The Outcome of Cardiac Dysfunction in Critically Ill Trauma Patients: Myocardial Contusion Complicated by Refractory Hypotension

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Abstract

Background: This work attempted to define the care and course of those most severely affected patients in the setting of blunt chest trauma, who had hypotension refractory to routine fluid resuscitation.

Methods: Twenty-three critically ill blunt trauma ICU patients were resuscitated and enrolled with ongoing hypotension required placement of a pulmonary artery catheter. The REF®Explorer (Baxter, Edwards, Anaheim, CA) catheter was placed in the right heart measuring pressure, volume and oxygen utilization information, as well as recording Injury Severity Score, EKG, CXR, CPK/MB and echocardiography over the initial 72-h time period.

Results: There were an approximately 2,300 Level I trauma patients admitted annually over a 4-year period with an overall mortality rate of 4.3% (100) patients with 3.4% (79) patients "ruling in" with elevated cardiac enzymes, associated with an increased mortality rate of 6.7% ($p < 0.05$). The 23 patients were male (17, 74%), mean age 41.2 years, with no past medical history (19, 83%), in a motor vehicle accident (21, 91%), with pulmonary injury (9, 39%), undergoing celiotomy in (10, 44%). They presented with moderate to severe trauma acuity defined as mean GCS of 8.6, TS of 11.3, and ISS of 34 with an increased mean hospital stay of 15 days versus 6 days in the ICU; and a 26 days versus 10 days overall stay for those with myocardial contusion ($p < 0.05$). Analysis of diagnostic variables found an abnormal EKG in (21, 91%), CXR in (20, 87%) and echocardiogram in (8, 37%). The total CPK was found to be elevated, mean 2,219 (204–8,278 U/l), while the MB fraction was normal 2.3 ± 1.3%. Invasive cardiac monitoring found an increase in CO of 1.6 l/min from 5.9 to 7.8 l/min during the first 24 h of recovery. Survival was worsened with increased ISS (29 vs. 43) $p < 0.02$, but improved with longer ICU (17 vs. 8) $p < 0.03$ and hospital (39 vs. 7) $p < 0.05$ stay in days. The analysis of commonly used diagnostic modalities – EKG, CXR, ECHO, or CO, did not correlate with survival, but the total CPK was increased in survivors (2,715 vs. 1,432 U/l) $p < 0.009$.

Conclusion: There is worsened morbidity with a 2-fold increase in ICU LOS and hospital stay, and a 1.5-fold increase in mortality in the severe myocardial contusion group. The diagnostic dilemma posed by lack of definitive testing continues unresolved after analysis of routine modalities – EKG, CXR, ECHO, CPK or CO – failing to yield a "best test".

Key Words

Blunt chest trauma · Chest trauma · Trauma · Myocardial contusion · Cardiac contusion · EKG · CXR · Echocardiogram · CPK · Cardiac output

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Introduction

Early analysis of myocardial contusion by Kahn in 1929 suggested that prognosis in thoracic contusions depends on the character of the injury – direct due to contusion or concussion of the thorax; or penetrating and indirect due to fall from height or "heart strain" [1]. The outlook was found to be grave in those cases associated with marked shock.

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Table 2. Assessment and prognostic data.

Patients (23)	Mean ± SD (range)	Survivors (9)	Non-survivors (14)	Significance
Age (years)	41.2 ± 19.0 (15–77)	39.8 ± 19.2	43.8 ± 18.4	NS
GCS	8.6 ± 5.8 (3–15)	8.1 ± 5.9	9.6 ± 5.7	NS
TS	11.3 ± 3.9 (5–16)	11.4 ± 3.9	11.3 ± 4.2	NS
ISS	34.6 ± 12.7 (17–75)	29.4 ± 6.6	42.7 ± 15.9	$p < 0.023$[a] $p < 0.019$[b]
ICU LOS (days)	13.4 ± 10.7 (1–40)	17.2 ± 10.1	7.6 ± 9.1	$p < 0.031$
Hosp LOS (days)	26.5 ± 38.1 (1–188)	38.7 ± 44.7	7.5 ± 9.1	$p < 0.053$

[a]Student's *t* test, Levine test for equality of variance ($p < 0.05$)
[b]Mann-Whitney *U*–Wilcoxon Rank Sum *W* test ($p < 0.05$)

Those with myocardial contusion had an average length of ICU stay of 13.4 days and hospital stay of 26.5 days compared to 6.6 and 10.7 days overall for trauma patients ($p < 0.05$). The mortality in those with myocardial contusion was increased slightly (6.7 vs. 4.3%; $p < 0.05$) compared to general trauma mortality. The remainder (4.5%) ruled out for myocardial contusion and included 66 patients or 2.8% of total trauma population. Their average length of hospital stay was decreased (4.5 days) compared to those with myocardial contusion (26.5 days, $p < 0.05$), as well as the overall trauma population (10.7 days, $p < 0.05$).

