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REVIEW ARTICLE

Clinical outcomes and effect of delayed intervention in patients with hollow viscus injury due to blunt abdominal trauma: a systematic review

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Abstract

Introduction Hollow viscus injury (HVI) due to blunt abdominal trauma remains a diagnostic challenge, often presenting late and results in delayed intervention. Despite several treatment algorithms, there is currently no consensus on how to manage patients with HVI. The aim of this review was to define clinical outcomes and the effect of delayed intervention in patients with HVI due to blunt abdominal trauma. The primary outcome of interest was difference in mortality between groups.

Methods Based on the preferred reporting items for systematic reviews and meta-analyses statement, a literature search was performed. Studies comparing clinical outcomes in adult patients with hollow viscus injury due to blunt abdominal trauma undergoing early or delayed laparotomy were included. Two independent reviewers screened the abstracts.

Results In all, 2288 articles were retrieved. After screening, 11 studies were included. Outcomes in 3812 patients were reported. Overall mortality was 17%. Ten studies reported no difference in mortality between groups. A statistical increase in morbidity was described in five studies, and a trend to increased morbidity was seen in a further two studies. Two studies reported increased mortality in delayed intervention in isolated bowel injury.

Conclusions This systematic review summarises the results of studies considering outcomes in patients with HVI due to blunt abdominal trauma who have early vs delayed intervention. Overall mortality was significant at 17%. If all patients with hollow viscus injury are considered, the majority of studies do not show an increase in mortality. As patients with isolated bowel injuries have higher mortality in the studies reviewed, to improve outcomes in this subset further investigation is warranted.

Keywords Blunt abdominal trauma · Hollow viscus injury · Trauma laparotomy

Introduction

Trauma is a significant health problem responsible for around 10% of global deaths as estimated by the world health organisation. In most modern healthcare systems, it is the leading cause of death in children and adults aged under 45 [1].

Blunt abdominal trauma (BAT) accounts for a significant proportion of injuries in most trauma series, and can result in both solid and hollow abdominal viscus injury. The paradigm shift in the management of solid organ injury, with the majority of patients being managed non-operatively, has been well documented, and indication for intervention in this group of patients is well understood [2, 3]. Patients with hollow viscus and mesenteric injury account for 2–6% of patients with BAT, and more often cause clinical uncertainty [4–9]. Direct injuries leading to perforation have the potential to be misdiagnosed on initial imaging, or HVI may present in a delayed manner due to ischaemic perforation or as a result of mural injury [6, 10–13]. All three injury patterns may therefore be found at delayed intervention. Symptoms and signs on initial presentation cannot reliably predict outcome. Indications for surgical intervention in HVI patients are therefore more difficult to define. Repeated clinical examination with or without serial imaging is often utilised for decision making with the aim of preventing septic complications and minimising negative laparotomy rate. Several

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algorithms have been proposed, with varying sensitivity and specificity, but no consensus on management has been agreed [14–16]. Even with modern treatment, mortality in patients with HVI is reported at between 10–20% and morbidity between 20–30% [5, 9].

The management of patients with hollow viscus injury is therefore a significant problem and an area of uncertainty for clinicians managing patients with abdominal trauma. Due to the diagnostic complexity and lack of agreed consensus on clinical management of these patients, surgical intervention is often delayed. The outcomes of patients undergoing delayed surgical intervention needs to be understood to help decrease morbidity and mortality in this group of patients.

The aim of this review was to define clinical outcomes and investigate the effect of delayed intervention in patients with hollow viscus injury due to blunt abdominal trauma.

Search strategy

Based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA), a systematic literature search was performed in 2016. The MEDLINE and EMBASE databases were searched using the following criteria ((((blunt AND ((hollow viscus) OR bowel OR intestinal OR mesenter*) AND (injur* OR trauma))))).ti, ab. The Cochrane Central Register of Controlled trial database was searched using the key term "hollow viscus injury" in the title, abstract and key word sections. The bibliographies of relevant articles were also interrogated to identify further studies. Only English language articles, or articles where there was on online English translation available, were included.

