Selective non-operative management of penetrating liver injuries at a UK tertiary referral centre

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ABSTRACT

INTRODUCTION Selective non-operative management (SNOM) of penetrating abdominal injuries has increasingly been applied in North America in the last decade. However, there is less acceptance of SNOM among UK surgeons and there are limited data on UK practice. We aimed to review our management of penetrating liver injuries and, specifically, the application of SNOM.

METHODS A retrospective review was performed of patients presenting with penetrating liver injuries between June 2005 and November 2013.

RESULTS Thirty-one patients sustained liver injuries due to penetrating trauma. The vast majority (97%) were due to stab wounds. The median injury severity score was 14 and a quarter of patients had concomitant thoracic injuries. Twelve patients (39%) underwent immediate surgery owing to haemodynamic instability, evisceration, retained weapon or diffuse peritonism. Nineteen patients were stable to undergo computed tomography (CT), ten of whom were selected subsequently for SNOM. SNOM was successful in eight cases. Both patients who failed SNOM had arterial phase contrast extravasation evident on their initial CT. Angioembolisation was not employed in either case. All major complications and the only death occurred in the operatively managed group. No significant complications of SNOM were identified and there were no transfusions in the non-operated group. Those undergoing operative management had longer lengths of stay than those undergoing SNOM (median stay 6.5 vs 3.0 days, $p < 0.05$).

CONCLUSIONS SNOM is a safe strategy for patients with penetrating liver injuries in a UK setting. Patient selection is critical and CT is a vital triage tool. Arterial phase contrast extravasation may predict failure of SNOM and adjunctive angioembolisation should be considered for this group.

KEYWORDS

Penetrating wounds – Abdominal injuries – Liver

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Until the end of the 19th century, the management of penetrating abdominal injuries was expectant and this strategy was associated with high mortality. By the time of the First World War, operative management had become the standard of care and improved outcomes were reported.¹ In the last half century, however, there has been concern that the pendulum has swung too far and the necessity of mandatory laparotomy for all patients has been questioned.² High rates of non-therapeutic laparotomy and attendant morbidity have provided the impetus for a more selective approach.³

A number of North American studies have subsequently demonstrated selective non-operative management (SNOM) of penetrating abdominal injuries to be safe in the appropriate setting and effectively reduce non-therapeutic laparotomy rates and length of stay for patients.^{4–8} Evidence-based US practice management guidelines support this approach⁹ and data from the North American Trauma Data Bank[®] indicate that SNOM has been applied increasingly over the last decade, with more than a third of abdominal stab injuries

and more than a fifth of gunshot injuries being managed non-operatively.¹⁰

There are marked differences, however, in the epidemiology and aetiology of penetrating abdominal injuries in the UK when compared with the US as well as fundamental differences in the way in which trauma care is organised. Such differences might reduce the applicability of US practice management guidelines in the UK. There are few published UK studies of penetrating abdominal injuries^{11–14} and it is not known to what extent SNOM is being applied in the UK.¹⁵ Survey results from 2012 indicate far less acceptance of SNOM among British and Irish surgeons than among their North American counterparts,¹⁵ and for most UK surgeons, penetrating abdominal injuries represent an infrequent presentation, for which they have limited training and experience.¹⁶

Queen's Medical Centre in Nottingham is one of the busiest acute hospitals in the UK with more than 164,000 emergency department attendances per year. In addition, it

provides specialist hepatopancreaticobiliary services to more than 2.25 million people in the East Midlands and, since April 2011, it has served as the regional major trauma centre 'hub' for the East Midlands major trauma network.

The aim of this study was to review the management of penetrating liver injuries at our institution. The specific objectives were to identify the criteria being used to select patients for non-operative management, to assess the manner in which SNOM is being applied and to assess outcome.

Methods

Liver injured patients presenting to our institution were identified from a combination of Hospital Episode Statistics records and the Trauma Audit and Research Network (TARN) database. Case notes, electronic records and imaging were reviewed to assess demographics, mechanism of injury, injury severity, co-morbidity, initial assessment/resuscitation/imaging and/or intervention, transfusion requirements, critical care stay, subsequent management, morbidity, length of stay and in-hospital mortality. Statistical analysis was performed using Prism® version 4.0 (GraphPad Software, La Jolla, CA, US). Non-parametric mean data were compared using the Mann–Whitney U test.

