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Contemporary characteristics of blunt abdominal trauma in a regional series from the UK

R Pande[1]*, A Saratzis[2]*, J Winter Beatty[1], C Doran[3], R Kirby[4], C Harmston[1]

[1]University Hospitals Coventry and Warwickshire NHS Trust, UK
[2]University of Leicester, UK
[3]University Hospitals Birmingham NHS Foundation Trust, UK
[4]University Hospitals of North Midlands NHS Trust, UK

**Contributed equally*

ABSTRACT

INTRODUCTION Blunt abdominal trauma (BAT) is a common injury in recent trauma series. The characteristics of patients with BAT have changed following the reconfiguration of UK trauma services. The aim of this study was to build a new profile for BAT patients undergoing immediate or delayed laparotomy.

METHODS All 5,401 consecutive adults presenting with major trauma between April 2012 and April 2014 in the 3 major trauma centres in the West Midlands were analysed to identify all patients with BAT. A total of 2,793 patients with a mechanism of injury or symptomatology consistent with BAT were identified (52%). Outcomes were analysed using local electronic clinical results systems and notes.

RESULTS Of the 2,793 patients, 179 (6.4%) had a mesenteric or hollow viscus injury, 168 (6.0%) had a hepatobiliary injury, 149 (5.4%) had a splenic injury and 46 (1.6%) had a vascular injury. Overall, 103 patients (3.7%) underwent an early (<12 hours) laparotomy while 30 (1.1%) underwent a delayed (>12 hours) laparotomy. Twenty (66.7%) of those undergoing a delayed laparotomy had a hollow viscus injury. In total, 170 deaths occurred among the BAT patients (6.1%). In the early laparotomy group, 53 patients died (51.5%) whereas in the delayed laparotomy group, 6 patients died (20.0%).

CONCLUSIONS This series has attempted to provide the characteristics of patients with BAT in a large contemporary UK cohort. BAT was found to be a common type of injury. Early and delayed laparotomy occurred in 3.7% and 1.1% of these patients respectively, mostly because of hollow viscus injury in both cases. Outcomes were comparable with those in the international literature from regions with mature trauma services.

KEYWORDS
Trauma – Laparotomy – Outcomes – Major trauma centre

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CORRESPONDENCE TO
Athanasios Saratzis, E: as875@le.ac.uk

Major trauma is an important threat to health; the World Health Organization estimates that trauma injuries account for 9% of the world's deaths.[1] In England and Wales, approximately 12,500 people die each year because of trauma, making it the leading cause of death among children and adults aged 44 years and under.[2]

Major trauma care in England underwent significant reorganisation in 2012 with the introduction of a nationwide trauma network delivery model and commissioning of 26 major trauma centres.[3–7] This has led to improvements in overall trauma care. Relevant data are collected nationally from trauma units by the Trauma Audit and Research Network (TARN) to help planning and configuration. Unfortunately, data collected via TARN do not include patients presenting through the major trauma pathway who were eventually found to have insignificant injuries. Additionally, 'soft' imaging findings such as free intraperitoneal fluid are not collected and data from a subsequent laparotomy or intervention are also not uniformly reported. The ability of TARN data to provide robust assessment and treatment algorithms is therefore limited for patients with blunt abdominal trauma (BAT).

BAT makes up a significant proportion of injuries in most contemporary trauma series; nevertheless, the current incidence in the UK remains unclear. BAT has the potential to result in both immediate and late life threatening complications. The indications for immediate intervention in this group of patients are fairly clear. Conversely, delayed complications and presentations in patients with BAT are not well understood. A shift in the paradigm of care of patients with solid organ injury has also taken place in recent years, with an increasing percentage

of patients managed conservatively with a period of observation.

Overall, BAT patients constitute a poorly understood group in terms of definitions, management[8–12] and initial imaging characteristics,[13] especially in the new trauma environment in the UK, following the recent service reconfigurations. The aim of this study was to build a profile for BAT patients presenting to a regional group of major trauma centres in terms of their characteristics and outcomes for immediate or delayed laparotomy.

Methods

All consecutive adult patients (age ≥16 years on first admission to hospital) presenting as a 'trauma call' between April 2012 and April 2014 in the three major trauma centres in the West Midlands were included in the analysis. Patients with trauma who did not present as a 'major trauma call' to the relevant institution were not captured for analysis in this study. All individuals aged <16 years were excluded as specialist paediatric major trauma services in the region are provided in a different institution.

