Blunt Myocardial Injury*

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CK=creatine kinase; RNA=radionuclide angiography; 2D=two-dimensional

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Trauma is the leading cause of death in persons younger than 40 years and is the third leading cause of death in the general population.1 Twenty-five percent of the traumatic fatalities result from chest trauma, which is most frequently caused by motor vehicle accidents.1,6 The combination of impact against a steering wheel followed by sudden deceleration is a common event. One of the most feared complications of chest trauma is myocardial contusion, which implies necrosis with or without hemorrhage into the myocardium.7 Patients who survive the initial trauma can present with life-threatening injuries and hemodynamic compromise. However, the extent of the investigation and management of the less symptomatic, hemodynamically stable patients remains controversial.

INCIDENCE

In an autopsy series of patients who died after major chest trauma, the incidence of cardiac contusion was 16%.8 The reported incidence depends on the diagnostic modality and criteria used and ranges from 8 to 71%.2,3,9,10 The true incidence remains unknown since there is no diagnostic gold standard. The lack of a clinical gold standard detracts from the interpretation of much of the literature.

CLINICAL SYNOPSIS

The spectrum of complications of myocardial contusion ranges from arrhythmias without histologic evidence of injury to exsanguinating rupture. Within this spectrum lies a wide range of clinical presentations of variable physiologic consequences. The complications encountered as a result of contusion are similar to those seen in myocardial infarction: arrhythmias, ventricular dysfunction, acute valvular regurgitation,11 ventricular aneurysm with thrombus, intracardiac structural damage, and free wall rupture. Despite the similarity of complications for myocardial contusion and infarction, major differences between the two groups must be emphasized. Patients with contusion are generally younger, have no underlying cardiovascular illness, and have an excellent outlook toward complete recovery.3,9,12,13 Patients with myocardial infarction are usually older, have progressive atherosclerotic coronary artery disease, and have underlying hypertensive and diabetic disease.

Several studies have confirmed that myocardial contusion patients who require emergency surgery have low mortality rates.2,5,9,13,14 However, Healey et al15 reported an incidence of 36% for cardiac-related complications, such as arrhythmias and hypotension. A prospective study of 201 patients with blunt thoracic trauma requiring emergency surgery within 24 h of hospital admission found an intraoperative mortality of 8%; 6 of 14 hearts had myocardial contusion seen intraoperatively or at autopsy.16 There were an additional 30 deaths (2 with myocardial contusion) in the postoperative period. When survivors and nonsurvivors were separated according to the presence (n=11) or absence (n=174) of myocardial contusion, patients with myocardial contusion (5.9%) were significantly more severely injured and had a higher mortality (56.5% vs 4.6%; p<0.0001), but were not more likely to experience arrhythmias or hypotension.16 However, one should remain alert and be ready to intervene for these potential problems with any blunt thoracic trauma patient; invasive intraoperative monitoring is warranted.

DIAGNOSIS

Diagnosis of myocardial contusion in chest trauma patients is suggested by a pericardial friction rub, an S3 gallop, pulmonary rales, or an elevated central venous pressure. The most common symptom is nonspecific chest pain arising from noncardiac chest structures.7,17 Chest radiography can be helpful if it demonstrates injury to the thoracic cage or findings of heart failure. Physical findings of thoracic trauma (eg, abrasions, crepitus, rib fractures) were observed in 73% of 41 patients with myocardial contusion (defined by enzymatic or ECG criteria).17 There remains, however, a large group of patients without physical findings of
cardiac damage. This group requires other diagnostic tests to further stratify their risk.

An ECG definition considered diagnostic of myocardial contusion is a conduction abnormality, ST segment depression or elevation of at least 1 mm, or T-wave inversion in two contiguous leads. One enzymatic definition requires the ratio cardiac creatine kinase (CK) isoenzyme (CK-MB) to total CK to be 5% or greater. One definition of suspected myocardial contusion is the presence of any reversible finding by radionuclide angiography (RNA): (1) right ventricular ejection fraction less than 40%; (2) left ventricular ejection fraction less than 50%; or (3) abnormal wall motion in one or more segments. Thallium 201 imaging requires the presence of defects that indicate decreased myocardial perfusion to diagnose myocardial contusion.20

**ECG**

The ECG is very helpful when it shows ST elevation, indicating myocardial injury. More commonly, however, the ECG findings are nonspecific. Potkin et al. performed ECGs on greater than 100 consecutive patients with significant chest trauma: 70% had abnormal ECGs, but 80% of the ECG abnormalities were nonspecific ST-T changes. Fifteen patients died; at autopsy, 5 patients had myocardial contusion and 10 did not. However, there were no differences in ECG findings among these patients who had undergone autopsies. Using either abnormalities of echocardiography or RNA to define the presence of contusion in 75 patients with nonpenetrating chest trauma, ECG ST-T wave changes were present in 25 patients, yielding a sensitivity of 47% and a specificity of 79%. Despite its lack of sensitivity, the ECG appears to have an excellent negative predictive value for cardiac complications. Healey et al. reported a 90% negative predictive value.

