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Accuracy of clinical, laboratory, and computed tomography findings for identifying hollow viscus injury in blunt trauma patients with unexplained intraperitoneal free fluid without solid organ injury

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A B S T R A C T

Background: We sought to define the accuracy of findings for detecting hollow viscus injury (HVI) in patients with blunt abdominal trauma (BAT) and unexplained intra-peritoneal free fluid without solid organ injury (UIPFFWSOI).
Methods: We screened all consecutive hemodynamically stable patients presenting to a quaternary-care trauma-centre who had an abdominal computed tomography (CT) scan for BAT and UIPFFWSOI (January 2007–December 2014).
Results: Of 3796 patients identified during the study period, 39 presented with UIPFFWSOI. Fifteen underwent therapeutic laparotomy. Seatbelt sign (+LR approaches infinity), diffuse peritonitis (+LR approaches infinity), number of CT cuts with fluid (c-statistic = 0.65), and a lower arterial pH at presentation (c-statistic = 0.62) were most predictive of HVI. Patients operated on within 24 h had shorter stays than those operated on later (median 9 vs. 14 days, p = 0.03).
Conclusions: Our findings suggest that clinical examination and measurements of intraperitoneal fluid volume may help identify HVIs in BAT patients.

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1. Introduction

Traumatic injuries are a significant public health issue worldwide.[1–3] In North America, they constitute the leading cause of death for people aged 1–44 years.[3,4] Abdominal trauma represents a significant proportion of this burden, with 61% of polytrauma cases including an abdominal injury.[5] The most frequently injured intra-peritoneal organs include the liver, spleen, and kidneys, which are often associated with intra-peritoneal bleeding.

The introduction of computed tomography (CT) scans, hemostatic resuscitation policies, and interventional radiology procedures such as angioembolization have resulted in a significant rise in the rate of nonoperative management of blunt abdominal trauma patients over the last two decades.[6] However, even in 2017, there remain pitfalls to nonoperative management. As some relatively uncommon anatomic injuries cannot be managed without operation, the opportunity for early and appropriate intervention may sometimes be missed through the pursuit of a non-operative strategy, therefore resulting in patient harm.

Hollow viscus injuries (HVI) are such an entity as they are uncommon and difficult to diagnose. Less than 1% of all patients who present with blunt trauma have a HVI, and only 0.3% of all blunt trauma patients have a perforated small bowel injury.[7] HVIs remain associated with substantial morbidity and mortality, and this morbidity and mortality only increases with delays to intervention of only hours rather than days.[8,9] The sensitivity of abdominal CT for detection of HVIs across diagnostic studies has been reported as low as 53%, likely because injuries to hollow abdominal organs are

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not readily visualized on CT, forcing radiologists and surgeons to use surrogate markers to detect these injuries.[10,11] The most accepted surrogate in patients without out a solid organ injury has been significant intraperitoneal free fluid.

The purpose of this study was therefore to determine if the presence of significant free intra-peritoneal fluid in isolation was a relevant marker for HVI, or if the usefulness of this sign had been supplanted by the greater imaging fidelity of newer generation CT scans. A secondary goal was to assess the diagnostic accuracy of clinical, laboratory, and computed tomography findings for identifying HVI in blunt trauma patients without solid organ injury. This included assessment of other predictive factors which, in association with intraperitoneal free fluid without solid organ injury, might assist in guiding management of patients with this injury pattern.

2. Methods

We conducted a single centre, cross-sectional study. The study was approved by the Conjoint Health Research Ethics Board at the University of Calgary.

2.1. Study cohort

We included all hemodynamically stable, consecutive blunt trauma patients with intraperitoneal free fluid without solid organ injury who presented to the Foothills Medical Centre (FMC) in Calgary, Alberta, Canada. The FMC is a University-affiliated, level I trauma centre, which provides quaternary care services to southern Alberta, southwest British Columbia, and southeast Saskatchewan.

