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Destination healthcare facility of shocked trauma patients in Scotland: Analysis of transfusion and surgical capability of receiving hospitals

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ABSTRACT

Aims: Haemorrhage is a leading cause of death from trauma. Management requires a combination of haemorrhage control and resuscitation which may incur significant surgical and transfusion utilisation. The aim of this study is to evaluate the resource provision of the destination hospital of Scottish trauma patients exhibiting evidence of pre-hospital shock.
Methods: Patients who sustained a traumatic injury between November 2008 and October 2010 were retrospectively identified from the Scottish Ambulance Service electronic patients record system. Patients with a systolic blood pressure less than 110 mmHg or if missing, a heart rate greater than 120 bpm, were considered in shock. The level of the destination healthcare facility was classified in terms of surgical and transfusion capability. Patients with and without shock were compared.
Results: There were 135 004 patients identified, 133 651 (99.0%) of whom had sustained blunt trauma, 68 411 (50.7%) were male and the median (IQR) age was 59 (46). There were 6721 (5.0%) patients with shock, with a similar age and gender distribution to non-shocked patients. Only 1332 (19.8%) of shocked patients were taken to facilities with full surgical capability, 5137 (76.4%) to hospitals with limited (general and orthopaedic surgery only) and 252 (3.7%) to hospitals with no surgical services. In terms of transfusion capability, 5556 (82.7%) shocked patients were admitted to facilities with full capability and 1165 (17.3%) to a hospital with minimal or no capability.
Conclusions: The majority of Scottish trauma patients are transported to a hospital with full transfusion capability, although the majority lack surgical sub-specialty representation.

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Introduction

Haemorrhage is the leading cause of potentially preventable death following traumatic injury[1–4] with torso haemorrhage identified as being particularly lethal.[5] Management of haemorrhage requires a parallel approach of haemorrhage control and concomitant resuscitation.[6] As traumatic injury rarely respects specialty boundaries, haemorrhage control may necessitate the involvement of multiple surgical specialties and interventional radiology. Furthermore, contemporary resuscitation strategies have seen a move towards the earlier use of balanced blood component transfusion[7,8] and the use of adjuncts such as tranexamic acid,[9,10] collectively termed damage control resuscitation.

In recognition of the complexities and resource requirements of trauma care, several countries have developed trauma systems which regionalise services in order to match capability with patient need.[11–14] This approach to trauma care has been shown to reduce mortality for over three decades[15] and is particularly well established in North America.[16,17] Historically, Britain has not had a similar framework for the delivery of trauma services, but recognition of the inadequacy of existing services has prompted a paradigm shift in health care policy in England, leading to a national system of regionalised trauma networks.[18–22]

At present, Scotland does not have a regionalised trauma system,[23] directing its ambulance service to transport patients to the nearest hospital emergency department. There are nearly 30 such hospitals in Scotland, but many are small and lack the resources required to manage major trauma, particularly those patients with haemorrhage. The aim of this study is to evaluate the resource provision of the destination hospital of Scottish trauma patients exhibiting evidence of pre-hospital shock.

Methods

This is a retrospective analysis of Scottish Ambulance Service (SAS) data using previously described methodology.[24,25] The SAS electronic patient record system is used to log details of incidents attended to, including the dispatch code, incident location, patient demographics, physiological parameters, a final diagnostic code, and the destination hospital. The initial dispatch code is generated by a caller interrogation system (MPDS, Medical Priority Dispatch System, Priority Dispatch Corp.™, Salt Lake City, Utah). A separate, final diagnostic code, using the same system, is subsequently recorded to accurately reflect patients' condition. The first component of the codes (also known as "protocol") indicates a broad category of emergency, and was used to extract data pertaining to incidents involving traumatic injury.

We included all attendances recorded as assaults (protocol 04), falls (protocol 17), penetrating injuries (protocol 27), traffic and transportation injuries (protocol 29), or other traumatic injuries (protocol 30) which occurred between 1 Nov 2008 and 31 Oct 2010. Final diagnostic MPDS codes were also used to define the mechanism of injury, with incidents recorded as protocol 27 coded as "penetrating mechanism of injury", and all other incidents as "blunt mechanism of injury". Children under the age of 16 were excluded, because the organisation of paediatric trauma care differs from that of adults, and because age-dependent variations in parameters such as heart rate and blood pressure make comparisons more difficult to perform. We also excluded episodes with missing location details. Other missing values were treated as missing, rather than replaced with normal or imputed values, or "0", and not included in subsequent numerical analyses.

