Incidence of Hollow Viscus Injury in Blunt Trauma: An Analysis from 275,557 Trauma Admissions from the EAST Multi-Institutional Trial

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Background: Blunt hollow viscus injury (HVI) is uncommon. No sufficiently large series has studied the prevalence of these injuries in blunt trauma patients. This study defines the prevalence of blunt HVI, in addition to the associated morbidity and mortality rates for this diagnosis on the basis of a series of over 275,000 trauma admissions.

Methods: Patients with blunt small bowel injury (SBI) were identified from the registries of 95 trauma centers for a 2-year period (1998–1999). Each HVI patient (case) was matched by age and Injury Severity Score with a blunt trauma patient receiving an abdominal workup who did not have HVI (control). Patient level data were abstracted by individual chart review. Institution level data were collected on total numbers for trauma admission demographics and on total diagnostic examinations performed.

Results: From 275,557 trauma admissions, 227,972 blunt injury patients were identified. HVI was rare, with 2,632 patients identified from this group. Perforating small bowel injury accounted for less than 0.3% of blunt admissions. Mortality and morbidity were high for HVI.

Conclusion: HVI is a rare but deadly phenomenon. The high mortality rates reflect the severity of the HVI and associated injuries. HVI patients should be carefully monitored for related injuries and complications.

Key Words: Blunt trauma, Hollow viscus injury, Small bowel injury, Stomach injury, Duodenal injury, Colon injury, Trauma, Incidence, Multi-institutional study.

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lunt hollow viscus injury (HVI) is an infrequent diagnosis in the trauma patient.1 Unlike patients with penetrating injury in whom HVI is frequent, the patient with blunt trauma rarely presents with clinical evidence of a ruptured viscus. Solid organ injury and resultant hemodynamic instability present a higher priority in the management of the patient with blunt abdominal trauma, and HVI is not usually suspected unless the clinical picture is highly suggestive.2–5 It has been previously reported that delays in the diagnosis and surgical management of small bowel injury (SBI) are associated with significant morbidity and mortality.1 The recent decreases in rates of penetrating injury at many trauma centers and the continued increases in blunt trauma make it likely that the rate of HVI as a percentage of all trauma will continue to increase.

As a result of its relatively low frequency, experience with this injury is limited, and exposure of surgeons to HVI occurs sporadically and over long periods of time. Few centers have a significant experience with these injuries, and as a result there is no large data set providing epidemiologic data about the incidence, prevalence, diagnosis, and outcomes of these injuries. Because of the low incidence of HVI in any single institution, a multi-institutional study was necessary to acquire enough cases for meaningful in-depth analysis. This sample allows a variety of statistical comparisons that might be useful in studies of the incidence, prevalence, diagnosis, and management of HVI.

The specific aims of this study were to determine the overall frequency of HVI, the relative frequency of various hollow organ injuries, and the outcomes associated with such injuries. The Multi-Institutional Trials Committee of the Eastern Association for the Surgery of Trauma endorsed this study and provided the candidate trauma centers from which the study population was drawn.

PATIENTS AND METHODS

Data were collected retrospectively from the registries of the 95 participating trauma centers. All ages were included. Data were abstracted on trauma patients with confirmed blunt HVI and, for comparison purposes, on patients who had workups for potential abdominal injury but who did not have HVI. In addition, data were collected on the numbers and types of all trauma patients admitted to participating institutions during the time frame of the study, January 1, 1998, to December 31, 1999.

The study used a retrospective, descriptive, case-control design with a 1:1 match of cases to controls. For matching purposes, cases were patients with any blunt HVI (Interna-
appropriate. Correlations were performed using Pearson’s r. The level of significance was set at \( p < 0.05 \) for all tests unless a lower level was indicated as being substituted for statistical stringency. This study received institutional review board approval before the initiation of data collection.

**RESULTS**

A total of 95 trauma centers contributed data from their databases and/or registries for the study period January 1, 1998, to December 31, 1999. The contributing institutions were predominately Level I (n = 68 [71.6%]) and Level II (n = 19 [20.0%]) trauma centers, with a small number of Level III and nondesignated institutions (n = 8 [8.4%]). The vast majority were teaching institutions (n = 82 [87.2%]). The mean number of total hospital beds per institution was 566 (low, 158; high, 1,600).