Recruiting centres

The three major trauma centres included in the study were Royal Stoke University Hospital, University Hospital Coventry and Warwickshire and Queen Elizabeth Hospital Birmingham. These centres provide major trauma services for the West Midlands and Northamptonshire, covering an ethnically diverse population of over 6 million people as per the 2011 census[14,15] with a geographical area of 13,000km^2.[16] The West Midlands includes the densely populated conurbation of Birmingham, which is the largest urban area in England outside London, as well as areas of remote countryside. It contains areas of high deprivation, particularly in Birmingham, Coventry and Stoke-on-Trent, and prosperous areas like Solihull, South Warwickshire and South Worcestershire. As a result, the patterns of trauma in the region are diverse and representative of those across the UK, including penetrating injuries (common in urban areas), agricultural injuries and high speed traffic collisions.

Queen Elizabeth Hospital has a regional specialist burns unit and also provides trauma services to the British armed forces; however, only civilian trauma was included in this analysis. The three centres are served by two air ambulance charities: the Air Ambulance Service and the Midlands Air Ambulance Charity. All three sites offer specialist general surgical, orthopaedic, vascular, neurosurgical and cardiac services with on-site interventional radiology cover, and have been commissioned as major trauma centres since April 2012.

Data collection

The primary patient cohort was identified from the hospital trauma call registers and was cross-checked with the TARN logs at each centre as well as accident and emergency department databases (admissions). The local electronic clinical results reporting systems, theatre logbooks, operative and clinical notes were interrogated retrospectively to provide further data, and to identify all patients that TARN logs could have missed. Relevant approval was granted at each site (audit of provision of trauma services) in order to access patient data. Data were entered into an electronic study database. The study adhered to the Declaration of Helsinki[17] and an independent study monitor was appointed from the West Midlands Trauma Network, overseeing data collection and reporting.

Definitions and reporting

Suspected BAT was defined as any blunt abdominal injury requiring exploratory laparotomy or computed tomography (CT) of the abdomen or pelvis during the index admission. Immediate laparotomy was defined as any patient requiring laparotomy before cross-sectional imaging of the abdomen or pelvis was obtained. Early laparotomy was defined as any patient requiring laparotomy after cross-sectional imaging but before 12 hours from the first admission in the accident and emergency department. Delayed laparotomy was defined as any patient requiring laparotomy after 12 hours after admission because of pathology secondary to the initial trauma. Major and minor surgical complications were defined and reported based on recommendations by Dindo *et al*.[18] All imaging studies were reviewed and reported by a consultant radiologist, and injuries were reported as per the injury scoring scale of the American Association for the Surgery of Trauma.[19]

Endpoints and outcomes

The primary aim was to report the radiological findings and clinical characteristics of patients presenting with suspected BAT. In addition, we aimed to report the number of laparotomies performed, intraoperative findings, in-hospital mortality and in-hospital major morbidity.

Statistical analysis

All analyses were performed using SPSS® version 21.0 (IBM, New York, US). In-hospital mortality was compared between groups using binary logistic regression adjusted for age and sex. A p-value of <0.05 was considered statistically significant.

Results

Over a period of 2 years (April 2012 – April 2014), 5,401 trauma calls (mean age: 47 years, standard deviation [SD]: 28 years) were identified and screened. Of these, 2,793 patients (52%) had suspected BAT, with 249 (9%) also having an associated major limb injury (Table 1). Forty per cent of the suspected BAT patients were female (n=1,113) and the mean age was 48 years (SD: 26 years).

Over half (51.2%) of the study population presented after a road traffic collision; Table 1 summarises other mechanisms of injury. Only six patients had an immediate laparotomy with no computed tomography (CT). All other patients who underwent a laparotomy (n=2,787) had CT of the abdomen and pelvis as part of their initial assessment. Further details on baseline imaging are given in Table 2. A second CT scan was performed in 668 patients (23.9%) during their index admission.

