Injury, Int. J. Care Injured 47 (2016) 1025–1030

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Imaging in blunt cardiac injury: Computed tomographic findings in cardiac contusion and associated injuries

Mark M. Hammer [a,1], Demetrios A. Raptis [a], Kristopher W. Cummings [b], Vincent M. Mellnick [a], Sanjeev Bhalla [a], Douglas J. Schuerer [c], Constantine A. Raptis [a,*]

[a] Mallinckrodt Institute of Radiology, Washington University in St. Louis, St. Louis, MO, United States
[b] Department of Radiology, Mayo Clinic Arizona, Phoenix, AZ, United States
[c] Department of Surgery, Washington University in St. Louis, St. Louis, MO, United States

ARTICLE INFO

Article history:
Accepted 5 November 2015

Keywords:
Trauma
Blunt cardiac injury
Myocardial contusion
Cardiac contusion
Computed tomography

ABSTRACT

Background: Blunt cardiac injury (BCI) may manifest as cardiac contusion or, more rarely, as pericardial or myocardial rupture. Computed tomography (CT) is performed in the vast majority of blunt trauma patients, but the imaging features of cardiac contusion are not well described.
Purpose: To evaluate CT findings and associated injuries in patients with clinically diagnosed BCI.
Materials and methods: We identified 42 patients with blunt cardiac injury from our institution's electronic medical record. Clinical parameters, echocardiography results, and laboratory tests were recorded. Two blinded reviewers analyzed chest CTs performed in these patients for myocardial hypoenhancement and associated injuries.
Results: CT findings of severe thoracic trauma are commonly present in patients with severe BCI; 82% of patients with ECG, cardiac enzyme, and echocardiographic evidence of BCI had abnormalities of the heart or pericardium on CT; 73% had anterior rib fractures, and 64% had pulmonary contusions. Sternal fractures were only seen in 36% of such patients. However, myocardial hypoenhancement on CT is poorly sensitive for those patients with cardiac contusion: 0% of right ventricular contusions and 22% of left ventricular contusions seen on echocardiography were identified on CT.
Conclusion: CT signs of severe thoracic trauma are frequently present in patients with severe BCI and should be regarded as indirect evidence of potential BCI. Direct CT findings of myocardial contusion, i.e. myocardial hypoenhancement, are poorly sensitive and should not be used as a screening tool. However, some left ventricular contusions can be seen on CT, and these patients could undergo echocardiography or cardiac MRI to evaluate for wall motion abnormalities.

Introduction

Cardiac injury is an important potential complication of severe blunt-force trauma. Blunt cardiac injuries (BCI) can be classified as a myocardial concussion (wall motion abnormality with no anatomic or cellular injury) or as a myocardial contusion (anatomic injury that manifests as increased cardiac enzymes or tissue damage at surgery or autopsy) [1]. Other cardiac injuries resulting from blunt trauma include pericardial or myocardial rupture, papillary muscle injury, and coronary artery injury; these are much rarer and will not be discussed explicitly in this study. Pathologically, contusion represents an area of haemorrhage and necrosis within the myocardium. Clinically, it can present asymptomatically, with arrhythmias, or with cardiogenic shock [2,3]. In autopsy series of patients who died from blunt trauma, myocardial contusions were found in 14–24% of patients [2,4]. Unfortunately, while autopsy is the gold standard, clinical and imaging parameters in living patients are highly variable and without consensus criteria. This leads to disparate incidences of BCI reported in studies of living patients, ranging from 3 to 56% [5–7].

* Corresponding author at: 510 S. Kingshighway, Campus Box 8131, St. Louis, MO 63110, United States. Tel.: +1 314 362 2927.
E-mail addresses: mark.hammer@uphs.upenn.edu (M.M. Hammer), raptisj@mir.wustl.edu (D.A. Raptis), Cummings.Kristopher@mayo.edu (K.W. Cummings), mellnickv@mir.wustl.edu (V.M. Mellnick), bhallas@mir.wustl.edu (S. Bhalla), schuererd@wudosis.wustl.edu (D.J. Schuerer), raptisc@mir.wustl.edu (C.A. Raptis).
[1] Current affiliation: Department of Radiology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, United States.

http://dx.doi.org/10.1016/j.injury.2015.11.008
0020–1383/

Accurate diagnosis of myocardial contusion is difficult due to its nonspecific clinical findings. Because of this, many ancillary tests have been used, including myocardial enzyme release (troponin and creatine kinase-MB fraction), electrocardiographic (ECG) changes, and findings on echocardiography [5,8]. Overall, the goal of these investigations is to risk-stratify patients who may develop later complications, especially arrhythmias, as well as to assess patients who may have cardiac signs and symptoms in order to determine their aetiology. Unfortunately, no one parameter is highly specific, and no consensus criteria have been established [3,5,8]. Many patients are screened with ECG and/or troponin tests, but these tests are susceptible to false positive results due to neurologic injury [9,10], catecholamine surge, skeletal muscle injury, and medication (or illicit drug) use. Echocardiography appears to be a more specific test, and echocardiography findings correlated with complications in a large meta-analysis [5,8]. Unfortunately, its sensitivity is lower than ECG or troponin tests [6], and data from other studies about its predictive power are contradictory [4,6]. As a further complicating factor, echocardiography is often difficult in patients with chest trauma, who may have rib fractures, overlying bandages, and pneumothoraces; in addition, its ability to evaluate the right ventricle is somewhat limited. One additional test that deserves mention is the nuclear myocardial perfusion scan; this test initially appeared promising with reported high sensitivity [11], but a large meta-analysis demonstrated that it correlates poorly with clinical outcomes [8]. Furthermore, nuclear medicine perfusion scans perform poorly in evaluating the right ventricle, the chamber most commonly injured in blunt force trauma.