Results

A total of 122 liver injured patients who presented to our institution with liver (with/without other) injuries between June 2005 and November 2013 were identified. Of these, 31 (25%) had sustained penetrating trauma and these formed the study cohort. Table 1 outlines the cohort characteristics. One injury was due to a low energy gunshot wound and the rest were stab wounds. More than half (52%) of liver injuries were 'high grade' (AAST [American Association for the Surgery of Trauma] grade $\geq$ III). A quarter of patients had concomitant thoracic trauma. There were no head injuries in the cohort. Two patients (6%) were tertiary referrals to our institution from surrounding

district general hospitals; the remainder presented directly via the emergency department.

Figure 1 shows the various management pathways for the group. Twelve patients (39%) underwent immediate surgery owing to haemodynamic instability, evisceration, retained weapon or diffuse peritonism. Three of these also required sternotomy/thoracotomy for concomitant thoracic injuries and, in all cases, this was carried out prior to laparotomy. Two of the immediately operated group required damage control liver packing while the remainder underwent definitive surgery.

The only death in the cohort occurred in the immediately operated group (overall survival 97%). This occurred in a 75-year-old man with severe chronic obstructive pulmonary disease who was operated for a retained weapon. No specific intervention was required at laparotomy (save for weapon removal) and there were no injury-specific complications. Respiratory support was withdrawn five days following surgery owing to inability to wean from the ventilator.

Nineteen patients were deemed stable to undergo CT, ten (53%) of whom were selected subsequently for SNOM. Of the nine patients selected for early laparotomy following CT, two had evolving haemodynamic compromise around the time of the imaging, four had CT suggestive of hollow visceral or diaphragmatic injury and one was felt to have evolving peritoneal signs after CT (subsequent non-therapeutic laparotomy). Two patients were operated owing to surgeon preference (no adverse physiological or CT features). Both underwent non-therapeutic laparotomy. In addition, two patients undergoing laparotomy for a retained weapon required no other specific intervention at laparotomy.

Of the ten patients selected for SNOM, two went on to require laparotomy because of haemodynamic instability. Both had evidence of active contrast extravasation during

Table 1 Cohort characteristics

Median age	29 years (range: 15–75 years)
Male-to-female ratio	6.75:1
Median ISS	14 (range: 4–50)
Liver injury severity	
AAST grade I	n=2
AAST grade II	n=13
AAST grade III	n=14
AAST grade IV	n=2
AAST grade V	n=0
ISS = injury severity score; AAST = American Association for the Surgery of Trauma	

the arterial phase on their initial CT. Angioembolisation was not employed in either case. They underwent laparotomy at 14 and 21 hours respectively following admission and had moderate transfusion requirements (5 and 6 units respectively). One of these patients required liver packing for haemostasis with a subsequent relook laparotomy. The other underwent definitive surgery with haemostatic liver suturing. Neither patient had significant postoperative complications. On an intention to treat basis, SNOM was successful in 80% of cases and, overall, 26% of penetrating liver injuries were managed non-operatively.

All major complications arose in the operated group. These included ventilator associated pneumonia ($n=4$), liver necrosis ($n=2$), major bile leak requiring endoscopic intervention ($n=1$), major wound dehiscence requiring resuturing ($n=1$) and incisional hernia ($n=1$). No significant complications of SNOM were identified and there were no transfusions in the non-operated group. Those undergoing operative management had longer lengths of stay than those undergoing SNOM (median 6.5 vs 3.0 days, $p<0.05$).

Discussion

We have reported previously that the majority of even high grade blunt liver injuries were successfully managed non-operatively at our institution.¹⁷ We hypothesised that our surgeons might be applying similar principles for penetrating liver injuries. Although the majority of evidence supporting SNOM is derived from studies of 'all comers' with penetrating abdominal trauma, it is worth noting that one of the earliest prospective studies of SNOM exclusively recruited patients with presumed isolated liver injuries.¹⁸ In contrast, our study cohort was not a homogenous group of isolated liver injuries. Concomitant thoracic and hollow visceral injuries were present in 25% and 16% of cases respectively.