Inclusion criteria

Studies comparing clinical outcomes in patients with hollow viscus injury due to blunt abdominal trauma undergoing laparotomy with associated analysis of time from hospital admission to surgery were included. Delay in intervention was as per individual study definition and in studies where multiple time periods were used it was assumed that increasing in time was increase in delay. In case series or registry reviews, patients had to be from a well-defined trauma population and be consecutive. Hollow viscus injury is defined as an injury of a hollow abdominal viscus or its mesentery where the organ is directly injured from trauma and needs resection, repair or control of bleeding for definitive treatment or where hollow viscus or mesenteric injury due to direct trauma is detected by CT and managed conservatively.

Exclusion criteria

Case reports, reviews and conference proceedings were excluded from this study.

Two independent reviewers (CH and ASP) screened the abstracts and full-text publications were reviewed if there was insufficient information in the abstract to deem suitability for inclusion. Any differences in opinion regarding inclusion were discussed with a third party (JW). Data were extracted from the studies using a data extraction sheet. Quality of studies was evaluated using the Methodological Index for Non-randomised studies score (MINORS score), by two reviewers.

Outcomes

The primary outcome of interest was difference in mortality in patients with hollow viscus injury due to blunt abdominal trauma undergoing early or delayed intervention.

Secondary outcomes of interest recorded were morbidity, length of hospital stay effect, quality of life and stoma rate.

PRISMA flow diagram

See Fig. 1.

Results

Studies identified according to the search strategy

In all, 2288 articles were retrieved from the search, of which 903 were duplicates. After review of all abstracts, 35 papers were deemed potentially suitable. The full-text publication of these 35 papers was scrutinized and 11 were found to meet the inclusion criteria.

In total, outcomes in 3812 patients were reported with rates of HVI and mesenteric injury in each study varying from 41 to 2639. The largest study contained 69% of included participants, but described only mortality comparisons and did not include morbidity comparison [5, 9, 14, 18–25]. Seven studies contained over 100 patients. Four studies included patients with bowel and mesenteric injury, four with all bowel injuries and three with small bowel injuries alone. In the eight studies that included all locations of HVI, six studies including 3263 patients stated the exact location. On average 87% (Range 59–90%) of injuries occurred in the small bowel, 23%

