calcified, with limited excursion and a reduced aortic valve area. Doppler echocardiography is an excellent tool for evaluating the severity of aortic stenosis by measuring jet velocity and gradients and calculating the aortic valve area [28]. Pericardial effusion can be detected as an echo-free space on 2D echocardiography. Small collections of pericardial fluid, which can be physiologic (25 to 50 mL), may be visible during ventricular systole. When the amount of effusion is more than 50 mL, an echo-free space persists throughout the cardiac cycle. The next step is to assess the size of effusion, its location, hemodynamic importance, and associated diseases [29].

2D-TTE exams were deemed negative if segmental wall motion disorders and/or other non-ischemic events were absent. Clinical findings on physical examination, ECG, cardiac computed tomography angiography (CTA), and cardiac MRI were used to verify whether echocardiographic diagnoses of IHD and NIHD that were made in the ED were correct or not.

Study results were presented as means±standard deviations (SD) in tables and figures. Statistical analysis was performed with the Statistical Package for the Social Sciences (SPSS), version 20 for Windows (Microsoft).

Results

Between August 2014 and October 2016, a total of 250 consecutive patients with chest pain were admitted to the ED and enrolled in this study. Age ranged from 18 to 80 years (mean age, 67±2.4 years); there were 110 (44%) males and 140 (56%) females (Table 1).

Patient demographic data and cardiovascular risk factors are presented in Table 1 and Figure 3. High blood pressure (150, 60%) and DM (128, 51.2%) were the most frequent causes of cardiovascular disorders in the patients. The least frequent causes of chest pain were a history of contraceptive pill use (18, 7.2%) and HRT (10, 4%) in females who had a history of breast and ovarian cancer (Table 1 and Figure 3).

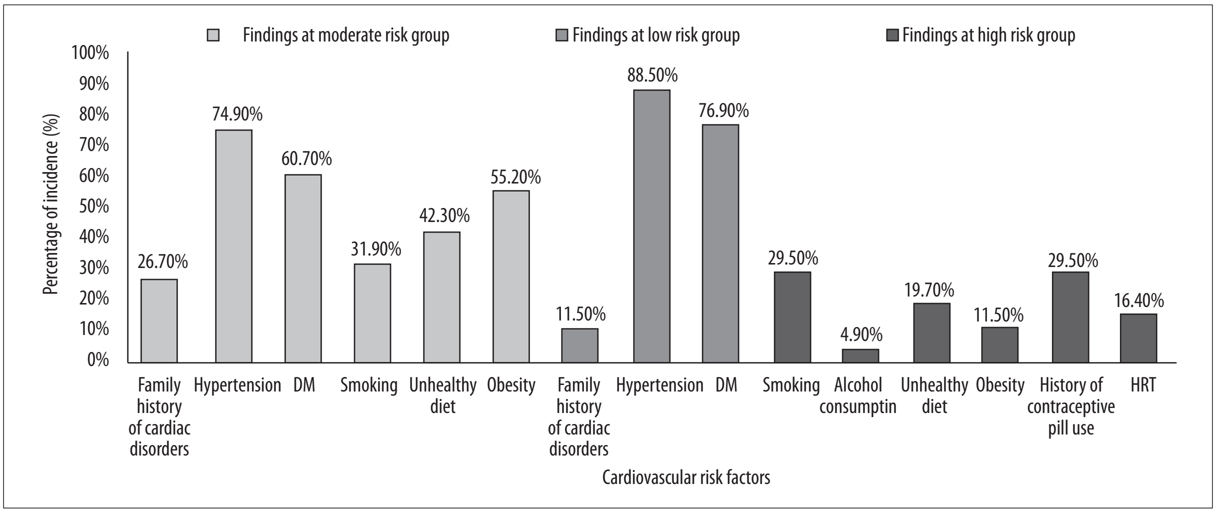

Figure 4. Distribution of cardiovascular risk factors in patients with high, moderate, and low risk of cardiac events.