For the purpose of this study, "shock" was defined as a systolic blood pressure (SBP) of less than 110 mmHg. This value, rather than the more conventional threshold of 90 mmHg, was chosen because two recently published, well-conducted studies have shown this level to be associated with an increased risk of mortality.[26–28] In the absence of a recorded blood pressure, a heart rate (HR) of 120 bpm was used as criteria, which is independently associated with hypotension.[28]

The rurality of incident locations was graded using the Scottish urban rural classification (SURC), using postcode look-up tables available from the Scottish Government.[29] SURC is a scale from one through eight where the lowest values are densely populated urban regions and the higher values are sparsely populated rural regions. The level of the destination healthcare facility was classified in terms of size and type of hospital (teaching hospital, large general hospital, general hospital and community hospital),[30] transfusion capability, and surgical capability. Transfusion capability was ascertained through personal knowledge of, or by contacting, the blood transfusion services at hospitals, and classified as "full" (red cell concentrate, plasma and platelets all available on site), "limited" (red cell concentrate and plasma available only), "minimal" (red cell concentrate available only) and "none" (all others) (Table 1). Surgical capability was ascertained through personal knowledge of hospitals, internet searches, or telephone enquiries, and similarly classified as "full" (general, vascular, cardiothoracic, orthopaedic and neurosurgery services all available on site), "limited", or "none". A "limited" capability was defined as the presence of a general surgical and orthopaedic service, which was deemed essential to the management of patients with haemorrhagic shock, but not a cardiothoracic or neurosurgical service. Some of these hospitals will also have vascular services on site.

Outcomes are presented as the number and proportion of incidents per SURC category, hospital type, transfusion capability and surgical capability.

Results

Between 1 Nov 2008 and 31 Oct 2010, 135 004 patients met the inclusion criteria. There were 68 411 (50.7%) male and 63 155 (46.8%) female patients. In terms of missing data, 3438 patients (2.5%) did not have gender and 8453 (6.3%) did not have their age recorded. The median age (interquartile range; IQR) for those with available data was 59 (46). SBP and HR was not recorded in 22 681 (16.8%) and 8775 (6.5%) patients respectively; with neither available in 8505 (6.3%). The vast majority of casualties had sustained injuries as a result of blunt trauma: 133 651 (99.0%).

There were 6721 patients (5.0%) who met the study criteria for "shock". Table 2 compares the demographic and

Table 1 – Transfusion and surgical capability of teaching, large general, and general hospitals in Scotland.

Type	Hospital	Transfusion capability	Surgical capability
Teaching	Aberdeen Royal Infirmary	Full	Full
	Edinburgh Royal Infirmary	Full	Full
	Gartnaval	Full	Limited
	Glasgow Royal Infirmary	Full	Limited
	Ninewells	Full	Limited
	Southern General (SGH)	Full	Limited
	Western General, Edinburgh	Full	Limited
	Western General Glasgow	Full	Limited
Large general	Ayr Hospital	Limited	Limited
	Borders General	Full	Limited
	Crosshouse Hospital	Full	Limited
	Dumfries & Galloway Royal Infirmary	Full	Limited
	Falkirk Royal Infirmary	Limited	Limited
	Forthvalley	Full	Limited
	Hairmyres, East Kilbride	Limited	Limited
	Inverclyde Royal Hospital	Full	Limited
	Monklands Hospital	Full	Limited
	Perth Royal Infirmary	Full	Limited
	Queen Margaret Hospital	Full	Limited
	Raigmore, Inverness	Full	Limited
	Royal Alexandra Hospital	Full	Limited
	St. John's at Howden	Full	Limited
	Stirling Royal Infirmary	Limited	Limited
	Stobhill, Glasgow	None	Limited
	Victoria Infirmary, Glasgow	Full	Limited
	Victoria Kirkcaldy	Full	Limited
	Wishaw General	Full	Limited
General	Arbroath Infirmary	None	None
	Arran War Memorial	Limited	None
	Balfour, Kirkwall	Limited	Limited
	Belford	Limited	Limited
	Caithness General	Limited	Limited
	Dr. Gray's, Elgin	Limited	Limited
	Galloway Community Hospital	Full	None
	Gilbert Bain, Lerwick	Limited	Limited
	Lorn & Islands District G.H.	None	None
	Mackinnon Memorial	Minimal	None
	Stracathro	None	None
	Vale of Leven, Alexandria	None	None
	Western Isles, Stornoway	Limited	Limited

physiological criteria of shocked and non-shocked patients. The gender and age distributions of the two groups were similar. Median SBP was lower in the shocked than the non-shocked group (103 mmHg (12) and 142 mmHg (32) respectively), but heart rate was similar (82 bpm (26) and 84 bpm (22) respectively). A greater proportion of shocked patients (1.7%) than non-shocked patients (0.9%) had suffered penetrating injuries.

Table 2 – Characteristics of shocked and non-shocked groups.