Computed tomography (CT) is now routinely performed in the acute evaluation of patients presenting with blunt trauma. However, while several review articles have listed potential imaging findings in cardiac injury [12,13], the imaging findings of blunt cardiac injury on CT have not been systematically investigated. One prior study had compared CT and trans-esophageal echocardiography in blunt trauma and found that CT did not detect any of the cardiac contusions in their small series [14], but this occurred in the era of single-slice CT. At least one recent review of potential CT findings in cardiac trauma has suggested that CT be used as part of the triage pathway in evaluating patients with potential blunt cardiac injury [12]. Thus, it would be important to know what imaging findings are present in patients with blunt cardiac injury and how frequently they are seen in the era of multidetector row CT. We set out to test two parallel hypotheses: (1) that myocardial contusions can be directly detected by hypoenhancement on CT and (2) that CT findings of severe thoracic trauma are associated with blunt cardiac injuries.

Methods

Patient selection

This study was conducted in accordance with Institutional Review Board and HIPAA guidelines.

Cases were selected from an initial pool identified using a searchable patient visit database maintained by our Center for Biomedical Informatics (Clinical Investigation Data Exploration Repository, CIDER). For our initial patient selection, we searched for patients with discharge summaries containing "myocardial contusion" or "cardiac contusion," or with visit ICD-9 codes corresponding to heart contusion or heart injury. Visit dates were restricted to years 2006–2013. We included only patients with blunt trauma and patients who underwent chest CT within 10 days of the trauma. A thorough chart review was performed to exclude spurious results (e.g. incorrect billing diagnosis); we recorded clinical parameters as well as laboratory and imaging test results. A total of 42 patients were included.

CT scans

Regarding the CT scan protocols, since this is a retrospective study, we were unable to apply a uniform protocol to all scans. Some were performed as standard, non-gated chest CTs, while others were pulmonary embolism or dissection protocols, and one study was a gated cardiac CT (see "Results" section and Table 1). All studies were performed on multidetector row CT scanners (40–64 row, Siemens Medical, Erlangen, Germany) using 100–120 ml of Optiray 350 (Ioversal 74%) intravenous contrast, with the exception of 3 studies done without intravenous contrast. Images were reconstructed as either 3 mm slice thickness at 2 mm intervals or 1 mm slice thickness at 1 mm intervals, depending upon the protocol used. Contrast delay was based on the employed protocol (automated bolus timing was used for pulmonary embolism and dissection protocols).

Image review

Two attending radiologists with a focus in emergency radiology reviewed the cases separately and were blinded to any clinical parameters. They were aware that these represented cases of blunt cardiac injury but did not know the location or extent of the injury. They recorded the presence of pericardial effusion, pericardial or epicardial stranding, and myocardial hypoenhancement as well as an impression of "normal" or "abnormal" imaging appearance of the heart. The "abnormal heart" category would encompass abnormalities of the pericardium, epicardial fat, and myocardium

Table 1
Patient characteristics and clinical findings.

	$n = 42$
Median age, years (range)	52 (21–79)
Male	36 (86%)
Motor vehicle collision	31 (74%)
History of CAD	13 (31%)
Unexplained or cardiogenic shock	14 (33%)
Arrhythmias	14 (33%)
Clinical diagnosis of cardiac contusion in notes	34 (81%)
Death	2 (5%)
Troponin I	
Initial, median (range), ng/ml	0.45 (0–33.4)
Initial, >0.24 ng/ml	24 (57%)
Peak, median (range), ng/ml	1.56 (0–368.4)
Peak, >0.24 ng/ml	34 (81%)
ECG changes	
ST/T changes	26/41 (63%)
Premature ventricular contractions*	6/41 (15%)
Right bundle branch block	12/41 (29%)
Abnormal ECG	32/41 (78%)
Echocardiography	
Performed	32 (76%)
Focal wall motion abnormality	9/32 (28%)
Diffuse hypokinesis, either ventricle	11/32 (34%)
Focal or diffuse hypokinesis	16/32 (50%)
Pericardial effusion	4/32 (13%)
Computed tomography protocols	
Routine	29 (69%)
PE protocol	6 (14%)
Non-contrast	3 (7%)
Other (dissection, etc.)	4 (10%)

Clinical parameters and characteristics of patients included in this study. CAD, coronary artery disease. The upper limit of normal for our laboratory's troponin I test is 0.24 ng/ml. ECG, electrocardiogram; known old ECG abnormalities were ignored. PE, pulmonary embolism. Arrhythmias were gathered from clinicians' notes.

* On ECG.