Table 1 Baseline and imaging characteristics of the study population

Number of trauma calls screened (2 years, 3 centres)	5,401
Suspected blunt abdominal trauma population	
Number of suspected blunt abdominal trauma cases (no penetrating abdominal injury)	2,793 (51.7%)
Mean age in years	48 (SD: 26)
Female sex	1,113 (40%)
Concurrent major limb injuries (blunt)	214 (7.6%)
Concurrent major penetrating injuries (not in torso)	35 (1.2%)
Road traffic collision (car vs car)	1,080 (38.7%)
Road traffic collision (motorbike)	320 (11.5%)
Pedestrian vs car	31 (1.1%)
Fall from a height (>2m)	573 (20.5%)
Other fall	324 (11.6%)
Unknown mechanism of injury or other	465 (16.6%)
Immediate laparotomy	6 (0.2%)
Associated severe head injuries	122 (4.4%)
Associated severe chest injuries	88 (3.2%)
Findings on initial CT*	
Number of initial CT scans	2,787 (99.8%)
Free intraperitoneal fluid	324 (11.6%)
Free intraperitoneal gas	61 (2.2%)
Mesenteric or bowel injury	179 (6.4%)
Hepatobiliary injury	168 (6.0%)
Splenic injury	149 (5.3%)
Urological injury	127 (4.6%)
Vascular injury (excluding spleen)	46 (1.7%)
No significant finding relating to abdominal or pelvic trauma	1,739 (62.4%)
Findings on subsequent CT (*n*=668)*	
Number of follow-up CT scans during same admission	668 (24.0%)
Free intraperitoneal fluid	14 (2.1%)
Free intraperitoneal gas	4 (0.6%)
Hepatobiliary injury	8 (1.2%)
Splenic injury	17 (2.5%)
Urological injury	19 (2.8%)
Vascular injury	2 (0.3%)

SD = standard deviation; CT = computed tomography
*All of the splenic injuries showing on repeat CT were evident on initial imaging. This was also the case for five of the hepatobiliary injuries on repeat CT but none of the other injuries were evident on previous imaging.

Table 2 Grading (as per the American Association for the Surgery of Trauma guidance)[19] and other characteristics of intra-abdominal injury for patients with suspected blunt abdominal trauma on initial CT (*n*=2,787)

Findings on initial CT	***n***
Free intraperitoneal fluid	324 (11.6%)
Free intraperitoneal gas	61 (2.2%)
Hollow viscus or mesenteric injury	179 (6.4%)
Splenic injury	149 (5.3%)
Grade I	57
Grade II	47
Grade III	37
Grade IV	8
Grade V	0
Kidney injury	127 (4.6%)
Grade I	51
Grade II	23
Grade III	33
Grade IV	14
Grade V	6
Pelvic fracture	102 (3.7%)
Vascular injury	46 (1.7%)
Active contrast extravasation	22
No active contrast extravasation	24

CT = computed tomography

Table 3 summarises the fate of the 2,793 patients with suspected BAT. Overall, 605 (21.7%) underwent a surgical procedure (including any type of surgical, orthopaedic or radiological intervention). Regarding abdominal procedures, 103 early (<12 hours after admission) laparotomies were performed (42 in Royal Stoke University Hospital, 40 in University Hospital Coventry and Warwickshire, 21 in Queen Elizabeth Hospital Birmingham). A total of 92 (89.3%) of the early laparotomy patients were found to have a hollow viscus injury (HVI), including all patients with free intraperitoneal gas on their initial CT. All these patients also had evidence of mesenteric injury or HVI on their initial CT. Of the 103 early laparotomies, 14 (13.6%) were 'damage control' laparotomies with a return to theatre within 48 hours in all cases for 're-look' surgery.

Thirty patients (1.1%) underwent a delayed laparotomy. Twenty (66.7%) of these had a HVI requiring some form of resection or intervention. A second unplanned laparotomy was performed in 28 patients (1.0%) during the index admission.

Of the 179 patients with HVI or mesenteric injury on initial CT, 83 (46.4%) were managed conservatively, 92 (51.4%) had an immediate or early laparotomy and 4 (2.2%)

Table 3 Fate of patients presenting with suspected blunt abdominal trauma (*n*=2,793)

	n
Immediate laparotomy	6 (0.2%)
Early laparotomy (<12 hours)	103 (3.7%)
Delayed laparotomy (>12 hours)	30 (1.1%)
Mesenteric or hollow viscus injury on delayed laparotomy	20 (66.7%)
Other orthopaedic intervention (surgery)	321 (11.5%)
Death during index admission	170 (6.1%)
Death due to intra-abdominal cause	44 (1.6%)
Death due to other associated injury	126 (4.5%)
Major morbidity or disability on discharge	248 (8.9%)

had a delayed laparotomy. Of the 149 patients with blunt splenic injury on initial imaging, 131 (87.9%) were managed conservatively (of which 17 had an embolisation) and 8 (5.4%) required an early laparotomy; 8 patients (5.4%) failed conservative management (all were embolised) and required a delayed laparotomy. Of the 168 patients with blunt hepatobiliary injury on initial imaging, 157 (93.5%) were managed conservatively (of which 9 had an embolisation), 5 (3.0%) required an early laparotomy and 10 (6.0%) required a delayed laparotomy. Table 4 summarises the outcomes for those patients with evidence of free fluid or free gas (intraperitoneal) on the initial cross-sectional imaging while the CT and surgical findings of patients undergoing delayed laparotomy are outlined in Table 5.