Since the right ventricle is more likely to be injured in steering wheel injuries, it is reasonable to consider that ST elevation in the right precordial leads might be more revealing than the left precordial leads. In a prospective study of 35 patients sustaining blunt chest trauma, all subjects without apparent antecedent heart disease had a conventional 12-lead ECG, right-sided precordial leads, and first-pass RNA performed. In this study, myocardial contusion was defined as a right ventricular ejection fraction less than 40%. Fifteen patients (43%) sustained a myocardial contusion according to this definition, but none of these patients had ST elevation 80 ms after the J point in leads V4R through V6R. Furthermore, left precordial leads were not helpful. This study found no utility for the ECG in evaluating blunt trauma patients.

**Arrhythmias**

Dysrhythmias, especially premature ventricular contractions, are very common after chest trauma. In the series of Potkin et al., 73% of patients had an arrhythmia. Although both atrial and ventricular arrhythmias have been encountered, there is no correlation between complexity of the arrhythmia and the degree of cardiac contusion. The arrhythmias following trauma have several possible etiologies, including electrolyte disturbances, blood gas alterations, high catecholamine states, and often alcohol and/or other drugs. Some patients may have preexisting heart disease or concomitant CNS injuries contributing to rhythm problems. McLean et al. identified atrial fibrillation as an independent and strong predictor of increased mortality. Therefore, arrhythmias in chest trauma patients should indicate cardiac contusion until proven otherwise, and therapy should be based on the type and hemodynamic consequences of the arrhythmia.

**Cardiac Enzymes**

The most widely used enzyme for the diagnosis of myocardial necrosis is the CK-MB isoenzyme. Its specificity for cardiac contusion has been questioned by several investigators. In a prospective evaluation of blunt chest trauma, 18 of 68 patients (26%) had echocardiographic evidence of cardiac injury, but only three had a CK-MB concentrations greater than 3%. The sensitivity and specificity of CK-MB were 29% and 90% using echocardiographic or radionuclide abnormalities as an indicator of myocardial contusion.

CK-MB is present in skeletal muscle, lung, pancreas, stomach, colon, small intestine, and liver. Although the heart has a high proportion of CK-MB, the small percentage of CK released from the heart may be obscured by high levels of total CK released from other noncardiac injured tissue. Perhaps, the absolute CK-MB level is more reflective of cardiac injury than the percent CK-MB. Healey et al. found that a CK-MB concentration of 200 mg/dL or greater had a 100% positive predictive value for cardiac complications. Alternatively, a CK-MB concentration of 5% or less combined with normal ECG had a 100% negative predictive value for treated arrhythmias. Recent studies suggest that cardiac troponin, a myocardial regulatory protein, is a more specific marker than CK-MB for cardiac injury.

**Cardiac Imaging Studies**

There appears to be little correlation between ECG changes or CK-MB and cardiac imaging studies. The cause of the discrepancy is probably multifactorial. Since the right ventricle seems to be more commonly involved than the left ventricle, no ECG changes are seen using the 12-standard leads. Furthermore, right precordial ECG leads
appear to be noncontributory.25

Some investigators have introduced the term cardiac concussion to describe this subgroup of patients at the lower end of the spectrum.9,15 Different definitions have been given to the term concussion. Some consider it as a functional impairment without evidence of histopathologic or enzymatic abnormalities.15 Others describe cardiac concussion as normal cardiac function by echocardiography with CK-MB release.9 The former definition seems to be more logical. Regardless of the definition, patients with cardiac concussion have an uneventful course.

There is disagreement among investigators about the usefulness of cardiac imaging in predicting cardiac complications. Frazee et al9 reported a 39% complication rate in chest trauma patients with an increased CK-MB concentration and an abnormal two-dimensional (2D) echocardiogram. However, the complication rate was 3% in those with an increased CK-MB level but a normal 2D-echocardiogram.9 Although cardiac enzymes were not predictive of cardiac events, Karalis et al15 reported cardiac events in 26% of 31 patients with echocardiographic myocardial contusion compared with 3% of 74 patients without echocardiographic myocardial damage (p=0.001). Other series have failed to demonstrate such a correlation.2,10,14,15,32

The cardiac imaging techniques often used in chest trauma are 2D echocardiography and RNA. These two studies have certain differences that are worth mentioning. 2D echocardiography has the advantage of visualizing wall motion abnormalities, intracardiac structures, including thrombi, and pericardial effusions. In one prospective blunt trauma series, 15 of 68 patients (26%) had echocardiographic evidence of cardiac trauma: 7 right ventricular contusions, 3 left ventricular contusions, 3 biventricular contusions, 4 pericardial effusions, and 1 traumatic ventricular septal defect.29 Echocardiographic study can be suboptimal in a significant proportion of patients owing to presence of chest tubes or significant chest wall bruising, resulting in substantial pain.23,27,33 Only 20 of 105 consecutive severe thoracic blunt trauma patients (19%) had suboptimal transthoracic echocardiograms.18 Transesophageal echocardiography detected regional wall motion abnormalities in 10 of these 20 patients (50%). Thirty-one of the 105 patients (30%) had evidence of myocardial contusion involving the following: (1) the right ventricle alone (39%), usually involving the distal anteropapical wall; (2) the left ventricle alone (6%), involving the distal left ventricular septum and apex; and (3) both right and left ventricle (55%). Right ventricular ejection fraction was likely to be decreased if there was extensive involvement of the right ventricular anterior wall.18 A subcostal and apical placement of the transducer is likely to provide the most information; however, transesophageal echocardiography will be more sensitive for detecting aortic injury. Cachecho et al13 observed that routine echocardiography was unlikely to provide added information for young patients with minor blunt thoracic trauma without evidence of rib fractures, pulmonary contusion, or flail chest.13