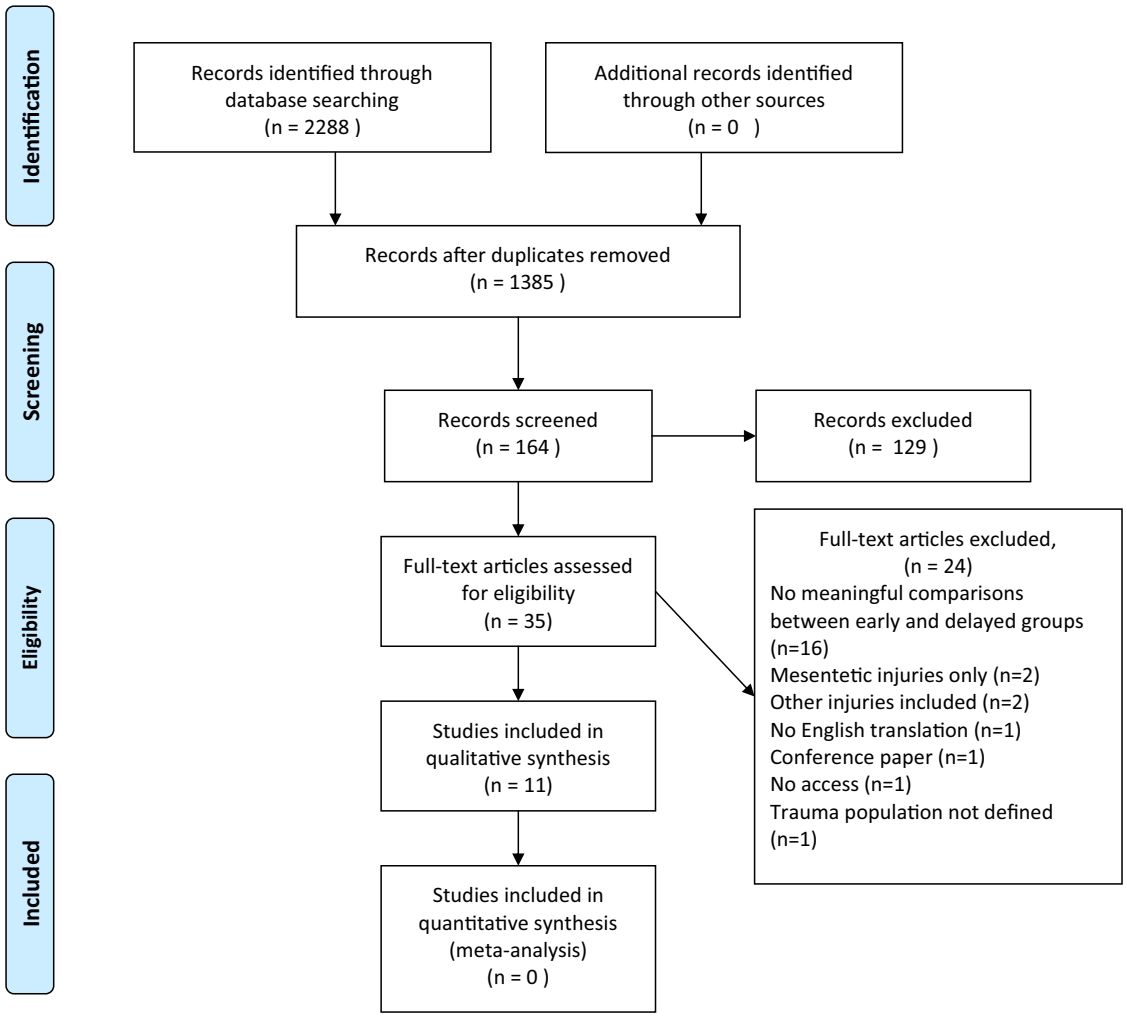

Fig. 1 PRISMA 2009 Flow Diagram. From Moher et al. [17]

in the colon and 3% in the stomach, including multiple injuries. Analysis of outcomes in different groups was not performed.

Definition of delayed intervention varied between studies with three studies employing multiple time periods, and those employing a single time cut-off utilising periods from 6 to 24 h (Table 2).

Three studies included patients of all ages, but the mean age was greater than 16 in all studies. One study included patients aged over 14 and one all patients aged over 13.

The delayed intervention rate varied from 6.8 to 43%. See Tables 1 and 2.

Quality of evidence

All the studies were observational retrospective case series. The quality of the studies is reflected in the methodological index of non-randomised studies scores which ranged from 8 to 11. The strengths of the studies were the relatively high number of patients, well-defined endpoints and pragmatic cohort identification. The principle weakness of the studies was the retrospective nature, the variability in the definition of delayed surgery and the variability of included groups. Several studies relied on hospital coding for detection of the primary cohort.

Table 1 Study characteristics

Author	Year	Yrs	Centres	Country	Injuries included	MINORS score	n HVI	Mortality difference	Morbidity difference	Other endpoints
Watts	2003	2	95	USA	BI	10	2639	No	N/A	No
Fakhry	2000	8	8	USA	SBI	9	198	No	No	No
Malinonski	2010	13	1	USA	BI	10	195	Yes	N/A	No
Hughes	2002	11	1	Australia	BMI	9	170	N/A	Yes	No
Fang	1999	5	1	China	SBI	10	111	No	Yes	LOS, injury location
Mcnutt	2015	5	1	USA	BMI	8	110	No	No	LOS, injury location
Al-Hassani	2013	3	1	Qatar	BMI	11	109	No	No	Type of injury, injury location
Fraga	2008	12	1	Brazil	SBI	10	90	N/A	No	No
Kemmeter	2001	10	1	USA	BI	10	87	No	Yes	No
Kafie	1997	4.5	1	USA	BI	10	62	No	Yes	No
Niederee	2003	11	1	USA	BMI	8	41	No	No	LOS