A total of 170 deaths occurred (6.1%) during the index admission after suspected BAT. None of these deaths were secondary to exsanguination. There were no mortalities among the six patients who underwent an immediate laparotomy. Of those who underwent an early laparotomy, 53 patients (51.5%) died and among the patients in the delayed laparotomy group, 6 (20.0%) died. Of these 59 deaths, 17 (28.8%) were secondary to other major injuries (head, chest).

Regarding radiological findings on admission and correlation with mortality, on adjusted analysis (for age and sex), free gas on initial CT (odds ratio [OR]: 2.43, $p<0.001$), presence of vascular injury on initial CT (OR: 4.23, $p=0.02$), and presence of splenic injury on initial CT (OR: 3.09, $p=0.01$) were the only three parameters associated with mortality during the index admission inpatient stay. In the suspected BAT cohort (*n*=2,793), those who underwent a delayed laparotomy were not more likely to die during their hospital admission (OR: 2.98, $p=0.31$) on adjusted analysis (age, sex).

Discussion

In this paper, we have attempted to provide a profile of BAT patients using contemporary data, following the reconfiguration of trauma services in England. The broad outcomes in this series are similar to those seen in large trauma series from developed countries that have mature trauma networks, such as the US and Australia. The proportions of injuries to different organs are similar to those published elsewhere, with liver and splenic injuries predominating.

As would be expected, the majority of solid organ injuries were managed conservatively with a low rate of failure. Our overall mortality rate of 6.1% is slightly lower than the 9% seen for all trauma patients in the TARN dataset for the included hospitals but the mortality rate for the patients in our study undergoing laparotomy (42.4%) is higher than that seen in other series of patients requiring laparotomy for blunt trauma.[12,20–25] The rate of BAT as a proportion of the total trauma population in our study (52%) is also higher than that seen in other large trauma series assessing HVI, where the incidence varied from 17% to 36%.[26–30]

In our series, HVI requiring intervention was present in 112 patients, which accounted for 4.0% of those with suspected BAT and 2.1% of all trauma patients. A review of the largest series of HVI published in the last 15 years suggests that the incidence of HVI varies from 0.6% to 9% for

Table 4 Outcomes for patients with suspected blunt abdominal trauma and evidence of free fluid or free gas (intraperitoneal) on initial cross-sectional imaging

	Initial CT findings		
	Free fluid	**Free gas**	**None**
Immediate laparotomy (*n*=6)	–	–	6*
Early laparotomy (*n*=103)	60 (58%)	61 (59%)	0 (0%)
Delayed laparotomy (*n*=30)	20 (66%)	0 (0%)	8 (26%)
Death (*n*=170)	32 (19%)	12 (7%)	0 (0%)
Hollow viscus injury, 1st operation (*n*=92)	54 (59%)	61 (66%)	0 (0%)
Hollow viscus injury, 2nd operation (*n*=20)	14 (70%)	4 (20%)	0 (0%)

CT = computed tomography
*No imaging performed

Table 5 Initial imaging findings and surgical findings for those requiring a delayed laparotomy after an initial period of observation (*n*=30)

	n
Initial CT findings	
Free intraperitoneal fluid	20
Free intraperitoneal gas	0
Splenic injury	8
Hepatobiliary injury	4
Hollow viscus injury	4
Kidney injury	4
Vascular injury (treated radiologically in all 4 cases)	4
Surgical findings	
Hollow viscus injury necessitating intervention	20
Splenic injury necessitating intervention	8
Kidney injury	4
Intra-abdominal abscess	4

CT = computed tomography

abdominally injured patients.[22] It is likely that this variation represents differences in the definition of BAT as in studies that included all trauma patients, the variation in incidence when all trauma patients were considered decreased to 0.3–1.2%. Despite a low incidence, HVI was the most common cause of delayed laparotomy in our series; a third of the patients in this group were eventually found to have significant HVI. It was also present in a high proportion of patients requiring an early laparotomy.

An interesting observation in our series was the high mortality rate for those undergoing laparotomy (42.4%) compared with other series from countries with mature trauma networks.[12,20–25] To a certain degree, this can be explained by the mechanism of injury; most patients were involved in a road traffic collision and had multiple associated injuries. For example, 61 patients had free intraperitoneal gas and 22 had active contrast extravasation on baseline CT, both of which are markers of very significant abdominal injury.

None of the patients in this series actually died directly because of an intra-abdominal cause or exsanguination. In fact, almost a third of the deaths in the laparotomy patients (17/59) were secondary to injuries in the peripheries or a head injury. Furthermore, we tried meticulously to capture all patients with blunt abdominal injury and included them in our analysis, which may have further contributed to the high mortality rate. (TARN will not necessarily capture these patients when assessing mortality rates.)