The patient demographic profile finds a threefold predominance of males (17, 74%) compared to females (6, 26%). The mean age was 41.2 years with a range of 15–77 years. Patients were healthy with no past medical history in (19, 83%), followed by a cardiac history in (2, 8.7%). The mechanism of injury was predominately motor vehicle accident (MVA) in (21, 91%). Those who were injured were found to have a pulmonary diagnosis in (9, 39%), orthopedic injury in (5, 22%) and other cardiovascular diagnosis in (4, 17%) of cases. Likewise, most patients underwent some surgical intervention – celiotomy (10, 44%), or open reduction and internal fixation in (5, 22%).

Patient profile defined by outcome assessment variables found a mean Glasgow Coma Score (GCS) of 8.6 (3–15), Trauma Score (TS) of 11.3 (6–16) and Injury Severity Score (ISS) of 34.6 (17–75) (Table 2). The mean length of ICU stay was 13 days (1–40) and hospital stay of 26 days (1–188) with mortality of 39% in the 23 most severely affected cases with 9 survivors and 14 non-survivors.

The noninvasive diagnostic variables analyzed demonstrated an abnormal EKG in (21, 91%) of cases, presenting mainly with sinus tachycardia or T wave/ST changes (Table 3). The chest radiography (CXR) was abnormal in (20, 87%) of cases usually indicating a pulmonary contusion or pneumothorax (Table 3). Echocardiogram was abnormal in (8, 37%) of cases where both the LV and RV exhibited dysfunction (Table 4).

Table 3. Diagnostic variables.

	Abnormal	Normal	Survival (p)
EKG	91.3% (21)	8.7% (2)	NS
CXR	86.9% (21)	13.1%	NS
Echo	37.5% (6)	62.5% (16)	NS

Chi square with Pearson correlation ($p < 0.05$)

Analysis of total CPK finds a mean value on presentation of 2,218 with a range of 204–8728 U/l (Table 4). There was little specificity offered by examining for abnormal total CPK (> 210 U/l) with all (100%) cases fulfilling this criteria. However, the CPK myocardial specific fraction was 2.3% with range of 0.8–5.9% with only 8.7% of cases positive. Lastly, invasive hemodynamic monitoring was compared with an initial cardiac output of 5.9 l/min was initially followed by increase to 7.8 l/min, which with mean change of 1.6 l/min (Table 4).

Demographic characteristics including scoring systems and testing variables were analyzed as predictors of survivorship. There was no significant decrease in survival based on risk or other demographic variables. Comparison of various scoring systems found no appreciable survival predictive ability using GCS or TS in the myocardial contusion population, while a decreased ISS (29 vs. 43) was associated with improved outcome ($p = 0.023$).

There was an association between survival and an increased ICU (17 vs. 8 days, $p = 0.031$) and hospital stay (39 vs. 7 days, $p = 0.023$) where longer stays where

Table 4. Diagnostic variables – cardiac enzymes – invasive.

	Mean/SD/range	Survival	Non-survival	Significance
CPK				
Total (iu)	2217.9 ± 2197.1 (204–8278)	2714.6 ± 2567.6	1432.5 ± 1198.6	$p < 0.009$
MB %	2.34 ± 1.3 (0.8–5.9)	2.3 ± 1.41	2.5 ± 1.4	NS
Variables – invasive Hemodynamic monitoring				
Co (l/min)				
0 h	5.9 ± 2.2 (2.3–9.2)	5.9 ± 1.9	6.2 ± 2.2	NS
	11	9	2	
24 h	7.8 ± 2.9 (2.5–13.5)	7.9 ± 3.4	8.3 ± 2.8	NS
	16	9	8	
CO_{24}–CO_0	1.6 ± 3.8 (0.43–8.6)	2.1 ± 4.7	1.8 ± 1.4	NS

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found in survivors. The analysis of diagnostic techniques found no prognostication of survival using EKG CXR or echocardiogram analysis (Tables 4, 5). Although, there was no difference in MB fraction, the total CPK was increased in the group that survived (2,715 vs. 1,432 IU/l, $p < 0.009$). Lastly, assessment of cardiac output found no change in absolute measurements at either the initial (0 h) or final (24 h) time points during the analysis.

