**A REVIEW OF**

**BLUNT AND PENETRATING AAST GRADE III - V LIVER INJURIES**

Data Collection Time: January 1, 2013-December 31, 2018

Background:

Complex hepatic injuries have been reported to be associated with high morbidity and mortality rates related to hemorrhage and biliary leaks.1 With improved resolution of CT scans, retrohepatic vascular abnormalities are readily identified but grade of injury has not shown to predict failure of non-operative management or necessarily suggest a higher morbidity or mortality. (1-2) In Grade 4 or 5, hemodynamically stable patients without another injury necessitating operative intervention and transient responders with limited transfusion requirements can be managed successfully non-operatively over 80% of the time. (3-7) Current grading systems including the AAST does not account for predictors of failure of non-operative management including arterial extravasation on CT scan, “peri-portal tracking” of blood, and evidence of multiple solid organ injuries. (8-13)

Up to 15% of patients with Grade 3-5 hepatic injury suffer delayed complications involving bile leaks and bilomas. (14) HIDA scan is reported to be 100% sensitive and specific for the detection of bile leaks with non-operative interventions including ERCP and/or percutaneous drainage resulting in a success rate of over 90%. (15) Early recognition and treatment of bile leaks leads to decreased morbidity. (16-18) In hemorrhagic and biliary complications of hepatic injury, failure of non-operative interventions has been shown to lead to operative intervention 25% of the time. (19,20) Despite the benefits of non‑operative therapy, the biliary and hemorrhagic complications associated with blunt hepatic injury are unchanged. (10,15,16,21-22)

In patients who do not meet clear criteria for non-operative management and have risk factors for failure of non-operative management or undergo operative intervention with complimentary non-operative management elucidation of an algorithm, respective of hemorrhage or biliary leak, for which each intervention(s) should be performed separately or in compliment to one another remains elusive.

The objectives of this study are:

1) to characterize hepatic injuries based upon CT findings intraperitoneal versus intra-parenchymal hemorrhage, contrast pooling, juxtahepatic injuries, number of couinaud segments injured and association with non-operative versus operative management

2) to examine timing of angiography in relation to CT scan for total blood products transfused

3) to define timing of intervention for bile leak or biloma (operative intervention, percutaneous drainage, ERCP) and resolution of bile leak or biloma.

Our hypotheses are:

1) Characteristics present on CT including intra-peritoneal hemorrhage, contrast pooling, retrocaval injuries and higher number of couinaud segments injured may be associated with either of increased risk of complications or failure of non-operative intervention or need for operative management.

2) Earlier angiography will reduce total blood products transfused.

3) Earlier identification, treatment of bile leak or biloma will result in shorter duration to resolution to bile leak or biloma.

References

1. Schwab CW. Selection of nonoperative management candidates. World J Surg. 2001;25:1389–92.

2. Malhotra, AK, Fabian TC, Croce MA, et al. Blunt hepatic injury: a paradigm shift from operative to nonoperative management in the 1990s. Ann Surg 2000;231(6):804-13.

3. Carrillo EH, Spain D, Wohltmann CD, et al. Interventional Techniques are Useful Adjuncts in Nonoperative Management of Hepatic Injuries. J Trauma 1999;46(4):619:624.

4. Goan YG, Huang MS, Lin JM. Nonoperative management for extensive hepatic and splenic injuries with significant hemoperitoneum in adults. J Trauma. 1998;45:360–

5. Meredith JW, Young JS, Bowling J, Roboussin D. Nonoperative management of blunt hepatic trauma: The exception or the rule? J Trauma. 1994;36:529–34.

6. American Association for the Surgery of Trauma. AAST Injury Scaling and Scoring System, Daphne, AL. 1998. [Last accessed on 2018 Mar 15]. Available from: <http://www.aast.org/injury/injury.html> .

7. Croce MA, Fabian TC, Menke PG, Waddle-Smith L, Minard G, Kudsk KA, et al. Nonoperative management of blunt hepatic trauma is the treatment of choice for hemodynamically stable patients. Results of a prospective trial. Ann Surg. 1995;221:744–53.

8. Malhorta AK, Latifi R, Fabian TC, et al. Multiplicity of solid organ injury: influence on management and outcomes after blunt abdominal trauma. *J Trauma*. 2003;54:925-929.

9. Pachter HL, Knudson MM, Esrig B, et al. Status of nonoperative management of blunt hepatic injuries in 1995: a multicenter experience with 404 patients. *J Trauma.* 1996;40:31-38.

10. Velmahos GC, Toutouzas K, Radin R, et al. High success with nonoperative management of blunt hepatic trauma: the liver is a sturdy organ. *Arch Surg*. 2003;138:475-481.

