Original article

Audit of time to emergency trauma laparotomy

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Background: **An analysis of the process of care may improve quality of care within a trauma system. Early operative control of haemorrhage is vital and any delay before surgery may adversely affect outcome.**

Methods: **Times from activation of the aeromedical team to arrival in the emergency department and the operating room for patients with liver or spleen injury were analysed to identify factors that delayed laparotomy. These results were compared with those of a national database.**

Results: **The median time from emergency call to operation was 127 min (140 min for blunt and 86 min for penetrating injuries). Time from arrival in the emergency department to the operating room was 54 min (56 min for blunt and 37 min for penetrating injuries). An audit filter, set at the upper quartile of the emergency call to operating room time, selected 21 patients whose records were examined; five correctable delays were identified. Compared with the national trauma database, these patients had longer on-scene times, but significantly shorter times to operation from the emergency call (127 *versus* 161 min) and arrival at the emergency department (54 *versus* 115 min), although the patients were more severely injured (median Injury Severity Score 34 *versus* 24).**

Conclusion: **The time to emergency trauma laparotomy may be used effectively as an audit of process for the clinical governance of a trauma system.**

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Introduction

Quality assurance and improvement programmes that analyse the provision of trauma care to injured patients have tended to utilize mortality, and to a lesser extent morbidity and disability, as markers of effectiveness. While these outcome measures are important and powerful indicators of the capability and efficacy of a trauma system, they have significant limitations. For a trauma system that manages patients from the moment of injury through to discharge from rehabilitation services, these distant end-points provide little information about the process of care that is delivered. Many factors are involved in determining the final outcome of a trauma patient. Management decisions that have clinically important consequences may become hidden among the myriad of other interventions that occur during multidisciplinary care. While outcome measures may identify the presence of deficiencies within a particular trauma system, it may be difficult to identify the points at which these deficiencies lie. It therefore becomes impossible to implement change and so neither quality assurance nor quality improvement is achieved.

Trauma audit can be made easier and more effective by an analysis of the process of care. By focusing the audit in this way the study becomes more directed and deficiencies in the system are more apparent. Improving one aspect of a system may lead to improvements in other areas. As an example, it is known that evacuation of an extradural haematoma is a time-dependent procedure[1]. If carried out within 4 h of injury there is a significant improvement in survival and disability. An audit of 'time to extradural evacuation' might identify and then correct a problem with access to computed tomography (CT). A subsequent improvement in the care of other patients with injuries requiring CT may also be seen.

An ideal audit tool is clinically relevant and important, related to outcome, easy to measure and to apply. It should be able to identify deficiencies in management on a local level and allow comparisons to be made against regional or

national norms. This study was undertaken to determine whether the time to emergency surgery for intraperitoneal solid organ injury qualifies as a tool for audit of the trauma process.

Patients and methods

The Helicopter Emergency Medical Service[2] subset of the trauma database of the Royal London Hospital (RLH) was used for the local audit. This is an integrated system of prehospital and in-hospital trauma care. These patients were not duplicated in the United Kingdom Trauma Audit and Research Network (UK-TARN)[3,4], the standard national trauma database for the study (previously the Major Trauma Outcome Study – UK).

The records for all patients injured between January 1991 and May 1996 were examined. The inclusion criteria were a liver or spleen injury with an Abbreviated Injury Score (AIS)[5] of 2 or more and laparotomy performed within 8 h of injury. The 8-h limit was taken to include delays and early failure of non-operative management but to exclude surgery for late complications in the patients' clinical course. Patients transferred to another hospital for surgery were excluded.

Data were collected on patient demographics, mechanism of injury, Injury Severity Score (ISS)[6], time of the initial emergency call, arrival time in the emergency department and time of arrival in the operating room. The initial emergency call time was as near to the injury time as was available. It was not possible to collect comparable physiological data. The UK-TARN database does not record prehospital physiological data and the RLH patients receive more resuscitation and interventions in the prehospital phase of their management, so making comparisons of emergency department figures meaningless.

