

CLINICAL ISSUES

Blunt Cardiac Trauma

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There is disagreement concerning the significance of blunt cardiac injury (BCI). While the statement has been made that cardiac injury may be the most common unsuspected fatal visceral injury, others have found that functional cardiac abnormalities as a result of blunt chest injury occur in only a minority of patients. One might think of the controversy as an "academic" diagnosis of BCI versus "clinically relevant BCI." There has yet to be defined a battery of tests that can identify BCI with high sensitivity and specificity. Furthermore, predicting which patients will develop subsequent complications, particularly intraoperatively, is also far from clear-cut. The purpose of this review is to summarize current understanding concerning the diagnosis and management of patients thought to have sustained some degree of blunt cardiac injury.

The majority of blunt cardiac injuries are associated with motor vehicle crashes. Blunt injuries are also observed after falls, crush and blast injuries, and cardiopulmonary resuscitation (CPR). Both seat belts and crash bags have been implicated in producing blunt cardiac injuries, and there is a remarkable incidence of cardiac rupture associated with seat belt use. The reported incidence of cardiac injuries associated with blunt chest injury varies widely, from 16% in autopsy series to 76% in clinical reports. Life-threatening BCI probably occurs in 5% to 15% of patients with severe blunt chest injuries.¹

A wide spectrum of blunt injuries exists, from the most minimal concussion, to focal cell death and necrosis (contusion), to papillary muscle or valvular disruption, coronary artery thrombosis, or, in the extreme, septal or free wall rupture. The rate of co-existing injuries (e.g., great vessel injury, pulmonary contusion, head and intraabdominal injuries, and pelvic and long bone fractures) is high, and these associated injuries are often life threatening. In recognition of this wide spectrum of injuries, the term "blunt cardiac injury" has been substituted for "cardiac contusion."

Clinical Presentation

Any patient sustaining blunt chest injury should be suspected of sustaining BCI. Review of the mechanism of injury may reveal important clues; for instance, a damaged steering wheel warrants concern. Patients may complain of chest pain or shortness of breath (assuming they are well enough to speak). Physical examination may reveal tenderness, bruising, or crepitation secondary to rib or sternal fractures. Auscultation may reveal a friction rub, gallop, murmur, or rales. Hemodynamic instability may be secondary to hypovolemia from

associated injuries, valvular disruption, cardiac rupture, or tamponade. It should also be noted that BCI may be present with minimal or absent signs of chest trauma.

Diagnostic Evaluation

No gold standard exists to identify with high specificity and sensitivity the patient who has experienced blunt cardiac injury. Electrocardiograms, chest radiographs, biochemical markers of cardiac injury, echocardiography, and radionuclide scanning have been used to identify patients so injured, yet all suffer from the lack of ability to accurately identify all patients sustaining BCI, exclude patients not sustaining BCI, and determining which patients will go on to have BCI-associated complications.

The Electrocardiogram (ECG). Clearly an ECG is indicated in any patient sustaining blunt chest injury. Dysrhythmias that have been associated with BCI include paroxysmal supraventricular tachycardia, multiple premature ventricular contractions, atrial fibrillation, ventricular tachycardia and fibrillation, second- and third-degree atrioventricular blocks, and complete heart block.² Sinus tachycardia and nonspecific ST-segment changes are the most common abnormal rhythms noted (in 35%–80% of patients) but these are very nonspecific disturbances. A significant portion of blunt cardiac injuries involve the right ventricle, and this is poorly evaluated by conventional ECG.³ ST-segment elevation in right precordial leads may subtly suggest right ventricular injury. Preexisting cardiac disease and events commonly associated with trauma, including the effects of alcohol, electrolyte abnormalities, acid-base disturbances, and pulmonary contusion may confound interpretation. Patients with normal ECGs usually do not develop any complications of BCI.⁴ However, Biffi and co-workers found 2 of 17 patients with significant complications presented with a normal ECG.⁵ All complications were noted within 24 hours.

Chest Radiography. The real value of chest radiography is detection of associated thoracic injuries. As many as 60% of patients suspected of BCI will have co-existing injuries detected by chest film.⁶ Occasionally, pneumopericardium or a globular cardiac silhouette may be observed.