	Shocked	Non-shocked
n	6721	128 283
Male, *n* (%)	3311 (49.3%)	65 100 (50.7%)
Female, *n* (%)	3255 (48.4%)	59 900 (46.7%)
Age/years, median (IQR)	57 (46)	60 (46)
Systolic blood pressure/mmHg, median (IQR)	103 (12)	142 (32)
Heart rate/bpm, median (IQR)	82 (26)	84 (22)
Blunt mechanism of injury, *n* (%)	6610 (98.3%)	127 041 (99.1%)
Penetrating mechanism of injury, *n* (%)	111 (1.7%)	1242 (0.9%)

Table 3 shows the level of destination healthcare facility where patients were admitted. Of the shocked patients, 3652 (54.3%) were taken to a large general hospital, 2630 (39.1%) were taken to a teaching hospital, and the remainder (439, 6.5%) to a general or community hospital. This translated to 1332 (19.8%) of shocked patients being taken to a facility with full surgical capability, 5137 (76.4%) to a hospital with limited surgical capability, and 252 (3.7%) to a hospital with no surgical service. The majority of shocked patients, 5556 (82.7%), were taken to a hospital with full transfusion capability and 1165 (17.3%) to a hospital with limited, minimal or no transfusion capability.

There are differences when comparing shocked patients with penetrating and blunt trauma (Table 4). A greater proportion of shocked patients with penetrating (54.1%) than blunt trauma (38.9%) were admitted to a teaching hospital. This difference is probably largely accounted for by the larger

Table 3 – Destination healthcare facility and capability, by subgroup.

	Shocked ($n = 6721$)		Non-shocked ($n = 128\ 283$)	
	n	(%)	n	(%)
Hospital type				
Teaching	2630	(39.1)	50 119	(39.1)
Large general hospital	3652	(54.3)	68 570	(53.5)
General hospital	309	(4.6)	6637	(5.2)
Community hospital	130	(1.9)	2957	(2.3)
Surgical capability				
Full	1332	(19.8)	24 985	(19.5)
Limited	5137	(76.4)	98 013	(76.4)
None	252	(3.7)	5285	(4.1)
Transfusion capability				
Full	5556	(82.7)	102 469	(79.9)
Limited	852	(12.7)	19 475	(15.2)
Minimal	34	(0.5)	483	(0.4)
None	279	(4.2)	5856	(4.6)

proportion of shocked patients with blunt trauma (54.6%), compared with penetrating trauma (41.4%) who are admitted to a large general hospital. Similarly, 91.9% of shocked patients with penetrating trauma were taken to a hospital with full transfusion capability, compared with 82.5% of shocked blunt trauma patients. This is in contrast to destination surgical capability, where a greater proportion of shocked patients sustaining blunt trauma (compared to penetrating trauma), are taken to facilities with full surgical capability (19.9% versus 17.1%).

The geographical distribution of shocked trauma patients is uneven (Table 5). The vast majority of incidents involving shocked patients (76.8%) occur in urban areas (Scottish urban/rural classification category 1 and 2). This pattern persists when accounting for differences in population size: the incidence rate is higher in urban areas than in rural areas. This signal is also present for blunt trauma patients.

Table 4 – Destination healthcare facility, shocked patients, by mechanism of injury.

	Shocked, blunt trauma($n = 6610$)		Shocked, penetrating trauma($n = 111$)	
	n	(%)	n	(%)
Hospital type				
Teaching	2570	(38.9)	60	(54.1)
Large general hospital	3606	(54.6)	46	(41.4)
General hospital	305	(4.6)	4	(3.6)
Community hospital	129	(2.0)	1	(0.9)
Transfusion capability				
Full	5454	(82.5)	102	(91.9)
Limited	847	(12.8)	5	(4.5)
Minimal	33	(0.5)	1	(0.9)
None	276	(4.2)	3	(2.7)
Surgical capability				
Full	1313	(19.9)	19	(17.1)
Limited	5049	(76.4)	88	(79.3)
None	248	(3.8)	4	(3.6)

There are, however, differences in the proportion of shocked penetrating and blunt trauma patients within urban areas. In large urban areas (category 1), the proportion of incidents involving shocked patients who have suffered penetrating trauma is greater than that of incidents involving shocked patients who have suffered blunt trauma (66.7% and 44.3% respectively). This trend is reversed in other urban areas (category 2), where incidents involving shocked patients who suffered blunt injury predominate over those who have suffered penetrating injury (32.4% and 21.6% respectively).

Discussion

This study has examined a cohort of 135 004 Scottish Ambulance Service trauma patients and identified a 5% incidence of shock, based on a contemporary, evidence based definition. Comparison of the shocked and non-shocked groups demonstrates lower blood pressure in shocked than non-shocked patients, but similar heart rates. The latter result may be the consequence of missing data, but – perhaps more likely – reflects the poor correlation between blood pressure and heart rate. Although tachycardia is traditionally believed to be closely associated with hypotension, and is often listed as an important sign in the initial diagnosis of hemorrhagic shock, a recent, well-conducted study has shown that the correlation between heart rate and hypotension is poor.[28] The lack of difference in heart rate between the two groups is therefore of little practical significance.