To identify a cohort of potentially eligible patients, we queried the Southern Alberta Trauma Registry for all patients who presented to the FMC with a blunt mechanism of abdominal injury that were aged >16 years and had a minimum Injury Severity Score (ISS) of 12 and an abdominal CT scan upon admission to hospital. The Southern Alberta Trauma Registry collects demographic, prehospital, and clinical data on all trauma patients presenting to the Foothills Medical Centre with an ISS >12. Patients were included if they were hemodynamically stable (presenting systolic blood pressure >80 mmHg and heart rate <120 beats/minute) at admission and had unexplained intraperitoneal free fluid without solid organ injury on their admission CT. "Explained" intra-peritoneal free fluid included free fluid on CT scan presumed to be present on the basis of a contiguous solid organ injury, obvious extravasation of oral contrast from a HVI or other obvious hollow viscus injury, observed mesenteric hemorrhage, and intraperitoneal bladder ruptures. Unexplained intraperitoneal free fluid included cases of free intra-peritoneal fluid without an obvious anatomic source visualized on CT. We excluded patients who did not meet the above criteria. In addition, we excluded patients who died within 24 h of admission of non-abdominal causes, such as severe closed head injuries.

Thirty-two (32) of the patients were scanned using a Siemens Somatom 64-slice CT scanner (Siemens Healthcare, Erlengen, Germany), 1 patient using a Toshiba Aquillion One 320-slice CT scanner (Toshiba Medical Systems, Tochigi-ken, Japan) and the remaining 27 patients using a General Electric Discovery 750 HD 64-slice CT scanner (General Electric Healthcare, Chicago, Ill). Each patient was injected with 120–140 mL of Optiray 320 intravenous contrast to enhance the CT images.

2.2. Data collection

We used the Southern Alberta Trauma Registry and personal health records of included patients with unexplained free fluid and no solid organ injury to collect additional demographic, clinical, laboratory, and operative data. Clinical data included whether patients presented with abdominal distention (a visible increase in abdominal girth),[12] peritonitis (abdominal tenderness to palpation, abdominal guarding, and rigidity),[13] seatbelt sign (bruising and skin abrasions across the neck, chest, and abdomen where a shoulder or waist seatbelt crosses),[14] and Chance fracture (a transverse vertebral splitting that spreads from the posterior spinal column to the anterior vertebral body, with no lateral displacement or rotation of the fracture fragments).[15] Laboratory data included arterial pH, lactate levels, and white blood cell count. Operative data included the timing of operation and operative findings as well as what procedures were performed in the initial (the first operative procedure undergone following admission to FMC) and any subsequent operations. Therapeutic laparotomy was defined as that resulting in a procedure to repair or resect a hollow viscus or mesenteric vascular structure. Non-therapeutic laparotomy was defined as a laparotomy in which there no intervention taken to repair or resect a hollow viscus injury or mesenteric injury. We also recorded data on in-hospital complications/morbidities (and classified these complications according to the Clavien-Dindo scale[16]), length of hospital and ICU stay, discharge location, and in-hospital survival. Finally, we identified any patients returning to hospital within 30 days of discharge and collected data on the charted reason for return.

2.3. Blinded radiologist review

All abdominal CT scans were read independently and in duplicate by a board-certified radiologist and a senior radiology resident. These physicians were blinded to initial CT reports and patient clinical information and outcomes. They noted injury patterns, the presence of intraperitoneal free fluid, the number of CT cuts containing free fluid, the two-dimensional area of the largest fluid pocket on the CT cut showing the largest extent of the pocket, and the Hounsfield units of the intraperitoneal free fluid (measured by taking the average Hounsfield unit density of a region of interest placed within the approximate centre of each free fluid pocket). They also noted bowel wall thickening (defined as any bowel wall greater than 3 mm in cross-sectional thickness), frank mesenteric injuries (defined as active extravasation of contrast from the mesentery, avulsion of the mesentery, or laceration of the mesentery) and mesenteric hematomas (contained collections of blood-density fluid within the mesentery).[17] Disagreements between radiologists were resolved by consensus.

2.4. Statistical analyses

We summarized continuous data using means [with standard deviations (SDs)] and medians [with interquartile ranges (IQRs)] as appropriate. Medians were compared using two-sided Mann Whitney U tests. Diagnostic accuracy was assessed for dichotomous clinical (e.g., peritonitis) and CT (e.g., mesenteric hematoma) findings by calculating estimates of sensitivity, specificity, and positive and negative likelihood ratios. For these calculations, the clinical, laboratory, or CT finding was considered the index test and compared against a reference standard of therapeutic laparotomy for HVI. We assessed the accuracy of continuous findings (e.g., number of CT cuts with intraperitoneal free fluid) by calculating c-statistics (the area under the curve when sensitivity is plotted against 1-specificity). C-statistics are a method of calculating the average accuracy of a continuous finding and may be interpreted as the average sensitivity across all values of specificity (or the average specificity across all values of sensitivity).

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