# Tomographic Findings are not Always Predictive of Failed Nonoperative Management in Blunt Hepatic Injury

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**Background:** The nonoperaitve management(NOM) has become the standard treatment of blunt hepatic injury(BHI) for stable patients. Contrast extravasation(CE) on computed tomographic(CT) scan had been reported as a sign that was associated with NOM failure. The goal of this study was to further investigate the risk factors of NOM failure in patients with CE on CT scan.

**Method:** From January 2005 to September 2009, patients with CE noted on CT scan due to blunt hepatic injury were retrospectively studied. Physiological parameters, severity of injury, amount of transfusion as well as treatment outcome were compared between patients with NOM failure and NOM success.

**Results:** A total of 130 patients were enrolled. ISS score, amount of blood transfusion before hemostatic procedure, and grade of liver injury were significantly higher in NOM failure than NOM success patients. There was no statistical difference in the NOM successful rate between patients with contrast leakage into peritoneum and those with contrast confined in hepatic parenchyma.

**Conclusions:** Higher ISS, more blood transfusion, and higher grade of liver injury are factors that correlate with NOM failure in patients with BHI. Contrast leakage into peritoneum is not always a definite sign of NOM failure in BHI. Early and aggressive AE is an effective adjunct of NOM in BHI patients even with contrast leakage into peritoneum.

## Introduction

Liver is one of the most commonly injured solid organs in blunt abdominal trauma that approximately 5% of all trauma admissions are associated with liver injuries.[1,2] Traditionally, operative intervention was thought to be the mainstay of controling hemorrhage in severe hepatic injuries but treatment outcomes remained poor with a mortality rate of 50-80% .[3,4],[5] The principles to manage blunt hepatic injury (BHI) has changed dramatically during the past three decades following the advancement of treatment concepts and improvements in diagnostic modalities that nonoperative management (NOM) has become the standard treatment of choice for stable patients.[1,2,6]

Currently, more than 80% of patients with BHI are treated nonoperatively with reported success rates of over 90%.[1,7,8] Studies have also shown that with the application of angioembolization (AE) the overall mortality rates in patients with severe hepatic trauma were as low as 8-22%.[9-15] Nowadays AE has been widely-accepted as a safe and effective therapeutic modality in selected patients with liver injury.[9,16]

Although NOM has been widely applied and was highly successful, failure were not uncommon on some high-risk patients and these patients usually required surgical interventions. Risk factors of NOM failure included hemodynamic instability, high grade of liver injury and periportal tracking.[6,8,17,18] Besides, contrast extravasation (CE) on computed tomographic (CT) scans, a sign of active bleeding, was also been reported as a risk factor for NOM failure. It has been proved that application of AE may significantly reduce NOM failure rate in those patients.[14,16,17,19-21] Some reports suggested that the type of CE could predict clinical outcomes following hepatic injuries.[19] However, whether the types of CE played a role in NOM of BHI has not yet been determined. Therefore, we tried to determine the risk factors associated with NOM failure in patients with CE on CT scans. The characteristics of patients who had a failed NOM and their outcomes were also discussed.

**Materials and Methods**

We reviewed the trauma registry and medical records of blunt hepatic injury patients at the China Medical University Hospital (CMUH) from January 2005 to September 2009. CMUH serves as a major trauma referral center in the central part of Taiwan and serves a population of six million people. During the 57-month investigation period, patients with BHI were treated according to our established algorithm (Fig. 1). Patients with unstable hemodynamics [systolic blood pressure (SBP) <90 mmHg] and concomitant hemoperitoneum received immediate celiotomies without further study. Routine CT scans were performed in patients with stable hemodynamics (SBP ≧ 90 mmHg) and suspected blunt abdominal injury. Angioembolization was performed on all patients with CE on CT scans. In our institution, AE was 24 hours available and was performed by a board-certified radiologist. However, those patients who deteriorated during the AE preparation period was converted to celiotomy immediately without delay. All patients were sent to an intensive care unit for close observation after AE or operaions. A secondary operation was indicated for those patients who could not achieve hemodynamic stability or required further blood transfusions following the primary intervention.

The exclusion criteria of this study were as follows: (1) patients who received immediate celiotomies due to unstable hemodynamics on arrival; (2) patients were operated due to indications other than liver injury (3) patients with other major causes of hemorrhage other than liver injury.