RLH patients for review were identified as those with a time from arrival in the emergency department to reaching the operating room of over 50 min for penetrating injury and 100 min for blunt injury. These patients were in the upper quartile of the distribution of this period and may have experienced unnecessary delay in their process of care.

The RLH times were then compared with those of the national UK-TARN database. Data were processed using Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) and Arcus Quickstat Biomedical (Longman Software, Cambridge, UK) software packages. For both patient groups the proportion of patients with penetrating trauma and isolated abdominal trauma was calculated and subjected to χ^2 analysis. Medians and interquartile ranges for ISS, the time between the emergency call and arrival at the operating room, and the time from arrival at the emergency department to arrival at the operating room were calculated, and the distributions compared using the Mann–Whitney *U* test. ISS, mechanism of injury and trauma system (RLH or UK-TARN) were examined in a multiple regression analysis. $P < 0{\cdot}05$ was used to define statistical significance.

Results

The characteristics of the patients from the RLH and UK-TARN databases are shown in *Table 1*. There was no significant difference in age or sex distribution between the two groups. A significantly greater proportion of RLH patients had abdominal AIS scores of 2 or more and proceeded to laparotomy within 8 h of emergency room arrival ($P < 0{\cdot}001$, χ^2 test). In addition they had a higher ISS (median 34 *versus* 24; $P < 0{\cdot}001$) and were less likely to have an isolated abdominal injury (6 *versus* 67 per cent; $P < 0{\cdot}001$). The proportion of patients sustaining penetrating trauma was similar.

The median time from the emergency call to arrival in the operating room was 127 min for the RLH patients. This was subdivided into 140 min for blunt and 86 min for penetrating injuries (*Table 2*). Overall, the median time from arrival in the emergency department to operation was 54 min; 56 min for blunt trauma and 37 min for penetrating (*Table 3*).

Patients with emergency call to operating room times over the third quartile had their case records reviewed. This audit filter level identified 16 patients with blunt trauma and five with penetrating injuries. These patients had delays identified in either their prehospital or in-hospital management. In the prehospital phase, unavoidable delays were due to entrapment and prolonged extrication. Avoidable delays were usually attributed to late activation of the helicopter by the dispatch system but there was one patient with an inappropriately long on-scene time.

Table 1 Study population

	RLH	UK-TARN
No. of patients	1617	51 408
Study group*	86 (5)	533 (1)
999 time recorded*	86 (100)	148 (28)
Sex ratio (M : F)	2·9 : 1	3·2 : 1
Age (years)†	30 (22–49)	26 (19–44)
ISS†	34 (17–46)	24 (13–34)
Isolated abdominal injury*	5 (6)	357 (67)
Penetrating injury*	21 (24)	100 (19)
On-scene time (min)†	62 (50–80)	46 (35–70)

*Values in parentheses are percentages; †values are median (interquartile range). RLH, Royal London Hospital; UK-TARN, United Kingdom Trauma Audit and Research Network; ISS, Injury Severity Score

Table 2 Time from emergency call to operation

	All		Blunt		Penetrating	
	RLH (n = 86)	UK-TARN (n = 148)	RLH (n = 65)	UK-TARN (n = 127)	RLH (n = 21)	UK-TARN (n = 21)
Emergency call to operation (min)	127 (94–163)	161 (124–245)*	140 (111–173)	169 (128–252)*	86 (78–118)	135 (90–212)†

Values are median (interquartile range). RLH, Royal London Hospital; UK-TARN, United Kingdom Trauma Audit and Research Network. *P < 0·001, †P = 0·011 *versus* RLH (Mann–Whitney U test)

Table 3 Time from emergency department arrival to operation

	All		Blunt		Penetrating	
	RLH (n = 86)	UK-TARN (n = 533)	RLH (n = 65)	UK-TARN (n = 433)	RLH (n = 21)	UK-TARN (n = 100)
Emergency department arrival to operation (min)	54 (37–88)	115 (73–180)*	56 (41–102)	123 (78–197)*	37 (29–51)	115 (73–180)*