All patients with evidence of haemodynamic instability or generalised peritonitis on initial assessment underwent immediate laparotomy. This has long been considered standard care and is supported by practice management guidelines.⁹ All those with visceral or omental evisceration or a retained weapon were also operated immediately.

All other patients underwent CT. While the earliest studies of SNOM for penetrating injuries relied on clinical examination alone, practice management guidelines recommend that CT is 'strongly considered as a diagnostic tool to facilitate initial management decisions'.⁹ In the setting of haemodynamically stable patients following penetrating trauma, a negative predictive value of 98% and an overall diagnostic accuracy of 95% has been reported.^{19,20} We consider CT an essential step in triaging potential candidates for non-operative management.

Failure of non-operative management occurred in two of the ten selected patients. In both cases, arterial phase contrast extravasation was evident on the initial CT. Both patients were haemodynamically stable at presentation and arrived overnight, in the era before availability of 24-hour interventional radiology at our institution. Angioembolisation was therefore not employed. Both patients showed

progressive clinical evidence of bleeding and were transfusion dependent prior to undergoing delayed laparotomy.

The global literature supporting angioembolisation for penetrating injuries is sparse. Extrapolation of data from blunt liver injuries might not be valid. However, it is worth noting that contrast extravasation is predictive of failure of SNOM in blunt liver injury and it is recommended that angioembolisation is considered in haemodynamically stable patients.²¹ We believe presence of arterial 'blush' on CT to be predictive of failure of SNOM following penetrating injury also and would strongly consider adjunctive angioembolisation for haemodynamically stable patients (without other indication for laparotomy).

Nine of the ten patients selected for non-operative management were admitted to a critical care or major trauma level 1 environment. We believe this should be standard care for these patients to assess for evolving clinical evidence of bleeding or missed injury. In a large retrospective review of patients admitted for serial examination, it was reported that all patients requiring surgery were identified within 12 hours,²² and guidelines suggest it is safe to discharge these patients after 24 hours in the presence of stable observations, reliable abdominal examination and minimal or no abdominal tenderness.⁹ The median length of hospital stay for these patients in our study was 3 days.

A valid concern regarding SNOM following penetrating abdominal trauma is the potential for missed diaphragmatic injury and subsequent herniation of hollow viscera leading to bowel obstruction or strangulation. Diaphragmatic injury cannot be excluded reliably on CT and the overall incidence of occult diaphragmatic injury after anterior upper abdominal stab injury has been reported as 7%.²³ Patients may present with complications many months following the initial injury and there may be significant associated mortality.²⁴ By virtue of the anatomical relations of the liver, right-sided stab injuries are less likely to lead to diaphragmatic injury and the natural history of right hemidiaphragm injury is thought to be more benign.^{23,24} Laparoscopic evaluation of the diaphragm is strongly recommended for patients with left thoracoabdominal wounds without other indication for laparotomy⁹ but the benefit of laparoscopy in stab wounds of other anatomical locations has not been established²⁴ and routine use in isolated right upper quadrant injuries appears to be unnecessary.⁹

Two diaphragmatic injuries were detected on CT in this cohort. Both patients underwent laparotomy and diaphragmatic repair. There were no occult diaphragmatic injuries detected at laparotomy in the operated group and no sequelae suggestive of missed injuries were found in the SNOM group.

There are a number of limitations to this study. Although our institution is busy in UK terms, we recognise that the study group is small. As a retrospective study, it is prone to selection bias and inaccuracies in coding or TARN data returns may have led to patient omission. In addition, long-term complications (eg as a result of missed diaphragmatic injuries) may have been missed if patients re-presented to another institution.

Conclusions

We believe that SNOM is a safe strategy for patients with penetrating liver injuries in a UK setting given careful patient selection. Haemodynamically stable patients without evidence of peritonitis, evisceration or a retained foreign body should undergo CT to further inform their management. In the absence of CT evidence of hollow visceral injury, all stable patients should be considered potential candidates for non-operative management. Active contrast extravasation on CT is predictive of failure of SNOM and adjunctive angioembolisation should be considered for haemodynamically stable patients. All patients selected for non-operative management should be monitored actively in an appropriate setting and undergo serial abdominal examination to exclude ongoing bleeding or missed injuries.

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