The American College of Surgeons Committee on Trauma has created a set of quality indicators for major trauma based on expert consensus and these are reported nationally using the Trauma Quality Improvement Program. Delayed laparotomy is one of these quality indicators, with historical data suggesting a poorer outcome in patients who have a delay before operative intervention.[22] A 2012 review of the association between trauma quality indicators and outcome for injured patients in over 200,000 patients from 35 US trauma centres showed that only 19% of patients had a laparotomy delayed for more than 2 hours from arrival in the emergency department.[31] Delay was associated with a reduced risk of in-hospital mortality but a higher risk of overall death or major complication.

Another two-year retrospective review of BAT patients requiring intervention from the US reported a laparotomy rate of 2.7%, with 29% classed as delayed laparotomies.[20] There were comparable findings from a South African study in 2012 that showed an 8% intervention rate with 24% of laparotomies performed more than 12 hours following admission.[12] The vast majority of injuries mandating delayed laparotomy were HVIs, very similar to our contemporary data from the UK. Overall, our series is comparable with these studies in many ways, with a 5.0% laparotomy rate, 21.6% of which were delayed more than 12 hours, and two-thirds of the delayed interventions having a mesenteric or bowel injury.

Predicting HVI that will require intervention remains challenging in this patient group. Despite CT suggesting a degree of mesenteric or bowel injury in 179 patients, only 103 early (<12 hours) laparotomies were performed and another 30 took place following a period of observation. Interestingly, in 16 of the 20 patients with HVI detected at delayed laparotomy, there was no bowel or mesenteric injury on the initial CT. Conversely, all of the 92 patients with HVI or mesenteric injury found during early laparotomy did have a degree of such injury depicted on their initial CT. This is in keeping with the published literature; the sensitivity of CT for detecting HVI requiring intervention has varied from 53% to 95% and the specificity from 78% to 96%.[22]

Some authors have also suggested that the presence of free fluid without solid organ injury can predict HVI and the need for laparotomy. The incidence of isolated free fluid in these studies was comparable with that in our series, at 5.4% and 5.7%.[21,32] On the other hand, this is not consistent across all studies; a series reported in 2014 showed that 72% of patients with free fluid did not require intervention.[33] The incidence of isolated free fluid in our study was high at 11.6% but the ability to predict the need for surgery was low, with only 18.5% of these patients requiring operative intervention at some stage.

It is important to note that our series was not powered or designed in a way that would allow analysis of free fluid at baseline as a predictive factor for intervention. This would require a large cross-sectional study with data from several centres. Until such data are available, HVI must be detected based on clinical grounds with or without repeat CT It is not known whether early laparoscopy in patients with higher risk features would be of benefit and again, our study was not designed or powered to answer this question. Clinical assessment remains the most important guiding tool, alongside cross-sectional imaging.

The role of interventional radiology in our series was also of interest. Overall, 30 BAT patients were managed

predominantly with radiological means: 17 splenic embolisations, 9 hepatobiliary embolisations and 4 arterial embolisations. Eight of the patients who had splenic embolisation went on to require a laparotomy (grade III injuries); however, they did survive. The remaining patients did not require surgical intervention. Especially in those with an arterial injury, radiological intervention proved a useful tool as major laparotomy with arterial reconstruction was avoided. The role of the radiologist, both in terms of diagnosis as well as management, is indeed crucial in the trauma team. All three centres in this series have an interventional radiology service that runs around the clock.

Study limitations

Data were collected across the three major trauma centres in the West Midlands, a populous region with diverse trauma patterns, to include a study population of over 5,000 individuals. Nevertheless, this study does have certain limitations. Primarily, data were collected retrospectively although they were cross-checked with and referenced to local TARN databases, Furthermore, they were validated by two independent investigators (AS and CH). Long-term follow-up information and functional status was unavailable for the vast majority of patients in the series. The TARN database suffers with similar limitations. It does not collect information regarding the presence of free intraperitoneal fluid or gas, or operative details for patients with BAT and these factors could not be cross-referenced with our retrospective findings.

Conclusions

This is the first large series of BAT patients from the UK following national reconfiguration of trauma services. The rates and cause of delayed laparotomy is in keeping with other large trauma series in the published literature from countries with mature regional trauma services but important differences were also noted. The majority of delayed laparotomies were due to HVI. Further studies are needed and should focus on the early detection (rather than the prediction of) HVI. A more systematic attempt to collect relevant imaging findings at baseline and operative outcomes after surgical intervention should be made to fully understand the natural history and optional management of this type of injury.

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