The admission hospital type is similar between patients with and without shock demonstrating adherence to the current policy of admission to the nearest hospital emergency department. Over three quarters of patients are treated in a hospital without full surgical specialty representation, although the majority of these facilities can provide full transfusion capability. While the shocked group only constitutes 5% of the overall cohort, in absolute numbers, 5137 patients were admitted to facilities which may not be able to provide definitive haemorrhage control. More concerningly, 852 patients in shock were admitted to facilities without full transfusion capability and therefore unable to provide modern damage control resuscitation. In terms of urban–rural distribution, there was a preponderance of incidents occurring in urban regions; indeed, penetrating trauma occurred almost exclusively in an urban setting.

This paper extends the work of our group's earlier studies.[24,25] We have previously analysed Scottish ambulance service data and demonstrated an association with deprived and urban regions.[25] There was also a suggestion that many patients were admitted to hospitals which may not have the necessary capabilities, although this was not qualified. A subgroup analysis of patients with a reduced level of consciousness (defined as a GCS < 14) identified that only 13.8% of patients with a suspected traumatic brain injury were admitted to an institution with a neurosurgical capability.[24] Our current study reinforces the finding of urban trauma association while highlighting the mismatch been the surgical and transfusion capability of hospitals admitting patients at risk of haemorrhage.

The issue of Scottish trauma has been the subject of several recent reports.[31,32] The Scottish Trauma Audit Group

Table 5 – Distribution of shocked patients, by mechanism of injury, and rurality.

SURC	Population	All shocked patients, any mechanism($n = 6721$)			Shocked, blunt mechanism($n = 6610$)			Shocked, penetrating mechanism($n = 111$)		
		n	(%)	IR	n	(%)	IR	n	(%)	IR
1	2 031 397	2999	(44.6)	738	2925	(44.3)	720	74	(66.7)	18
2	1 597 963	2165	(32.2)	677	2141	(32.4)	670	24	(21.6)	8
3	443 879	400	(6.0)	451	397	(6.0)	447	3	(2.7)	3
4	135 775	170	(2.5)	626	168	(2.5)	619	2	(1.8)	7
5	62 665	77	(1.1)	614	75	(1.1)	598	2	(1.8)	16
6	605 764	595	(8.9)	491	591	(8.9)	488	4	(3.6)	3
7	177 551	160	(2.4)	451	158	(2.4)	445	2	(1.8)	6
8	161 885	145	(2.2)	448	145	(2.2)	448	0	(0.0)	0

SURC, Scottish urban/rural classification; IR, incidence rate/1 000 000 population/year.

audited 5045 trauma admissions during 2011 and performed a historic comparison with data from the previous decade.[31] Overall, there was moderate improvement in 30-day survival for all patients (1.1%, $p < 0.05$), but particularly so for major trauma (8.0%, $p < 0.05$). This was largely attributed to an increase in consultant led care, although 40% of major trauma patients still did not have their initial care led by a consultant. Unfortunately, cause of death was not reported as an outcome, therefore it is unclear where surgical or transfusion capability played a role in adverse outcomes.

Following the creation of trauma networks in England, the Royal College of Surgeons of Edinburgh convened a working group to examine Scottish trauma care planning.[31] Although their review pre-dated the most recent evidence from STAG and our group, they concluded that Scotland would likely benefit from a regionalisation of trauma care, similar to England.

This study suffers from a number of important limitations. The ambulance dataset was not designed as a research tool, but as an electronic patient record, and thus there may be inconsistencies in data recording. Furthermore, this systems generates final diagnostic codes based on the pre-hospital assessment rather than the final hospital diagnosis. There is also the risk that missing data may introduce bias. Specifically, one in six patients had a missing blood pressure, of which it is impossible to quantify the direction of bias, although the use of heart rate has reduced the number of excluded patients. Our classification of hospitals' surgical and transfusion capability was based on a combination of personal knowledge, internet searches, and telephone enquiries, and may be inaccurate. The existence of regional services further adds to the difficulty of classifying facilities. Finally, this evaluation does not include hospital outcomes data, to corroborate the findings; or injury severity scores, which require a complete list of injuries to calculate. There are linkage projects underway which may answer these questions in the future.

Conclusion

In aggregate, there is emerging evidence that Scotland has a measureable volume of trauma that has seen improvements in outcome in the recent decades. However, there is significant room for improvement in order to minimise the mismatch between the patients need and admission hospital capability. It is likely that further improvements this can only be achieved by the use of a regionalised trauma network as is currently being implemented in England.

Competing interests

None.

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