Discussion

Our study sample consisted of over 2,300 annual trauma admissions. The 23 patients evaluated were included due to the presence of refractory hemodynamic instability and only accounted for 0.1% of the total population. While, overall those admitted with blunt chest trauma accounted for only 3.4% of patients with over 50% "ruling-in" for myocardial contusion.

Although not comprising a significant proportion of the trauma patients generally, myocardial contusion assumes significance due to its 1.5-fold increase (9 vs. 14) in mortality in this trauma population. Therefore, an effective diagnosis and treatment strategy can potentially impact the survivability of significant myocardial contusion, as well as decreasing morbidity with a twofold increase in length of ICU (13 vs. 6 days) and 2.5-fold increase in length of hospital stay (26 vs. 10 days) in those with myocardial contusion compared to the general population.

The demographic analysis was not helpful as a survival discriminator based on small sample size. However, the myocardial contusion patient profile – healthy, middle aged adult males involved in motor vehicle accidents may be useful as a general descriptor of those at risk.

Likewise, resource allocation may be improved by defining necessary interventions in those with antecedent pulmonary (9, 39%) and cardiovascular (4, 17%) disease, which may affect the perioperative outcome of those who undergo celiotomy (10, 44%) or orthopedic intervention (5, 22%). This awareness may require operative delay it warranted or careful hemodynamic monitoring by both invasive and noninvasive routes to protect those at risk for further cardiopulmonary compromise.

Qualitative scoring systems predict a moderate to severe injury with mean GCS 9, TS 11, and ISS 34. Although neither triage score – GCS or TS – measured prospectively correlated with outcome, the ISS measured on admission correlated inversely appropriately with survival. However, this linear relationship cannot absolutely predict outcome and limits of a small representative sample fail to delineate a discriminator between survivors and non-survivors limiting clinical utility.

Likewise, very little definitive information can be inferred from the current diagnostic armatarium currently utilized for myocardial contusion. Clearly, the admission EKG (91%) and CXR (81%) were sensitive, but not specific markers for this disease condition, while the echocardiogram offered slightly better specificity (63%) but poor sensitivity.

The "best" conventional testing battery would probably be a combination of total CPK offering 100% sensitivity and the CPK/MB fraction offering 91.3% specificity [8, 9]. This acknowledges the cross-reactivity between cardiac and other body regions, such as brain resulting in decreased specificity in head injury cases. However, most recent data offered by Biffl suggest no correlation of CPK measurement to the diagnostic accuracy in myocardial contusion with a 30% myocardial contusion rate and complications in 5% [10]. However,

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this and other similar methodology is currently followed since there is no "gold standard" diagnostic resulting in incorporation bias. Even in this group of the most severely affected blunt chest trauma patients only 37.5% have an abnormal echocardiogram. Thus, little of the routinely employed diagnostic testing can be recommended as being confirmatory of myocardial contusion, causing it to remain largely a clinical diagnosis.

However, some prognostic information was noted with a significant increase in total CPK activity in survivors. There is little clinical relevance as this finding appears to be a function of the rapid demise of those severely injured who succumb prior to enzymatic degradation product release.

Lastly, even invasive cardiopulmonary monitoring failed to diagnose myocardial contusion with most patients with a normal CO 5.9 l/min at 0 h and > 7.8 l/min at 24 h. Analysis of the ΔCO 24–0 was limited by small sample size. Therefore, further study will evaluate other cardiopulmonary variables more carefully examining markers of cardiac performance and oxygen delivery.

The contention that in fact patients did not have significant myocardial injuries is probably not the correct conclusion. It is important to note that in a relative robust trauma program, with 2,300 patients admitted only a small number actually met criteria for myocardial contusion. So again, these were patients that were deemed to be critically ill by comprehensive trauma and critical care providers as manifested by hypotension refractory to emergency department resuscitation yet did not have cardiac contusion as the driving force behind this dysfunction.

Conclusion

This study was a preliminary evaluation that described the demographic, diagnostic and outcome profile of patients with blunt chest trauma and presumed myocardial contusion, accompanied by severe hemodynamic instability. The routine diagnostic modalities including EKG, CXR and CPK are perhaps overly sensitive; while CPK/MB and echocardiograms are too specific, acknowledging that a true "gold standard" for myocardial contusion is lacking.

Some prognostic information was offered by the inverse correlation of ISS and survival, while no further delineation in outcome was offered by invasive cardiopulmonary monitoring and CO assessment. The proper "diagnosis" and clinical management of significant myocardial contusion has remained elusive requiring good medical judgment, factoring often conflicting test results, to generate an effective and efficient plan of care.

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