The participating institutions had a combined total of 275,557 trauma admissions for the 2-year study period. This was a mean of 1,450 trauma admissions per institution annually, ranging from a low of 63 to a high of 7,998. The mean number of trauma admission averaged 1,677 at Level I centers, 929 at Level II centers, and 652 at Level III and nondesignated centers. From all the admissions, 227,972 blunt HVI patients were identified (82.7%), of whom 37.6% (n = 85,643) had an abdominal workup. The mean number of blunt HVI patients (cases) seen annually was 14 per institution (range, 1–62). The total number of cases was 2,639, which is less than 1% of all trauma admissions and 1.2% of blunt trauma admissions. Only 3.1% of patients receiving an abdominal workup after blunt trauma had an HVI. Controls outnumbered cases at a rate of approximately 31:1. The mean number of controls was 437 per institution (range, 38–2,580).

Of the 2,639 cases, 2,416 (91.5%) of the eligible patients were available for analysis. Of the 83,004 control patients, 1,728 (2.1%) were analyzed. A total of 4,144 charts were analyzed.

The most common site of HVI was small bowel (93.0%), followed by jejunum/ileum (80.9%), colon/rectum (30.2%), duodenum (12.0%), stomach (4.3%), and appendix (0.4%). Most of these injuries were hematomas or serosal tears. Of the patients with HVI, the percentage of patients with full-thickness perforation was 25.7% for small bowel, 23.1% for jejunum/ileum, 20.3% for colon/rectum, 3.2% for duodenum, 2.1% for stomach, and 0.3% for appendix. A summary of prevalence estimates for different types of HVI is given in Table 1 as a percentage of all admissions, all blunt admissions, all blunt abdominal workups, and all HVI patients.

Morbidity was assessed by looking at complications and unplanned readmissions in the hollow viscus and non–hollow viscus patients. Information on all complications for all patients was collected and patients were first categorized as to whether or not they had any complications (yes/no). The most frequently occurring complication diagnoses were then further grouped into the major complication categories of intra-abdominal abscess, acute renal failure, acute respiratory distress syndrome, systemic sepsis, pneumonia, and deep vein thrombosis.
The overall complication rate for all patients was 21.8%. Patients without HVI had the lowest complication rate (13.7%). Not unexpectedly, patients with colon/rectum injuries had the highest complication rate at 32.3%. HVI patients had a significantly higher rate of complications on all of the major complication groupings than did non–hollow viscus patients. Nearly all of the individual subgroups of HVI were significantly higher than non-HVI as well. Complete results are summarized in Table 2.

The overall unplanned readmission rate was 4.2%. The control patients had a lower readmission rate (2.4%) compared with the HVI cases (5.5%, \( p < 0.001 \)). The readmission rate for the individual subgroups of HVI cases by site were 5.8% for small bowel, 6.0 for jejunum/ileum, 7.3% for colon rectum, 4.8% for duodenum, and 2.9% for stomach. All of these readmission rates were statistically significantly greater than the control patient rate readmission rates \( (p < 0.001) \) except for the stomach injury. The most common causes for unplanned readmission were sepsis/surgical wound infection (18.9%), respiratory problems/pneumonia (12.0%), abdominal pain (12.0%), small bowel obstruction (9.7%), and abdominal abscess/fistula (8.0%).

Mortality was high for HVI. Overall, the mortality rate for cases was 19.8%. This was significantly higher that the mortality for control patients \( (p < 0.001) \). Duodenal injury (perforating and nonperforating) was the only diagnosis that did not put patients at increased risk for death. However, if only perforating duodenal injuries were included, the relative risk (RR) of death became significant (RR, 1.9; 95% confidence interval, 1.5–2.3). Stomach injury carried that greatest mortality risk, with patients presenting with stomach injury at a 2.8 times greater risk of dying than patients without HVI. It should be noted, however, that stomach injury patients also had significantly higher Injury Severity Scores than did any other group of patients. This increased mortality is likely because the tremendous energy required to produce blunt stomach injury also causes other severe concomitant injuries because, in the nine patients with isolated gastric injury, there were no deaths. The mean ISS was not statistically significantly different between any of the other HVI subgroups (Table 3).

Time to operative intervention did not significantly affect mortality in the HVI patient with multiple injuries. However, in looking at the relatively small number of patients who had isolated perforation of the hollow viscus (no other injury with Abbreviated Injury Scale score > 1), time to operative intervention was a factor in mortality for the small bowel patients. In this group, mortality was significantly increased by delaying operative repair past 24 hours (5% vs. 16%, \( p < 0.02 \)) (Table 4).