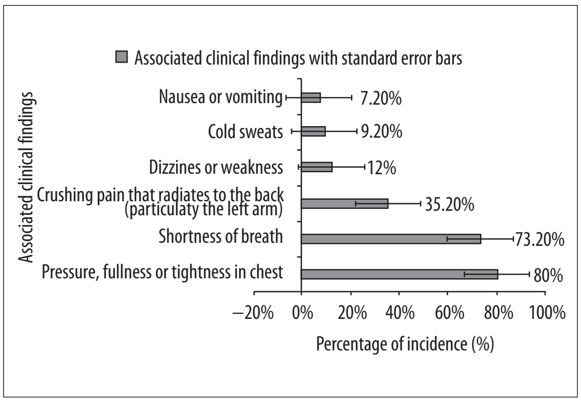

Figure 5. Clinical findings in patients presenting with chest pain.

As regards the presence of cardiovascular risk factors, 163 (65.2%) patients were at high risk of cardiovascular events, 26 (10.4%) and 61 (24.4%) patients were at moderate and low risk, respectively. A family history of cardiac disorders (43, 26.7%), hypertension (122, 74.9%), DM (99, 60.7%), smoking (52, 31.9%), unhealthy diet (69, 42.3%), and obesity (90, 55.2%) were common in high-risk patients. In patients at moderate risk, the frequency of cardiovascular risk factors as follows: family history of cardiac disorders (3, 11.5%), hypertension (23, 88.5%), and DM (20, 76.9%). In patients at low risk, the frequency of cardiovascular risk factors was as follows: smoking (18, 29.5%), alcohol consumption (3, 4.9%), unhealthy diet (12, 19.7%), obesity (7, 11.5%) history of contraceptive pill use (18, 29.5%), and HRT (10, 16.4%) (Figure 4).

All patients admitted to the ED with chest pain were screened for the presence of any associated clinical symptoms and signs (Figure 5). Clinical presentation of pressure, fullness, or tightness in the chest (200, 80%), and shortness of breath (183, 73.2%) were the commonest findings. Cold sweats (23, 9.2%) and nausea/vomiting (18, 7.2%) were least frequent. Shortness of breath (183, 73.2%) and dizziness or weakness (30, 12%) were also detected (Figure 5).

2D-TTE was conducted immediately on arrival to the ED. Out of 250 patients with chest pain who were enrolled in this study, 170 (68%) patients had positive 2D-TTE findings. Positive findings were detected in 147 (86.5%) patients in the high-risk group, in 13 (7.6%) patients in the moderate risk group, and in 10 (5.9%) patients in the low risk group.

The incidence of IHD was frequent in the high-risk group, as compared to the incidence of NIHD in the same group. Non-ischemic cardiac events were abundant in the remaining two groups in comparison to ischemic disorders (Table 2).

The remaining patients with negative 2D-TTE findings (80, 32%) were discharged and scheduled for follow-up stress testing within 24–48 hours; all were considered as high-risk patients at the time of the initial evaluation. On follow-up, stress testing revealed that only 28 (35%) had an AMI; ECG was abnormal and the average level of creatine kinase (CK) was 207 U/L.

As regards all risk groups, it was found that 2D-TTE had sensitivity of 85.86% (95% confidence interval (CI): 80.21% to 90.39%) and specificity of 100% (95% CI: 93.15% to 100%) for detecting IHD and NIHD. Furthermore, it had positive predictive value (PPV) of 100% (95% CI: 97.85% to 100%) and NPV of 65% (95% CI: 53.52% to 75.33%). In the current study, it was found that the prevalence of cardiac events was 79.2% (95% CI: 73.64% to 84.06%), with a negative likelihood ratio of 0.14 (95% CI: 0.10 to 0.20) (Table 3).