Values are median (interquartile range). RLH, Royal London Hospital; UK-TARN, United Kingdom Trauma Audit and Research Network. *P < 0·001 *versus* RLH (Mann–Whitney U test)

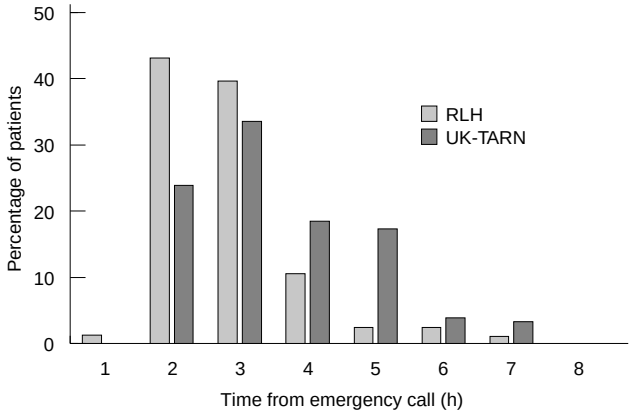

Fig. 1 Time to operation from emergency call. RLH, Royal London Hospital; UK-TARN, United Kingdom Trauma Audit and Research Network

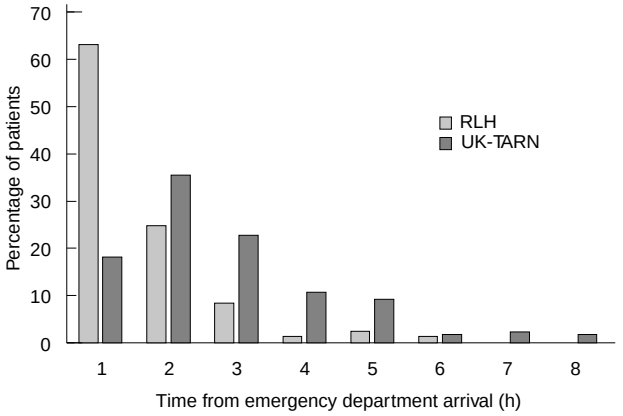

Fig. 2 Time to operation from arrival in the emergency department. RLH, Royal London Hospital; UK-TARN, United Kingdom Trauma Audit and Research Network

In hospital, some patients with an identified intraperitoneal injury went on to laparotomy after failure of non-operative management. Patients in a second group were haemodynamically stable and would normally qualify for non-operative management but for the presence of significant multiple injuries. In these patients, laparotomy was carried out after treatment of the higher priority injuries. However, five patients were identified in whom the clinical decision to proceed to the operating room was delayed incorrectly, either by prolonged resuscitation or by inappropriate investigations (CT). There were data collection errors relating to two additional patients identified by the audit filter, who did not fall into the delayed surgery category.

The local RLH data were then compared with the national UK-TARN data. The time of the call to the emergency services was available for only 28 per cent of these patients. RLH patients spent a median of 16 min more time on scene than the those in the national data set (P < 0·001). Overall, the UK-TARN patients had a median

time to operation from emergency call of 161 min, 34 min longer than that of the RLH patients. Patients with blunt trauma spent 29 min longer in the preoperative phase and victims of penetrating trauma 49 min longer. All these differences were statistically significant. *Fig. 1* shows the distribution of times for patients to proceed to laparotomy from the time of emergency call.

With respect to the times from emergency department arrival to operation, the RLH patients also proceeded to laparotomy significantly faster. Overall, UK-TARN patients arrived in theatre 61 min after the RLH patients (median values), 67 min for blunt and 78 min for penetrating injury. *Fig. 2* shows the distribution of times for patients to proceed to laparotomy from the time of arrival in the emergency department.

The interrelationship between ISS, penetrating injury and trauma system effect was examined in a multiple regression analysis. All three factors proved highly significant ($P < 0{\cdot}001$). Patients with a high ISS, penetrating trauma and RLH patients were more likely to arrive in the operating room faster than other patient groups. This indicates that the trauma system effect was independent of injury severity and mechanism.