LOS length of stay, *BI* Bowel injuries, *SBI* small bowel injuries only, *BMI* Bowel and mesenteric injuries

Table 2 Definition and analysis of delayed intervention, cause of death

Author	*n* HVI	Delayed rate	Number of groups	Time cut-off	Analysis	Cause of death description	
Watts	2639	N/A	2	24 h	Univariate	No	
Fakhry	198	39%	4	6–24 h	Multivariate analysis	Yes	43% of deaths attributable to HVI. All deaths over 8 h attributable to the HVI. In the HVI only group 88% of deaths were due to the HVI
Malinonski	195	43%	9	Hourly	Multivariate analysis	No	
Hughes	170	N/A	Not stated	N/A	Chi-squared	Yes	35% of deaths attributable to HVI
Fang	111	N/A	4	Variable	One-way analysis of variance	Yes	17% of deaths attributable to HVI
Mcnutt	110	15.50%	2	4 h	Univariate analysis	No	
Al-Hassani	109	33%	2	8 h	Univariate	Yes	50% of deaths occurred in first 24 h and were not due to HVI. Most of the deaths after were due to HVI
Fraga	90	N/A	N/A	N/A	N/A	No	
Kemmeter	87	6.80%	Various	N/A	Kruskal–Wallis	Yes	17% of deaths attributable to HVI
Kafie	62	27%	2	24 h	Student's *t* test	No	
Niederee	41	N/A	2	24 h	Chi-squared	No	

Differences in description of the cohorts with respect to timing of intervention as well as differences in inclusion criteria prevented meta-analysis of primary endpoints. Averages of demographics and outcomes were averaged across studies.

Mechanism of injury

Nine of eleven studies stated mechanism of injury (MOI) in 978 patients [14, 18–25]. In all studies that recorded MOI motor vehicle accidents (including motorcycles) were the most common cause of injury accounting for on average 77% (Range 52–88%) of cases across all studies. Pedestrians 7%, falls 3% and all other causes 13%, made up the remainder.

Extra-intestinal injuries

Rate and type of extra-intestinal injuries associated with HVI were poorly reported. Four studies did not report site or rates of additional injury. In the largest study reporting additional injuries 45% were stated as being thoracic injuries and 42% head injuries [19]. A further study stated that 53% of patients were polytrauma and one that 90% had extra-abdominal injuries [23]. Hughes et al. gave a detailed breakdown of additional injuries with 72% having orthopaedic injuries, 31% head injuries and 27% chest injuries [22]. Additional abdominal injuries were also outlined in this study with 20% having splenic injuries, 14% liver injuries and 13% renal injuries. Two further studies examined

other abdominal injuries in patients with HVI, Kemmeter et al. having similarly high rates with 25% splenic injuries and 29% hepatic injuries, and Fraga et al. having lower rates of splenic injury at 8%, but similar rates of liver injury at 13% [21, 24].

Primary outcome of interest: mortality difference in patients undergoing early compared to delayed intervention for blunt hollow viscus injury

Overall mortality was reported in of the ten of the eleven studies across 3722 patients and mortality comparison between early and delayed interventions was reported in nine of the eleven studies across 3552 patients.

The overall mortality varied from 6 to 29% with a mean mortality of 17%. Mortality in patients having early intervention varied from 2 to 27% and in those having delayed intervention from 4 to 36%. See Table 3.

Ten of the eleven studies reported no significant difference in mortality of the primary cohort, including the largest study which included 2639 patients and defined delayed intervention as > 24 h (watts et al.). A single study comprising 195 patients described a significant difference in mortality between the early intervention and delayed intervention group at 5 h, on multivariate analysis (Malinowski et al.).

Two studies defined a subgroup of patients with isolated or near isolated small bowel injuries. In both these studies, considering 237 and 98 patients, respectively, time to intervention was directly associated with mortality. In the former, a cut-off of 24 h was applied; in the later a multivariate analysis was used based on time to surgery, with mortality increasing as time to intervention increased.