Radionuclide Scans. A meta-analysis of 2210 patients studied prospectively and 2471 patients studied retrospectively found no value for any radionuclide scan, including radionuclide ventriculography, multiple gated acquisition (MUGA), single photon emission computed tomography, and technetium pyrophosphate scanning.⁷ Though advocates of various radionuclide examinations can be found, the cost, complexity, and time required to complete the examination (when other matters are likely more pressing) limit their utility.

Echocardiography. The utility of transthoracic echocardiography in evaluating for BCI is much less clear than for penetrating cardiac injuries. Echocardiography may be

insensitive, and echocardiographic abnormalities do not seem to predict clinical complications reliably.⁸ Frazee's group was impressed with the myriad information that can be gained by a two-dimensional echocardiographic examination.⁹ Detectable abnormalities include regional wall motion abnormalities, intramyocardial hyperlucency secondary to contused myocardium, chamber dilation, mural thrombi, valvular abnormalities, shunts, myocardial rupture, and tamponade. Echocardiography discriminates between left and right ventricular injury and can also differentiate between right ventricular failure and cardiac tamponade, two entities that may present similarly but have distinctly different therapeutic options.

Hiatt et al commented that echocardiography is an important tool for diagnosis and triage and may assist in risk stratification and optimal use of resources.¹⁰ For instance, a normal echo and normal ECG negate the need for intensive care unit (ICU) admission, other injuries notwithstanding. Echocardiography seems particularly valuable prior to an urgent surgical procedure when the patient's full clinical picture remains incomplete.

Transesophageal echocardiography (TEE) may be of value in patients ventilated with positive end expiratory pressure (PEEP) and in those with mediastinal or subcutaneous air collections. The lack of easy availability of TEE at most centers limits its utility.

Biochemical Markers of Cardiac Injury

There has been hope that biochemical markers of cardiac injury might assist in establishing a diagnosis and offer prognostic value, but these hopes have not been realized. Creatine kinase (CK) is an enzyme long useful in diagnosing ischemic myocardial infarction but has proven both insensitive and nonspecific for evaluating blunt cardiac injury, as it is also found in skeletal muscle. Bertinchant and associates found that the percentage of patients with elevated CK-MB was not different in two groups with blunt chest trauma, one group having myocardial contusion established by echocardiographic or electrocardiographic evidence, the other having normal echo and ECG.¹¹ Biffi also found CK-MB of no value and believes the cost does not justify its value.⁵ However, studies can easily be found touting the prognostic value of CK-MB elevations.⁸

Cardiac troponins have been investigated and thought promising. Troponins are regulatory proteins associated with the actin filament of the contractile apparatus and specific to cardiac muscle. They are highly sensitive and specific for the detection of ischemia-related cardiac injury. Hence, it was thought, this would be an excellent marker for blunt cardiac injury. Data have been conflicting. In 1996, Adams et al concluded that measurement of cardiac troponin I accurately detected BCI.¹² However, their patient numbers were small (only 44 patients were included in the analysis and only 6 of these, or 14%, had echo-documented BCI). Subsequently, Bertinchant found significant elevation of cardiac troponins I and T in hemodynamically stable patients having echocardiographic- or ECG-documented BCI (26 of 94 patients [28%]).¹¹ However, though sensitivity was high (97%–100%), specificity (12% for troponin T and 23% for troponin I) and predictive value were disappointingly low. The author concluded that troponins were not an improved method for diagnosing BCI and the risk of significant morbidity from BCI in hemodynamically stable patients is minimal, even when troponins are elevated. A possible limitation of this study is that no patients developed cardiogenic shock or major electrocardiographic or

echocardiographic abnormalities. Ferjani and associates investigated the utility of cardiac troponin T for diagnosing BCI (29 of 128 patients [23%]) and found high specificity (91%) but low sensitivity (31%).¹³ They suggested myocardial cell damage with release of intracellular contents was less important in contusion compared with ischemic injury and, indeed, focal myocardial necrosis rarely occurs in BCI. Like Bertinchant, they encountered no patients with cardiogenic shock.

Do Patients with Blunt Cardiac Injury have Increased Anesthetic Risk?