**DISCUSSION**

This large multi-institutional study confirms that HVI is an uncommon entity. Less than 1% of all patients who...
present with blunt trauma will have an HVI, and only 0.3% of all blunt trauma patients will have a perforated SBI. It is probable that most trauma centers in the United States have limited exposure to patients with HVI because the trauma centers in this study reported seeing 14 patients with HVI per year on average. It is therefore likely that most trauma surgeons in the United States will manage fewer than five HVI patients annually. The possibility of a delay in diagnosis becomes more pronounced, given this relatively low exposure rate at most centers. Small bowel injury continues to be the most common type of HVI; however, in keeping with the other subtypes of HVI, individual surgeons at trauma centers will rarely be exposed to more than a few cases per year. The implications of this limited exposure are impossible to ascertain from this study, but if competence increases with higher volumes of cases, patients with HVI are severely disadvantaged compared with patients with solid organ injury.

The highest mortality rate was recorded for stomach injury, at 28.2%. The mortality rate for SBI was 15%, and for colon and rectal injury it was 19.4%. The lowest mortality rate noted was for duodenal injury, at 14.8%. Stomach injuries carried the highest raw mortality rate but also had the highest ISS. Even when adjusting for the ISS, stomach injury continued to carry the highest mortality of any of the organs studied in this report. This may be related to the forces that may occur because of this retrospective design. Some patients with multiple injuries generally had other life-threatening injuries that brought them to the operating room quickly and from which they eventually died. This is borne out by the analysis of patients with isolated perforating HVI. In these patients, a delay to operative intervention greater than 24 hours was associated with a significantly higher mortality rate than that encountered in patients having operative repair within 24 hours (5% vs. 16%, p < 0.18). These findings support our previously reported experience that delays in diagnosis of perforated SBI are associated with a significantly increased mortality. This is independent of associated injury.

Because these data were drawn from a large multi-institutional group of mostly Level I trauma centers (71.6%) within the past few years, it is difficult to attribute the delays in diagnosis to outdated diagnostic equipment or to the lack of awareness of the diagnostic challenge that HVI presents. The continued reliance on computed tomographic scans for the diagnosis of blunt abdominal injuries and the strong present-day preference for nonoperative management in blunt trauma must be implicated in the cause of these delays in diagnosis.

Despite its size and its multi-institutional composition, this study has limitations related to its retrospective design. This study used a case-control design to minimize the potential biases that may occur because of this retrospective design. Some patients with HVI may have been missed. The data collection relied on chart review at the participating institution as the HVI (19.8 vs. 12.2; p < 0.001; RR, 1.8). This increased mortality cannot be attributed to differences in injury severity or age because these patients were case-matched with controls with similar characteristics, and the ISS did not differ significantly between any HVI subgroup. These data suggest that patients with HVI are more likely to die of their injuries than patients without HVI even when the injury severities are comparable. Whether this is related to delays in diagnosis, to inadequate therapy, or to other causes cannot be definitively determined from this retrospective study.

Comparison of HVI patients with multiple injuries showed that patients going to the operating room in less than 24 hours had a higher mortality (16.2%) than those going after 24 hours (15.1%), although the difference was not statistically significant. The most obvious explanation for this is that patients with multiple injuries generally had other life-threatening injuries that brought them to the operating room quickly and from which they eventually died. This is borne out by the analysis of patients with isolated perforating HVI. In these patients, a delay to operative intervention greater than 24 hours was associated with a significantly higher mortality rate than that encountered in patients having operative repair within 24 hours (5% vs. 16%, p < 0.18). These findings support our previously reported experience that delays in diagnosis of perforated SBI are associated with a significantly increased mortality. This is independent of associated injury.

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source of our data, and the data set may thus contain errors or omissions. Because HVI can often only be definitively diagnosed via surgery, any patient who died before laparotomy may not have had their HVI diagnosed. In addition, patients with minor hollow viscus hematomas or serosal tears that did not require or receive surgical intervention may also have been discharged without a diagnosis of HVI being made. It must therefore be emphasized that the prevalence estimates likely represent the minimum extent of occurrence of this very serious injury. The true prevalence may be higher.

HVI is a rare but potentially deadly phenomenon. The increased mortality rates seen with HVI reflect the severity of the HVI and the high energy dissipation required to inflict it, which may cause other serious injuries. Because these injuries are rare and have high associated mortality, greater vigilance is required to ensure timely diagnosis and treatment.

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REFERENCES


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