Discussion

Making correct diagnoses in patients presenting to the ED with chest pain is important to emergency physicians. To avoid discharging patients with AMI, most emergency physicians attempt to admit all patients in whom the possibility of acute coronary ischemia exists. These patients occupy expensive, intensive care beds, substantially increasing the financial cost of diagnosis and treatment of myocardial ischemia and AMI. Therefore, 2D-TTE, a rapid test, can provide very useful information on the cardiovascular system. Additionally, the test can be easily performed at bedside. This makes it a very useful adjunct in evaluating ED patients with chest pain due to IHD and/or NIHD, resulting

Table 2. IHD and NIHD (by incidence and type) in different patient groups according to the number of risk factors.

<table>
<tr><th>Patient groups</th><th>Incidence of IHD (n,%)</th><th>Incidence NIHD (n,%)</th><th>Total (n,%)</th></tr>
<tr><td>High risk group</td><td>(125, 85%)</td><td>(22, 15%)</td><td>(147, 100%)</td></tr>
<tr><td>Moderate risk group</td><td>(6, 46.2%)</td><td>(7, 53.8%)</td><td>(13, 100%)</td></tr>
<tr><td>Low risk group</td><td>(2, 20%)</td><td>(8, 80%)</td><td>(10, 100%)</td></tr>
<tr><th>Patient groups</th><th>Type of IHD (n,%)</th><th>Type of NIHD (n,%)</th><th>Total (n,%)</th></tr>
<tr><td rowspan="4">High risk group</td><td rowspan="2">Acute myocardial infarction (AMI) (33, 22.5%)</td><td>Hypertrophic cardiomyopathy (HCM) (12, 8.2%)</td><td rowspan="4">(147, 100%)</td></tr>
<tr><td>Restrictive cardiomyopathy (5, 3.4%)</td></tr>
<tr><td rowspan="2">Angina (stable/unstable) (92, 62.6%)</td><td>Valvular abnormalities (3, 2%)</td></tr>
<tr><td>Pericardial effusion (2, 1.3%)</td></tr>
<tr><td rowspan="4">Moderate risk group</td><td rowspan="2">Acute myocardial infarction (AMI) (2, 15.4%)</td><td>Hypertrophic cardiomyopathy (HCM) (3, 23%)</td><td rowspan="4">(13, 100%)</td></tr>
<tr><td>Restrictive cardiomyopathy (2, 15.4%)</td></tr>
<tr><td rowspan="2">Angina (stable/unstable) (4, 30.8%)</td><td>Valvular abnormalities (1, 7.7%)</td></tr>
<tr><td>Pericardial effusion (1, 7.7%)</td></tr>
<tr><td rowspan="4">Low risk group</td><td rowspan="2">Acute myocardial infarction (AMI) (1, 10%)</td><td>Hypertrophic cardiomyopathy (HCM) (1, 10%)</td><td rowspan="4">(10, 100%)</td></tr>
<tr><td>Restrictive cardiomyopathy (1, 10%)</td></tr>
<tr><td rowspan="2">Angina (stable/unstable) (1, 10%)</td><td>Valvular abnormalities (2, 20%)</td></tr>
<tr><td>Pericardial effusion (4, 40%)</td></tr>
</table>

Table 3. Performance of 2D-TTE in the evaluation of cardiac events in patients with chest pain.

Absence or presence of cardiac event in 2D-TTE	Number of cases (n)	
True positive	170	
True negative	52	
False positive	0	
False negative	28	
Performance of 2D-TTE in the evaluation of cardiac events	**Value**	**95% CI**
Sensitivity (%)	85.86%	80.21% to 90.39%
Specificity (%)	100%	93.15% to 100%
Negative likelihood ratio	0.14	0.10 to 0.20
Cardiac events prevalence (%)	79.2%	73.64% to 84.06%
PPV (%)	100%	97.85% to 100%
NPV (%)	65%	53.52% to 75.33%

in lower morbidity and mortality rates [30]. Such 2D-TTE findings with respect to the incidence of IHD and NIHD in different patient groups are presented in Table 2. The patients were grouped according to the presence of cardiovascular risk factors (Figure 4).

