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Traumatic Intraparenchymal Pseudoaneurysm on Initial Imaging Predicts Injury Progression in Patients with Nonoperative Major Blunt Liver Injury

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Most patients who present with hemodynamic stability and no evidence of peritonitis after blunt liver injury are successfully managed nonoperatively. Little information is available regarding the utility of reimaging major blunt liver injuries for patients who are managed nonoperatively. A retrospective review of patients admitted to a level I trauma center with major blunt liver injuries (AAST grades 3–5) was conducted. Inclusion criteria were those admitted from July 2012 to June 2014 with blunt liver trauma who survived the first 24 hours and underwent repeat imaging. Data included demographics, procedures performed, and computerized tomography (CT) scan findings. Findings on the second CT scan were categorized as Unchanged, Worse, Improved, or Negative. A total of 128 patients had blunt major liver injuries; 66 patients underwent repeat imaging. The mean time to repeat CT was 1.95 days. On repeat CT, 47 were Unchanged, 3 Worse, 14 Improved, and 2 Negative. Three patients underwent angiography. One required embolization of a pseudoaneurysm. In 63 patients (95%), the second CT did not change the management plan. The presence of a pseudoaneurysm was significantly related to a worsening of the second CT ($P = 0.0475$). Patients with admission hematocrit (Hct) below 32% were more likely to have a worsened second CT ($P = 0.0370$). A pseudoaneurysm on admission CT and Hct <32% predict major liver injury progression suggesting that routine reimaging is warranted in this group.

Key words: Blunt liver trauma – Trauma imagine – Trauma reimaging – Major liver injury

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The management of liver trauma has been evolving as operative management of severe liver injuries carries significant morbidity and mortality.[1] While the presence of shock and peritoneal signs have been found to be associated with increased risk of failure of nonoperative management,[2] multiple studies have demonstrated that nonoperative management of blunt liver trauma in hemodynamically stable patients is safe.[3,4]

Despite the acceptance of nonoperative management (NOM) for potentially all grades of liver injuries, the consensus as to if and when repeat computed tomography (CT) imaging should be performed remains debatable. While some studies have suggested that selective reimaging should be performed based on symptoms,[5,7,8] or initial severity of the liver injury,[8] others have concluded that routine follow-up CT scans were not indicated.[6] The Eastern Association for Surgery of Trauma practice guidelines for management of blunt hepatic trauma published in 2012, recommends the use of clinical criteria such as an unexplained drop in hemoglobin level as indications for reimaging although it was for all grades of liver trauma and not only for major injuries.[4]

The purpose of this study is to identify factors that would predict which patients would benefit from repeat imaging within a few days of admission to the hospital in an attempt to identify a worsening injury and potential early complications of blunt liver trauma.

Materials and Methods

Patient population and variable definitions

Study design

This retrospective study evaluated trauma patients who were treated between July 2012 and June 2014 at the University of Alabama at Birmingham (UAB), an American College of Surgeons verified level I trauma center. The UAB institutional review board approved this study. Inclusion criteria were major blunt hepatic injury defined as American Association for the Surgery of Trauma grade of 3 to 5. To be included in the analysis, the patient must have had a follow-up CT scan within 96 hours of admission. We chose 96 hours, as it was common practice within our department to order a repeat CT scan of patients with major blunt hepatic injury within 3 days of admission; though with the challenges of coordinating care of a complex patient, at times the repeat scan occurred on the 4th day.