Discussion

This study evaluated the use of 'time to emergency trauma laparotomy' as an audit tool for the process of trauma care. There is an underlying assumption within an audit of process that the activities under review have previously been shown to have a beneficial outcome. It is known that timely arrest of uncontrolled haemorrhage is clinically relevant and important. In the Advanced Trauma Life Support Program of the American College of Surgeons, only oxygenation and ventilation manoeuvres take precedence[7]. Ongoing haemorrhage and increasing blood product administration are known to affect survival adversely[8] and increase the incidence of multiple organ failure[9], systemic inflammatory response syndrome and acute respiratory distress syndrome[10].

The three time variables of emergency call, emergency department arrival and operating room time are easy to measure, and readily available from prehospital and in-hospital records. This study shows that it is possible to collect and analyse these data on both a local and national basis. Using these times it was possible to identify a subset of patients for case review, and potential problems with the system were highlighted for further study and action.

Time to emergency trauma laparotomy therefore fulfils the criteria necessary of a tool for auditing the process of trauma care. It can be applied to assess efficiency and performance of both a trauma system (time from injury to surgery) and an individual institution (time from emergency department arrival to surgery).

Whether the time from injury or from hospital arrival should be used is open to question. In-hospital audit will focus on the time from emergency department arrival to operation. Nationally, a median of 46 min will already have elapsed after the injury occurred. From the patients' perspective, the time from injury must be the most relevant and is a better measure of the overall process of care. The small number of patients whose time of injury was available from the UK-TARN database reflects the lack of medical control or interest in the prehospital arena.

Prehospital and in-hospital care are integrated in the RLH trauma system. Patients receive many of their initial critical interventions in the prehospital phase of their management with most necessary airway and ventilation procedures carried out at the scene. While prolonging the time at the scene, this will result in emergency department to laparotomy times that systems without advanced prehospital medical care are unlikely to be able to achieve. However, even when considering the whole period from injury to laparotomy, the RLH patients arrived in the operating room 34 min faster than the national average, even though the patients had more severe injuries and more multisystem trauma.

While it is well known that control of haemorrhage is important, and therefore time to emergency laparotomy may be a useful performance indicator, there is inadequate scientific evidence to determine at which level to set the audit filter. This would represent a limit for the time to operation, over which the details of a case should be reviewed. Without a scientific limit, it is appropriate to choose a filter that selects a certain proportion of the patients, perhaps a number that can feasibly be reviewed adequately in an audit meeting. Selecting the upper quartile for the UK-TARN database would choose patients with a time from arrival at the emergency department to operation of over 200 min for blunt trauma and 180 min for penetrating trauma. These values may be used as a guide for trauma audit in other hospitals. However, a delay to laparotomy of over 2 h, as used by the American College of Surgeons[11], has been shown to affect outcome adversely[12].

This method will identify patients who have experienced excessively long delays; however, it will miss those who have a laparotomy within this timespan, but should have been in the operating room much sooner. For example, 3 h from emergency department to operation would be unacceptable in a haemodynamically unstable patient with an abdominal stab wound. Conversely, for individual patients, surgery beyond these times may be entirely appropriate. Case-note review may reveal a failure of non-operative management of a liver or spleen injury. None the less, review of these cases is

important, if only to discuss the validity of the original treatment decision.

There are wide discrepancies and variations in the provision of trauma care across the UK. In the UK, all hospitals with an emergency department can receive victims of major trauma. Participation in the UK-TARN is voluntary and quality assurance is not a requirement for verification, as it is in the USA, despite a national recommendation by the Royal College of Surgeons in 1988[13]. Every doctor is required to participate in medical audit[14] and all doctors involved in trauma management have a duty of care to the injured patient. Audit of the process of care is a practical and useful tool for clinical governance within trauma services. Time to emergency laparotomy for intraperitoneal solid organ injury fulfils the criteria of an audit tool to be used as part of a quality improvement programme.

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