The effect of real time 2D-TTE on medical decision making in the ED was previously studied in 100 consecutive patients presenting with suspected cardiac pathology [23]. Echocardiography altered the diagnosis in 37% of patients, led to changes in treatment in 25% of patients, and increased physician confidence in their diagnosis in 50% ofcases [23]. In addition, the latest information available on the performance of early echocardiography in the prediction of cardiac events in ED patients with chest pain was as follows: sensitivity of 91% (95% CI: 79% to 97%), which was higher than that of ECG (40%; 95% CI: 27% to 55%; $P<0.0001$). Specificity of echocardiography was 75% (95% CI: 69% to 81%), which was significantly lower than that of ECG (94%; 95% CI: 90% to 97%; $P<0.0001$). PPVs were not significantly different (44%, 95% CI: 34% to 54%, and 60%, 95% CI: 42% to 76%; $P=0.12$) [31]. In this study (Table 3), 2D-TTE was characterized by sensitivity of 85.86% (95% CI: 80.21% to 90.39%) and specificity of 100% (95% CI: 93.15% to 100%) for detection IHD and NIHD. Furthermore, 2D-TTE had PPV of 100% (95% CI: 97.85% to 100%) and NPV of 65% (95% CI: 53.52% to 75.33%). A low negative likelihood ratio of 0.14 (95% CI: 0.10 to 0.20) was also noted (Table 3).

Several recent studies that used 2D-TTE in EDs were focused on identifying only those patients who had AMI [32–34]. In contrast, the current study analyzed risk factors in different patient groups (Figure 4), and the onset of angina, either stable or unstable ones (Table 2). Focusing on MI exclusion alone may result in failure to identify patients with ongoing ischemia who have a significant risk of short- and long-term cardiovascular morbidity and mortality. Furthermore, early identification of patients with unstable angina may significantly reduce the risk of MI (Table 2). Also, as mentioned earlier in this study, 28 (35%) out of 80 (32%) patients with negative 2D-TTE findings had an AMI on echocardiography stress testing, where ECG was abnormal and the average level of CK was 207 U/L. Such findings could be compared with the ability of stress echocardiography in distinguishing IHD from NIHD, as described by Duncan et al., 2003 [35]. They found that 2D-TTE was a quantifiable, reproducible, and noninvasive technique for differentiating ischemic from non-ischemic cardiomyopathy with good sensitivity and specificity. In addition, Peteiro et al., 2003 [36] studied the role of exercise echocardiography in differentiating dilated cardiomyopathy from ischemic left ventricular dysfunction. They found that global and/or regional left ventricular function impairment with exercise is accurate for identifying patients with ischemic left ventricular dysfunction, which is in line with the current findings of 2D-TTE stress testing.

Among the limitations of the current study is that, as a part of the risk stratification process, not all patients were admitted, since low risk patients undergo early myocardial perfusion imaging and are discharged home, if the study is negative. However, all admitted patients underwent an evaluation by emergency physicians. The initial evaluation included patient history, physical examination, ECG, and 2D-TTE. Patients with negative findings were discharged and scheduled for follow-up stress echocardiography testing within 24–48 hours. Enrolment of consecutive patients who were grouped into three groups according to cardiovascular risk could be considered as one of the strengths of this study.

Conclusions

The results demonstrate that 2D-TTE was applied for determining a wide range of IHD and NIHD findings in patients at high, moderate, and low risk of cardiac events. It can be used to help determine the need for hospital admission, confirm or exclude specific diagnosis, and guide urgent therapy. 2D-TTE increased the specificity and sensitivity of diagnosis for the causes of chest pain, when compared to patient history, clinical symptoms and signs, and ECG findings. 2D-TTE stress testing is recommended, whenever there is a negative 2D-TTE finding among patients presenting to the ED with chest pain, because NPV of 2D-TTE is insufficient.

Acknowledgements

The author would like to thank the staff of the Emergency Department of King Khalid Hospital & Prince Sultan Center for Health Services for their cooperation and support during data collection.

Conflicts of interest

The author declares that there is no conflict of interest.

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