Patients with CE on CT scans were the focus of the current study. These patients were expected to be managed by angioembolization (AE) for hemostasis. However, some patients deviated from the algorithm and required surgical interventions. In the current study, NOM failure was defined as receiving a celiotomy in the initial 24 hours of admission either before or after AE. Patients who did not require surgical intervention after AE were defined as NOM successes. The demographic characteristics, initial SBP values, abbreviated injury scales (AIS), injury severity scores (ISS), amounts of blood transfused before hemostatic procedures (angioembolization or celiotomy), grades of liver injury, and prothrombin time (PT)/international normalized ratio (INR) values were compared between patients with NOM failure and success (Table 1). The differences between patients with contrast leakage into peritoneum (Fig 3-1) or with contrast confined to the hepatic parenchyma (Fig. 3-2) were also compared (Table 2). Table 3 lists the characteristics of the patients who experienced NOM failure.

## Results

From January 2005 to September 2009, 148 patients with BHI were admitted to the CMUH trauma center. The patient distribution is listed in Fig. 2. Eight patients who received immediate celiotomies due to unstable hemodynamics and ten patients who received celiotomies due to associated intraabdominal injury other than liver were excluded from the study. Among the 130 enrolled patients with BHI, 119 (91.5%) were treated conservatively without surgical interventions. Thirty-two of these 130 patients were noted to have CE on their CT scans. In these 32 patients, 11 received celiotomies due to hemodynamic deterioration before (N = 8) or after AE (N = 3). The remaining 21 patients received AE and NOM successfully without further complications.

The mean age of the 148 BHI patients was 32.1 ±15.6 years. Of these patients, 96 were male (64.9%) and 52 were female (35.1%). In patients with CE on their CT scans, there were no significant differences with regard to age, gender, SBP, PT/INR or AIS between NOM success and NOM failure patients (Table 1). ISS values (29.5 ±12.5 vs. 19.7 ±8.5, $p < 0.05$), amounts of transfused blood prior to hemostatic procedures (4.1 ±2.8 vs. 1.8 ±2.6 U, $p < 0.05$), and grades of liver injury ($p < 0.05$) were significantly higher in NOM failure than in NOM success patients (Table 1).

Table 2 compared the differences between different types of CE. There were no statistical differences in age, gender, AIS values, and ISS values between patients with contrast leakage into the peritoneum and with contrast confined to the hepatic parenchyma (Table 2). For those patients who had contrast leaked into the peritoneum, they were transfused with more before hemostatic procedures were started (3.6 ±3.4 vs. 1.3 ±1.5 U, $p < 0.05$) than those patients with contrast confined to the hepatic parenchyma. In patients with contrast leakage into the peritoneum, the NOM success rate was 52.9% compared to 80% of the corresponding patients who had contrast confined to the hepatic parenchyma. There was no statistical difference in NOM success rates between these two groups of patients.

## Discussion

As the liver is a commonly injured organ in blunt abdominal trauma, mortality rates of blunt hepatic injury can be as high as 50-80%.[2,5] With improvements in diagnostic technologies and revoluting treatment concepts, NOM has become the standard treatment in BHI patients with stable hemodynamics.[1-3,16,17,19] However, there are still some patients who had a failed NOM. Several risk factors that predict NOM failure in blunt hepatic injuries include hemodynamic instability, high AAST grade of liver injury, periportal tracking, and contrast extravasation on CT scan.[1.6,8,10,16,17,19,20,22-24] Improved outcomes have been achieved with the application of AE, which has been reported as a safe and effective adjunct in NOM.[9,16]

At our institution, AE can be performed within a short period of time and is used in our established algorithm for patients with BHI. In our series, the overall success rate of NOM is 91.5% when AE is used as an adjunct. On the other hand, the NOM success rate is 65.5% for those patients with CE on CT scans. Abdominal AIS values were not significantly different between NOM failure and NOM success patients. However, ISS values were significantly higher (29.5 ±12.5 vs. 19.7 ±8.5, $p < 0.05$) in NOM failure patients compared to NOM success patients (Table 1), suggesting that NOM failures might be related to associated injuries of other body regions. As a result, associated injuries play a significant role on NOM success. The current literature also indicates that concomitant injuries are major determinants in BHI patient outcomes.[25]

Moreover, a significantly higher grade of liver injury was observed in NOM failure patients that 64% of NOM failure patients had high-grade liver injuries (grades IV & V) (Table 1). This difference was statistically significant and indicates that the grade of liver injury is an important predictive factor for NOM failure in BHI patients in the current study. As described in other studies, most patients required surgical interventions had grade IV or V injuries and underwent urgent celiotomies due to hemodynamic instability.[1,2,6,8,17,19,22,25,26] It has been reported that the amount of blood transfusions were thought to be an independent predictor of increased mortality in blunt hepatic and splenic injuries. Patients who required either urgent or delayed operations received more blood transfusions than those who were managed nonoperatively and it has been suggested that nonoperative management should be deemed a failure if a transfusion of more than two units were required.[27-29] In our study, more blood was transfused prior to hemostatic procedures in NOM failure patients compared to NOM success patients (4.1 ±2.8 vs. 1.8 ±2.6 U, respectively, $p < 0.05$) (Table 1). Furthermore, 81.8% of NOM failure patients had a blood transfusion of greater than three units. This cutoff value was statistically significant, suggesting that blood transfusions of greater than three units seemed to be a risk factor for NOM failure.