Table 1 Patients demographics

Demographic	Value
Sex, N (%)	
Male	37 (56.1)
Female	29 (43.9)
Race, N (%)	
AA	25 (37.9)
White	37 (56.1)
Hispanic	4 (6.0)
Liver grade, N (%)	
3	25 (37.9)
4	27 (40.9)
5	14 (21.2)
PSA on arrival, N (%)	
Yes	3 (4.6)
No	63 (95.4)
Age, M ± SD	35.29 ± 16.87
Systolic BP on adm, M ± SD	126.03 ± 20.73
Diastolic BP on adm, M ± SD	77.30 ± 13.59
ISS, M ± SD	31.00 ± 16.73
HCT on adm, M ± SD	37.79 ± 7.12
Height, M ± SD (N)	67.75 ± 3.97 (57)
Weight, M ± SD (N)	180.51 ± 44.05 (65)
BMI, M ± SD (N)	27.68 ± 5.75 (57)
Glucose on adm, M ± SD (N)	159.86 ± 52.16 (65)
Lactic acid on adm, M ± SD (N)	2.63 ± 2.05 (66)
PT, M ± SD (N)	14.85 ± 2.33 (66)
PTT, M ± SD (N)	29.20 ± 5.46 (66)
INR, M ± SD (N)	1.23 ± 0.28 (66)

AA, African American; adm, admission; BP, blood pressure; PTT, partial thromboplastin time; PT, prothrombin time.

Routine repeat imaging was defined as repeat CT scan obtained after the admission CT scan with no identifiable indication (e.g., clinical condition, requirement for transfusion of blood, etc.) upon review of a patient's chart. Patients who underwent surgery for the liver injury after the first scan or had repeat imaging later than 96 hours from admission were not included in the analysis.

For each patient, data from the patient' chart and from the trauma registry were collected on demographics [i.e., age, sex, race, body mass index (BMI) and sex]; injury characteristics [i.e., mechanism, injury severity score (ISS)]; clinical data [systolic blood pressure, lactic acid on admission, glucose level on admission, prothrombin time, partial thromboplastin time and international normalization ratio (INR)]; hospital disposition; and payer.

Other data collected included operations and procedures performed [including surgeries, procedures performed by interventional radiology (IR)]; findings (by report) in first and second CT scans, time interval between the 1st and 2nd CT scan; and number of scans obtained during the hospitalization. Findings in the second CT scan were catego-

Table 2 Predictors from separate logistic regressions of a worse-appearing 2nd CT

Variable	2nd CT not worsened (n = 63), N (%)	2nd CT worsened (n = 3), N (%)	*P* value[a]
Sex			0.7874
Male	35 (55.6)	1 (33.3)	
Female	28 (44.4)	2 (66.7)	
Liver grade			0.8385
3	24 (38.1)	1 (33.3)	
4	26 (41.3)	1 (33.3)	
5	13 (20.6)	1 (33.3)	
PSA on arrival			0.0475
Yes	2 (3.2)	1 (33.3)	
No	61 (96.8)	2 (66.7)	
HCT, N			0.0367
<32	9 (14.3)	2 (66.7)	
≥32	54 (85.7)	1 (33.3)	

[a]*P* values from Firth's penalized likelihood approach for addressing issues of separability, small sample sizes, and bias of the parameter estimates in logistic regression.

rized into negative, unchanged, improved, or worse based on the radiologist imaging report. A "worse" categorization was assigned if the grade of the injury was found to be higher with significantly increased amount of blood in the abdomen or increased "blush".

Statistical analysis

Pearson χ^2 tests were performed to assess associations among categorical variables. Welch *t*-tests were used to compare the means of continuous variables across categories. Logistic regression models were used to assess whether any factors were predictive of a worsened second CT scan. Firth's penalized likelihood approach to logistic regression was used to address issues of separability, small sample sizes, and bias of the parameter estimates in some analyses. All analyses were performed with statistical software (SAS 9.3).

Results

Of the original 128 patients with blunt major liver injuries identified from the trauma registry who were admitted to our level 1 trauma center over the study period, 38 did not have a second CT scan.

After excluding patients who underwent surgery on the liver after the first scan, 66 patients were identified that underwent repeat imaging within 96 hours of admission. Table 1 shows their demographics and clinical characteristics. Findings on repeat CT were: 47 unchanged, 3 worse, 14 improved, and 2 negative. Negative was assigned to 1 CT scan because the abnormality could not be identified on the repeat scan and another because the radiologist determined that the abnormality seen on the original CT scan was not due to an injury. The mean time to routine repeat CT imaging was 1.95 days (SD = 0.83) with a range of 0 to 4 days. A total of 3 patients underwent angiography and only 1 required embolization of a pseudoaneurysm (PSA), which was present on admission CT.