The majority of reports suggest general anesthesia is safe in patients with BCI, both in the immediate post-injury period and beyond. Fabian reported on 37 patients with BCI having surgery: no arrhythmias requiring treatment nor unexplained hypotension were noted.⁸ Devitt et al prospectively examined perioperative cardiovascular events in a group of patients with blunt chest trauma having emergency surgery and found the group of patients with myocardial contusion had no greater incidence of intraoperative hypotension or arrhythmias than the group without myocardial contusion.¹⁴ Myocardial contusion was found in 5.9% of the patients studied and was diagnosed by anatomic inspection or radionuclide angiography. Overall mortality was greater in the group with myocardial injury, but their Injury Severity Score (ISS) was significantly higher, suggesting that the other injuries sustained by patients having myocardial injury were severe and life threatening. All intraoperative deaths, with the exception of one patient with cardiac tamponade, were from non-cardiac causes.

Ross et al reviewed 100 patients admitted and evaluated for cardiac contusion based on mechanism of injury.¹⁵ Sixty-four percent were diagnosed with contusion based on elevation of CK-MB and electrocardiogram. Thirty of these patients underwent general anesthesia; no deaths were attributable to myocardial contusion. There was one incident each of ventricular ectopy, ventricular fibrillation, nodal rhythm, and pulmonary edema in the perioperative period. They concluded that essential surgery, such as repair of complex lacerations or skeletal fixation, need not be delayed in a patient diagnosed with a cardiac contusion, but close hemodynamic monitoring is appropriate.

Flanbaum and associates prospectively studied a group of 19 patients sustaining severe multisystem injury and myocardial contusion.¹⁶ Nine patients (47%) arrived in shock and had severe multisystem injuries. Patients in shock had significantly elevated ISS (average 31) compared with the hemodynamically stable group. Fifteen patients (79%) required extensive surgery the day of admission. Twelve patients received pulmonary artery catheterization; 11 patients (including the 9 who arrived in shock) required inotropic support during surgery to maintain cardiac output. No complications attributable to the myocardial contusion per se were recognized. The authors concluded that severely injured patients with myocardial contusion and requiring pressor support to maintain cardiac output can safely undergo definitive surgical treatment with appropriate hemodynamic monitoring.

Not all studies offer such encouraging advice. Eisenach and associates retrospectively reviewed 76 patients having two-dimensional echocardiography after blunt chest injury.¹⁷ Twenty-three patients (30%) had abnormal echo results, including segmental wall motion abnormalities, enlarged right ventricle, pericardial effusion, acute valve abnormality, and right ventricular

thrombus. These patients had an increased incidence of preoperative and intraoperative hypotension and intraoperative dysrhythmias, including bradycardia, supraventricular tachycardia, and ventricular fibrillation. Fifty-eight percent of these patients received intraoperative pharmacologic therapy. The investigators found that ECG abnormalities were poor markers of BCI, as abnormal ECGs were noted with equal frequency in the groups having echo or no echo abnormalities. Five of the 23 patients with abnormal echocardiograms had pulmonary catheters inserted, and one case each of cardiac tamponade, right ventricular failure, and left ventricular failure were diagnosed based on hemodynamic information. It was not noted if there were any particular clinical features in the patients having pulmonary artery catheter insertion, which suggests this monitor might be beneficial. No correlations were observed with the type of surgery or anesthetic agents used, and no complications were noted in patients having surgery more than 1 month after injury. Eisenach et al concluded that echo-documented BCI is sensitive in predicting patients likely to experience intraoperative hypotension and dysrhythmias in the early post-injury period.

Healey and colleagues reported on a group of patients with BCI with significant cardiac-related mortality and morbidity.¹⁸ They reviewed 342 consecutive blunt trauma patients and found cardiac injury in 44 patients, or 13%, of their series. Arrhythmias or cardiogenic hypotension were noted in 61% of the cardiac-injured subgroup (27 patients). Heart injuries contributed to 6 of the 12 deaths in this group. An important observation for interpretation of this study is that the patients with BCI had significant injuries, with average ISS of 35. Surgical procedures were performed on 22 of these patients and 8 (36%) developed intraoperative cardiac-related complications, including 3 cases of ventricular fibrillation. There were no intraoperative deaths. CK-MB elevations and abnormal ECGs were observed in 100% of the patients requiring treatment for cardiac complications. Healey et al commented in summary that the diagnosis of cardiac injury was less important than the ability to identify the subgroup of patients at high risk for development of cardiac complications. Certainly a multiplicity of injuries as evidenced by the high ISS identifies a high-risk group.