CT scan is an extremely valuable tool for evaluation of abdominal injury. Many studies have reported CE on CT scans as a specific sign of vascular injury and active bleeding[19,30] and the scale of CE is related to the possibility of NOM failure.[16,17,19,30] Fang et al. described different types of CE on CT scans and made a prediction of patient outcomes after hepatic injury using his classification. He found that contrast leakage into the peritoneum (Fig. 3-1) represented massive or direct active bleeding into a relatively low-pressure space and was associated with 100% of NOM failures. In contrast, contrast confined to the hepatic parenchyma (Fig. 3-2) had a high probability of spontaneous hemostasis.[19] However, in the current study, we found that there was no difference on NOM failure rate between different types of CE. Our study showed that 9/17 (52.9%) of the patients with contrast leakage into the peritoneum were managed successfully without operative interventions. This is a significant improvement compared to that reported by Fang et al. which can be explained by: First, improvements in CT resolution have made CE more easily visible. A state-of-the-art multidetector CT scan can precisely locate active bleeders accurately via optimized contrast injection protocol and provide valuable information for the selection of appropriate treatment.[30] Second, a strategy to apply AE early and aggressively has contributed significantly to the improved NOM success rate not only in liver injury but also in other solid organ injuries such as splenic, renal injury as well as unstable pelvic fracfture.[31-34] Third, the constantly improving interventional radiology instruments and techniques in the past 20 years may be helpful in conjunction with other treatment modalities to improve NOM success rate.[10] Finally, the integrity of the trauma care system, including pre-hospital phase and in-hospital critical care, also helps to increase NOM success rate. Taken together, these factors has made successful NOM in patients with bleeding high grade liver injuries possible. As a result, different types of CE did not seem to significantly affect the success rate of NOM in current study.

The characteristics of patients who received celiotomies (N = 11) in the current study are described in Table 3. Eight patients received celiotomies due to hemodynamic deterioration during the AE preparation period. The other three received celiotomies after AE due to ongoing bleeding or hemodynamic deterioration. Among these 11 patients, 7 (63.6%) had high-grade (grades IV & V) injuries and the other 4 patients (36.4%) had low-grade injuries. Eight patients (72.7%) presented with contrast leakage into the peritoneum. There were two mortalities in this study. One patient was involved in a traffic accident and had a hemorrhagic shock due to a juxtahepatic vein tear, liver laceration, and renal laceration (ISS = 50). He was dead during emergency celiotomy. Another patient was also injured in a traffic accident and had an ISS of 50. He received two celiotomies for hemostasis in the initial three days and was complicated with increased intracranial pressure after surgery. The patient died on the fourth day due to brainstem dysfunction caused by diffuse brain swelling with uncal herniation.  One limitation of the current study is its retrospective nature and small number of examined cases. A possible selection bias may limit our conclusions. Nonetheless, we demonstrated improved results of NOM by timely and effective AE for those patients with severe BHI. Further studies with larger sample size and prospective designs are needed to update the current algorithms for prompt diagnoses and precise treatment of patients with blunt abdominal trauma.

## Conclusion

In the current study, a higher ISS score, more blood transfusions, and a higher grade of liver injury are factors that correlate with NOM failure in patients with BHI. Although contrast leakage into the peritoneum indicates severe injury and active bleeding, it is not longer a sign that predicts NOM failure in BHI. Early and aggressive AE is an effective adjunct of NOM in BHI patients even for those patients with contrast leakage into the peritoneum.


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**Legends:**

Figure 1: The algorithm for the management of patients with blunt hepatic injuries.

Figure 2: The patient distribution in the current study.

Figure 3-1: Contrast leakage into the peritoneum. The large arrow indicates contrast extravasation into the hepatic parenchyma, and the small arrow indicates contrast pooling into the hemoperitoneum.

Figure 3-2: Contrast confined to the hepatic parenchyma. The large arrow indicates contrast extravasation into the hepatic parenchyma.

Table 1. The NOM success patients had higher ISS, AIS and larger amount of blood transfusion before hemostatic procedure.

Table 2. The NOM successful rate was not significantly different between contrast leakage into peritoneum and contrast confined in hepatic parenchyma

Table 3. There were two mortalities in NOM failure patients due to multiple organ failure. There were three patients received celiotomy after angioembolization