Five studies examined the cause of death in more detail. In all these studies, less than 50% of deaths could be directly attributed to the HVI (see Table 2), and the majority of non-HVI deaths occurred within 24 h. In studies that analysed a subgroup of patients with isolated small bowel injury, up to 88% of deaths were directly attributable to the injury.

Secondary outcomes

Morbidity

Overall morbidity rate was reported in ten of the eleven studies across 3617 patients and ranged from 14.6 to 52.2%; average morbidity rate across all studies was 29%. Eight of the eleven studies stated the nature of complications in 3420 patients. The most common complication was pneumonia (13%), followed by sepsis (9%), ARDS (6.4%) and intra-abdominal abscess (4%).

Morbidity comparison between early and delayed intervention was reported in nine of the eleven studies across 978 patients. Morbidity in the early intervention group varied from 14.1 to 62% and in the delayed intervention group varied from 35 to 63.6%. See Table 3.

A statistical increase in morbidity was described in five studies, and a trend to increased morbidity was noted in a further two studies. There was one study which confirmed that the increased morbidity seen in patients undergoing delayed intervention was due to the subgroup of patients with isolated small bowel injury. In another study where equal morbidity was observed with early and delayed intervention, the number of patients in each group was small as half the patients in the study were managed conservatively. Furthermore, delayed intervention was defined as any surgical intervention after failure of conservative management. Contrary to these studies, there was one report on 90 patients from Brazil which described an increase in morbidity in the early intervention group, even if patients with isolated small bowel injury were analysed separately.

Type of injury in early and delayed groups

Two studies provided more information on the types of injury found intraoperatively in the early and delayed groups.

Al hassani et al., in 109 patients with HVI, showed small bowel perforations were significantly more common in the delayed intervention group vs the early group (28 vs 12%) and mesenteric tears were significantly more common in the early group than the delayed group (38 vs 8%). There was no significant difference between the early and late groups in the rate of small bowel devascularization (18.5 vs 8%), transections (11 vs 12%) or serosal tears (31 vs 32%). Isolated small bowel injuries were more common in the delayed group (37 vs 60%). No significant difference was found between early and delayed groups in the type of operation needed, suturing without resection (48 vs 48%), resection and anastomosis (33 vs 44%) resection without anastomosis 15 vs 0% [18]. Mcnutt et al. in 60 patients showed no significant difference in operative findings with rates of ischaemic bowel (47 vs 41%), full thickness perforation (9 vs 24%), serosal tear (7 vs 18%) actively bleeding vessel (21 vs 12%), and mesenteric rent (7 vs 0%) [14].

Length of stay

Length of stay comparison was performed in two studies across 152 patients. Both studies reported a significant increase in length of stay in patients undergoing intervention after 24 h.

QOL and stoma formation rate

None of the eleven studies reported on quality of life or stoma rate formation comparisons in the early vs delayed intervention groups.

Table 3 Study outcomes

Author	n HVI	Overall mortality	Mortality early	Mortality late	Mortality difference	Morbidity early	Morbidity late	Morbidity diff	Subgroups	Other endpoints
Watts	2639	19.80%	N/A	N/A	No	N/A	N/A	N/A	Increased mortality in the isolated HVI group	
Fakhry	198	10.60%	N/A	N/A	No	35.80%	Variable	No	Increased mortality in the isolated HVI group	
Malinonski	195	9%	6.40%	12.20%	Yes	N/A	N/A	N/A		
Hughes	170	13.50%	N/A	N/A	N/A	N/A	N/A	Yes		
Fang	111	5.40%	2%	Variable	No	Variable	Variable	Yes		Increased LOS in delayed group
Mcnutt	110	6%	6%	7%	No	35%	35%	No		Increased LOS in delayed group
Al-Hassani	109	16%	19.30%	4%	No	25%	40%	No		
Fraga	90	N/A	N/A	N/A	N/A	62%	47.50%	No		
Kemmeter	87	13.80%	N/A	N/A	No	14.10%	42.90%	Yes		
Kafie	62	18%	16%	29%	No	1.1/Patient	3.3/Patient	Yes		
Niederee	41	29%	27%	36%	No	40%	63.6%	No		

LOS length of stay

See Table 2.