11. Gao J, Du D, Zhao X, et al. Liver trauma: experience in 348 cases. *World J Surg*. 2003;27:703-708.

12. DiGiacomo JC, McGonigal M, Haskal Z, et al. Arterial bleeding diagnosed by CT in hemodynamically stable victims of blunt trauma. *J Trauma*. 1996;40:249-252.

13. Davis KA, Brody JM, Cioffi WG. Computed tomography in blunt hepatic trauma. *Arch Surg*. 1996;131:255-260.

14. Alicuben, ET, Matsuoka L, Alexopoulos S, et al. Bile Leaks after Severe Liver Trauma. J Am Coll Surg 2016;233(4):196.

15. Wahl WL, Brandt MM, Hemmila MR, Arbabi S. Diagnosis and management of bile leaks after blunt liver injury. Surgery 2005;138:742‑7.

16. Velmahos GC, Toutouzas KG, Radin R, Chan L, Demetriades D. Nonoperative treatment of blunt injury to solid abdominal organs: A prospective study. Arch Surg 2003;138:844‑51.

17. Kozar RA, Moore FA, Cothren CC, Moore EE, Sena M, Bulger EM, *et al.* Risk factors for hepatic morbidity following nonoperative management: Multicenter study. Arch Surg 2006;141:451‑8.

18. Miller PR, Croce MA, Bee TK, Malhotra AK, Fabian TC. Associated injuries in blunt solid organ trauma: Implications for missed injury in nonoperative management. J Trauma 2002;53:238‑42.

19. Tinkoff G, Esposito TJ, Reed J, Kilgo P, Fildes J, Pasquale M, *et al.* American Association for the Surgery of Trauma Organ Injury Scale I: Spleen, liver, and kidney, validation based on the National Trauma Data Bank. J Am Coll Surg 2008;207:646‑55.

20. Bala M, Gazalla SA, Faroja M, Bloom AI, Zamir G, Rivkind AI, *et al.* Complications of high grade liver injuries: Management and outcomewith focus on bile leaks. Scand J Trauma Resusc Emerg Med 2012;20:20.

21. Mohr AM, Lavery RF, Barone A, Bahramipour P, Magnotti LJ, Osband AJ, *et al.* Angiographic embolization for liver injuries: Low mortality, high morbidity. J Trauma 2003;55:1077‑81.

22. Bertens KA, Vogt KN, Hernandez‑Alejandro R, Gray DK. Non‑operative management of blunt hepatic trauma: Does angioembolization have a major impact? Eur J Trauma Emerg Surg 2015;41:81‑6.

This will be a multicenter study with participation open to all trauma centers. Data will be entered into AAST approved data repository at each respective center. Enrollment of sites will tentatively open July 1, 2018. General information to be submitted per institution: Resolution of CT scanner and trauma multiphasic CT A/P protocol of respective institution and outside hospital if CT scans used from patients transferred in from outside hospital. A data dictionary will be provided.

Entrance criterion:

All adult (> 18 years) patients who sustained Grade 3 - 5 hepatic injuries per the American Association for the Surgery of Trauma (AAST) Organ Injury Scale and underwent Non-Operative Intervention (Angiography/ERCP/ Percutaneous Drainage) or Operative intervention or no intervention with or without CT Scan of the Abdomen/Pelvis within 24 hours of admission.

Exclusion criteria:

 Patients who are:

< 18 years

 Pregnant

 Cirrhotic

 Diagnosed with hepatocellular carcinoma

 Not a candidate for ERCP

Data to be collected:

 Name

MRN

Encounter Number

Admission to ED Date/Time

Age

 Sex

 Blood Pressure on admission to ED

 Heart rate on admission to ED

 Shock index on admission to ED

 Base Deficit on admission to ED

 Antiplatelet agents

 Anticoagulant indication

 TEG result on admission (if done) and location Date/Time

 Rotem (rotational thromboelastometry) and location Date/Time

 PT/INT/PTT/Fibrinogen on admission to ED

 ISS (after imaging, operation or autopsy)

Was CT performed? Grading scale used to assess injury (e.g. AAST). If so pre or post ex lap/damage control operation if applicable? Number of Couinaud segments involved in injury? Couinaud’s segments involved? Estimation of hemoperitoneum if present (% surrounding liver—25,50,75,100%)? Contrast extravasation present, Couinaud’s segment of liver, size in millimeters. Percentage of liver devascularized and which Couinaud’s segments. Will need to upload CT AP to data collection database in de-identified manner.