Anesthetic Recommendations

It cannot be said that any particular anesthetic technique is better or worse than any other. With the possible exception of peripheral procedures, it is apparent that general anesthesia will be the appropriate anesthetic for most situations. The reviewer's recommendation is to conduct the anesthetic in a manner familiar and comfortable to the practitioner. That is, "do what you do best." However, a few important points need to be mentioned in regard to such patients.

Invasive monitoring should be predicated upon the surgery planned and the condition of the patient, though there may be a lower threshold for line placement in patients believed to have sustained BCI. Arrhythmias and pump failure should be treated in a standard fashion. Institutions familiar with the use and interpretation of transesophageal echocardiography data might find this appropriate.

Precipitous cardiovascular collapse may be caused by cardiac rupture, cardiac tamponade, acute valvular decompensation, air embolism, unappreciated hypovolemia, malignant ventricular arrhythmias, or tension pneumothorax. A patient

having multiple procedures may have become latex sensitive and develop anaphylaxis.

Cardiac Rupture

This is a special subset of patients worthy of comment. They usually present in extremis from hypovolemia and tamponade. Patients with ventricular rupture have over 75% mortality despite expeditious surgical treatment. The diagnosis can be difficult to make and is often made when an emergency department cardiac arrest leads to left anterior thoracotomy, aortic cross-clamping, and detection of a hemopericardium or pericardial laceration. Fluid resuscitation is essential. Inotropic support and intra-aortic balloon counterpulsation is often required. Vasodilator therapy may be indicated but should be titrated cautiously. The management of these patients somewhat resembles that of patients with penetrating cardiac injuries, as pericardial windows under local anesthesia often precede median sternotomy and the lesions are oversewn.

Pulmonary Contusion

If pulmonary contusion is associated with BCI, it may be particularly difficult to separate the effects of increased pulmonary vascular resistance from right ventricular pump failure.³ A pitfall in the management of a traumatically injured patient with an increased pulmonary capillary wedge and decreased cardiac output would be to assume the condition was caused by left ventricular failure. The pulmonary artery catheter data reflect pulmonary and right ventricular injury but do not accurately reflect left ventricular loading conditions; the patient may be acutely hypovolemic and require fluid resuscitation. Another concern is that PEEP can be catastrophic if acute tamponade develops.


Treatment Recommendations

- The diagnosis of cardiac contusion in the absence of any clinical abnormalities is of questionable clinical importance.
- The vast majority of patients with clinically significant BCI have evidence of such injury at the time of presentation.
- There is a high association between patients having BCI and other major system injuries, including head, chest, and abdominal injury, as well as pelvic and long bone fractures. The outcome of these coexisting injuries is usually more significant to the patient than the BCI.
- There is no "gold standard" for the evaluation of blunt cardiac injury. A diagnostic battery with high sensitivity, specificity, and predictive value has yet to be identified.
- Determinations of cardiac enzymes and radionuclide scans are insensitive and nonspecific in the evaluation of BCI.
- Echocardiography also lacks sensitivity and specificity, yet the information gained may prove somewhat valuable to the anesthesiologist faced with emergently anesthetizing such a patient.
- Cardiac morbidity in young patients with echocardiographic or electrocardiographic evidence of BCI is low when associated injuries are absent or minimal. Monitoring by telemetry for 24 hours is an acceptable plan.
- If possible, surgery should be delayed for 24 to 48 hours after injury if myocardial dysfunction is evident on ECG or echo.
- General anesthesia has been found safe in numerous, though not all, clinical studies. In terms of anesthetic technique, no method has been found superior to any

other. Do what you do best.

- Arrhythmias and pump failure, should they occur, should be treated with standard pharmacologic therapy.
- Pulmonary artery catheterization should be limited to patients with hemodynamic instability, pulmonary contusions, and overt mechanical (cardiac or pulmonary) disturbances.

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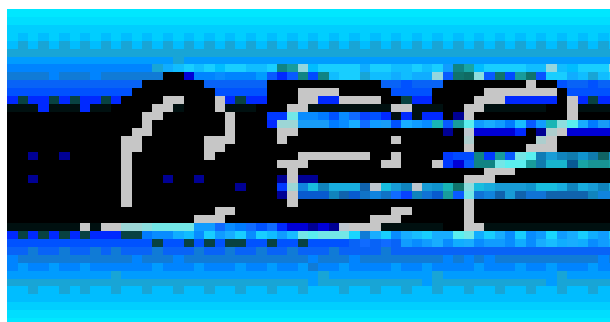
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