Discussion

This systematic review summarises the results of studies considering outcomes in patients with HVI due to blunt abdominal trauma and helps define mortality and morbidity in those who have early vs delayed intervention. Importantly, it identifies areas for future focus and research.

In short, eleven studies fulfilled the inclusion criteria. If all patients with hollow viscus injury are considered, the majority of studies do not show an increase in mortality. However, there is sufficient data to indicate higher morbidity, especially if surgical intervention is delayed for more than 24 h. In a subgroup of patients with isolated small bowel injury, outcomes are worse when intervention is delayed, including mortality. Further studies are warranted in this group of patients to facilitate early intervention and improve outcomes.

Hollow viscus injury due to blunt abdominal trauma occurs in between 2–6% of patients suffering blunt abdominal trauma. It is recognised that it can be difficult to diagnose and can present late leading to delayed intervention. Patients are often severely and multiply injured leading to a mortality of between 10–20%. The shift to non-operative management of solid organ injury has meant that HVI is now one of the commonest reasons for a laparotomy in blunt abdominal trauma, and probably the commonest reason for a delayed laparotomy [26]. It has also increased the possibility of injuries to hollow viscus being missed as the rate of laparotomy has reduced. It is also known that injuries can be missed on initial imaging and that ischaemia due to mesenteric injury or mural haematoma can lead to a delayed perforation. This is in contrast to the majority of traumatic injuries that are identified early, even if managed conservatively. It is possible that late presentation manifests with peritonitis and/or sepsis with the potential for worse outcomes. It is therefore assumed that earlier detection of injuries missed on CT, or prediction of injuries that will perforate later will lead to improved outcomes. This has to be balanced against the morbidity of negative laparotomy in the large group of patients with blunt abdominal trauma and no injury [27]. HVI therefore remains a difficult clinical problem for surgeons managing abdominal trauma.

Difference in mortality between the two groups was chosen as the primary outcome of interest because it was consistently reported, easily defined and of a rate that allowed a significant difference in outcomes to be detected. In all studies, there was consistency in the cohorts included in the early and delayed groups with regard to additional injuries, i.e. multiply injured patients were compared to multiply injured patients and isolated injuries to isolated injuries. The mean mortality and morbidity in the two groups were high, but often not due to the HVI in multiply injured patients. An important finding of this review, however, was that in the studies where a subgroup of patients with isolated hollow viscus injury were analysed, significant differences in mortality were detected. It is likely that this group of patients present the biggest challenge in terms of diagnosis and decision to intervene due to "soft" signs on CT such as mesenteric or mural haematoma. It is also likely that the mortality increase is detectable in this group as death did not occur due to other more serious injuries. Further data regarding this subgroup of patients is therefore needed, and adoption of algorithms that can predict need for intervention based on initial radiological and clinical findings may be appropriate for this group. A further interesting finding was that in the two studies that looked at type of injury in more detail no difference in the rates of ischaemic bowel was seen between the early and delayed groups, and that full thickness perforations were common in the delayed groups. There was also a 12% rate of transections found in a delayed manner. This highlights that with better initial assessment more injuries may be treated earlier and not all delayed injuries are as a result of ischaemic perforation.

This review considered a large number of patients across multiple institutions in several countries. Although there was heterogeneity between the studies, reporting of secondary endpoints were consistent. There was also heterogeneity of injuries within those with HVI, however, the nature of presentation and clinical pathways in these patients are similar. Clinician treating patients with abdominal trauma will recognise the group of patients described.

Overall, it is likely that the clinical assumption that earlier intervention will improve outcomes in patients with hollow viscus injury due to blunt abdominal trauma is true, but that overall mortality may be difficult to improve due to the number and severity of other injuries. Despite this the development of clinical algorithms and guidelines should be supported as well as consensus regarding the definition of delayed intervention, to allow well-designed prospective data collection to take place. Future investigations should focus on early detection and intervention in patients with isolated hollow viscus injury.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interests that could inappropriately influence or bias their work.

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