Alternatively, it has been suggested that RNA is more sensitive in detecting an isolated injury to the right ventricle12 and gives a more accurate estimation of right ventricular and left ventricular ejection fraction, especially when a wall motion abnormality exists. Forty-two of 77 blunt trauma patients (55%) had segmental wall motion abnormalities by RNA. Involvement of the left ventricle alone (17%) was less common than focal defects of the right ventricle (64%). The remaining patients had biventricular involvement (17%) or septal dyskinesia. The right and left ventricular ejection fractions were significantly lower among those patients with segmental abnormalities. Wall motion improved or resolved in 84% of the 32 patients who underwent repeated studies. ECG changes suggesting acute injury were present in 26% of patients with a wall motion abnormality vs 11% without RNA changes. Mortality was higher (29% vs 6%, p=0.05) with changes in wall motion. Of 111 subjects with blunt chest trauma, 15 (14%) had a segmental wall motion abnormality, 24 (22%) had right ventricular global hypokinesia by RNA, and most abnormalities resolved.32 RNA will be suboptimal when arrhythmias (eg, frequent ventricular ectopy or atrial fibrillation) are present and will not visualize intracardiac structures. Cachecho et al13 observed that routine RNA was unlikely to provide added information for young patients with minor blunt thoracic trauma without evidence of rib fractures, pulmonary contusion, or flail chest.

Technetium-99m pyrophosphate scan can detect myocardial necrosis.34 Although it was introduced as a diagnostic tool for cardiac contusion, recent studies have been disappointing since there are high rates of false negatives.22 In the study of Potkin et al,22 only 2 of 100 chest trauma patients had abnormal scans.22 The rest had normal scans, including five patients with positive findings on autopsy. Since there is a higher likelihood of injury of the right ventricle and the right ventricle has a lower mass relative to the left ventricle, the scintigraphic detection of right ventricular necrosis is difficult. Since technetium-99m pyrophosphate can be taken up by bone, false positive would be expected with sternal fractures.7

Small studies with thallium 20118,21 suggest that it is useful. Thallium defects demarcate segments of decreased myocardial perfusion as a consequence of blunt trauma.19 Thirty-eight of 48 blunt trauma patients (79%) with interpretable thallium 201 scintigrams had defects. Electrocardiographic ST-T segment abnormalities were present in 31 of the 38
patients with thallium defects vs 4 of the 10 patients without defects. Segmental hypokinesia by echocardiography was present in 16 and was absent in 17 of the 38 patients with an abnormal result of a thallium test. Six patients, including one with segmental hypokinesia, had pericardial effusion detected by echocardiography. None of the ten patients without thallium defects had an echocardiographic wall motion abnormality or pericardial effusion. When thallium 201 combined with single-photon emission CT was performed within 24 h in 123 subjects who had sustained blunt chest trauma, 75 (61%) had abnormal scans with most defects being subepicardial and located at the apex, periapical region, or anterolateral wall of the left ventricle. All 11 patients with serious arrhythmias had abnormal scans.21 It should be noted that the right ventricle is not normally imaged by this technique.20 Also one should appreciate that the presence of a thallium defect says nothing about the age of the defect or its etiology. In other words, the defect could be due to a prior myocardial infarction.

Antimyosin, a Fab fragment of the monoclonal antibody to cardiac myosin, has been tagged with indium 111. Indium 111 antimyosin scintigraphy has been tested in a small cohort with blunt chest trauma.33 However, further studies are required before such expensive tests can be recommended.

Conclusion

The incidence of cardiac contusion is still unknown because of the lack of diagnostic gold standard. Established diagnostic criteria are lacking; therefore, the use of tests as predictors for complications is more useful than establishing the diagnosis. Future studies should focus on this issue rather than trying to establish the diagnosis.

The overall prognosis of the stable chest trauma patient is favorable and complete recovery is the rule. Long-term functional sequelae are unusual.33 The ECG has a good negative predictive value, especially when combined with normal CK-MB levels. Absolute CK-MB values seem to have a good positive predictive value for cardiac complications. Based on the above, it seems reasonable to discharge patients from the hospital after 24 h of monitoring if their ECG and CK-MB level are normal and no other major injuries are present. Until further studies indicate otherwise, it is probably reasonable to reserve imaging studies for patients with an abnormal ECG and/or elevated CK-MB level or preexisting cardiac disease. For patients who require emergency surgery, invasive intraoperative monitoring is often advocated although these patients tend to do well.

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References

25. Mooney R, Niemann JT, Bessen HA, et al. Conventional and right precordial ECGs, creatine kinase, and radionuclide angiography