In 63 patients (95.5%), the repeat CT scan was not worse (either improved, negative, or unchanged) and only 2 of these patients (3.3%) had a PSA on arrival (Table 2). Logistic regression found that PSA was significantly related to a worsening of the second CT ($P = 0.0475$).

The 63 patients who did not have a worse second CT had a mean admission hematocrit (HCT) level of 38.1 (SD = 7.1); whereas the mean admission HCT level of the 3 patients who did have a worse repeat CT was 30.7 (SD = 1.5). We also found that patients with admission HCT below 32 were significantly more likely to have a worsened second CT ($P = 0.0370$). A total of 3 patients had PSAs on their admission CT; on repeat imaging, 1 improved (without an intervention); 1 remained unchanged; and only 1 worsened, for an overall incidence of 4.5%. All 3 underwent angiography by our interventional radiology team and only 1 patient had embolization (the 1 with worse repeat CT). The other 2 had no evidence of PSA on angiography. These 3 patients survived.

Discussion

Repeat CT imaging following severe blunt hepatic injury has been recommended only for the development of symptomatology and decreases in hematocrit. Although multiple studies debated its utility,[6,7] follow-up images of major solid organ injuries are still obtained at some centers. However, the question remains as to who would benefit from selective routine reimaging in the absence of clinical or laboratory indications.

This study finds that in patients with major blunt liver trauma treated with NOM, the presence of an intrahepatic pseudoaneurysm on admission CT scan is predictive of a worsened repeat CT scan. It appears that in the absence of PSA on admission, routine repeat imaging of these patients was not beneficial. A study by Osterballe and colleagues[11] found that follow-up CT scans helped in detection of

posttraumatic pseudoaneurysms in liver trauma and suggested reimaging as part of the management of this patient population.

As PSAs in liver injury are usually associated with a high grade of injury[10] and are known to cause complications like upper GI hemorrhage[12] and spontaneous intraperitoneal hemorrhage from delayed rupture,[10,13] the presence of an intraparenchymal PSA may be indicative of a more severe degree of injury to the liver than is apparent on the initial CT scan. An intraparenchymal hepatic PSA with an associated low hematocrit (less than 32%) on admission suggests that the patient might have been exposed to a more severe injury than identified on the admission CT. Further studies are needed to confirm these findings.

The management of traumatic intraparenchymal PSAs continues to evolve and ranges from observation and follow-up imaging to angioembolization (AE). Arguments in favor of observation are that solid organ PSAs have been shown to thrombose spontaneously[14,15] and using AE to thrombose them is associated with multiple complications,[16] while arguments in favor of treating them are that PSAs are associated with potential lethal complications.[17,18] Although there were 3 patients in this study with PSA on admission CT, only 1 of them had PSA on angiography and they all survived. In the absence of long-term data, it is prudent to treat them. This is consistent with prior studies that demonstrate spontaneous resolution of most hepatic posttraumatic pseudoaneurysms.[19]

Our study has several limitations. First, our study is retrospective in nature and hence suffers from the limitations common to these studies. Secondly, because of the small number of patients (n = 3) with a worse second CT scan, the statistical estimates of the odds ratios are unstable. With a larger number of patients, the statistical estimates would have been more accurate and the results might have been potentially different. This study is relevant because it sheds light on the patient population who may benefit from reimaging after major hepatic trauma, though further study is needed to confirm these findings.

Conclusion

This study shows that the majority of patients with blunt major liver injury did not have worsening features on repeat CT scan. However, the presence of a pseudoaneurysm on admission CT in a patient with an admission HCT below 32 should be used as an indication for routine follow-up imaging.

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