CT imaging of abdomen/pelvis

 Was ED Thoracotomy performed? If so, Date/Time aorta clamped, duration

 Was REBOA performed? If so, Date/Time of occlusion of aorta, duration

Hepatic Injury Diagnosed in OR or on CT: Date/time and respective AAST Grade of Injury

 Damage control laparotomy: Yes/No, Date/time of start based on incision

Exploratory laparotomy: Yes/No, Date/time of start based on incision

Hepatorraphy: Yes/No (during damage control laparotomy or exploratory laparotomy) and nature of intervention

* Peri-hepatic packing
* Topical hemostatic agents
* Extensive hepatorrhaphy with suture ligation
* Hepatotomy with selective vascular ligation
* Resectional debridement with selective vascular ligation
* Lobectomy or segmentectomy
* Selective hepatic artery ligation
* Other, please specify

Drain placement during damage control or exploratory laparotomy: Yes/No Number of drains, type (JP, chest tube) date/time of damage control or exploratory laparotomy when they were placed.

 Wound vac use: Y/N, Date/Time

 Silo used: Y/N, Date/Time

 If damage control surgery performed, date/time of fascia closure

 AAST Injury Score for:

 Liver

Extrahepatobiliary

 Chest Wall

 Lung

 Heart

 Diaphragm

 Adrenal

 Spleen

 Kidney

 Pancreas

 Esophagus

 Small Bowel

 Colon

 Rectum

 Diaphragm

 Cervical Vascular Injury

 Thoracic Vascular Injury

 Abdominal Vascular Injury

 Associated injuries

 Major vessel (aorta, vena cava, iliac artery, iliac vein, SMA, SMV)

Pelvic fracture

 Long bone fractures (humerus, radius, ulna, femur, tibia, fibula)

 TBI (GCS > 8)

 Spinal cord injury

 Number of units of blood, plasma, platelets cryoprecipitate, crystalloid, albumin transfused within first 24 hours and during hospitalization

 3 units of blood transfused within 1 hour for the first 24 hours: Y/N

Procedures:

 HIDA scan, Date/Time performed

 Indication for HIDA

ERCP: Yes/No, time of common bile duct cannulation is start time, +/- stent

 Serial ERCPs until stent removed: Yes/No, Date/Times

 Angioembolization: Yes/No, date/time of puncture, date/time of closure of arteriotomy

 Indication for angiography

If angioembolization performed, name/number of branches embolized.

Was hybrid suite used for operative and non-operative interventions? Yes/No, if so, which operative and non-operative interventions?

 CT scan/US guided drainage of fluid collection: Yes/No, location abdomen or chest

 Indication for CT/US guided drainage

* Fluid collection: fluid without evidence of infection or bile
* Biloma/Bile leak: drainage of bile without evidence of infection based upon culture data
* Infected biloma/bile leak: drainage of fluid with evidence of infection based upon culture data
* Abscess: fluid with evidence of infection but no bile

 Unplanned reoperation: Yes/No, Date/Time

 Indication for unplanned reoperation

Complications:

 Ongoing bleeding (need for transfusion of greater than 2 units in 24 hours without hemodynamic improvement)

Sepsis, based upon SOFA score at admission and 72 hours into ICU stay (within 12 hours of each timeframe)

 Wound infection: Yes/No, Date/Time

 Intraabdominal abscess: Yes/No, Date/Time

 Fistula: type, Date/time of diagnosis, intervention Date/Time

 Bowel obstruction: Yes/No, Date/time of diagnosis, duration for conservative management (NPO, NGT), and Date/time of operative intervention (ERCP, Percutaneous drainage) Date/Time, intervention Date/time, and resolution Date/time, and criteria for resolution (drains removed without further clinical signs of leak/biloma/fluid collection/abscess or ERCP) Date/time

 Clinically significant reaccumulation of bile leak or biloma: Yes/No, Date/time, means of diagnosis (CT, US, ERCP, OR), intervention (non-operative, operative or both), Date/time, resolution based on last drain removal, Date/time.

 Hemobilia: Yes/No, Date/time of diagnosis, intervention, resolution, and diagnosis

 ICU Length of Stay (LOS)

 Number of Ventilator free days in Intensive Care Unit (ICU)

Hospital LOS

Outcome:

 Live

 Die

Discharge destination: Home, Skilled Nursing Facility, Rehab, Long term Care Facility

 Was patient discharged home with drains? If so, number of drains and location.

 Duration of days drains in place post discharge

 Criteria used to pull drains

30 day unplanned readmission: Yes/No and Indication

Statistical analyses:

 Bivariate analysis will be performed to determine if there are differences between those with the exposure of interest and those without.  Factors found to be associated with the outcomes of interest on bivariate analysis will be included in multivariable models.  The multivariable models will be used to determine if the exposure of interest is associated with the primary and secondary outcomes