

# Outcomes of Multi-Trauma Road Traffic Crashes at a Tertiary Hospital in Oman

Does attendance by trauma surgeons versus non-trauma surgeons  
make a difference?

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## نتائج حالات الرضوح المتعدد في حوادث المرور

### في مستشفى ثالثي عمان

هل ثمة فرق بين حضور جراحي الرضوح وحضور غيرهم من الجراحين؟

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**ABSTRACT: Objectives:** Trauma surgeons are essential in hospital-based trauma care systems. However, there are limited data regarding the impact of their presence on the outcome of multi-trauma patients. This study aimed to assess the outcomes of multi-trauma road traffic crash (RTC) cases attended by trauma surgeons versus those attended by non-trauma surgeons at a tertiary hospital in Oman. **Methods:** This retrospective study was conducted in December 2015. A previously published cohort of 821 multi-trauma RTC patients admitted between January and December 2011 to the Sultan Qaboos University Hospital, Muscat, Oman, were reviewed for demographic, injury and hospitalisation data. In-hospital mortality constituted the main outcome, with admission to the intensive care unit, operative management, intubation and length of stay constituting secondary outcomes. **Results:** A total of 821 multi-trauma RTC cases were identified; of these, 60 (7.3%) were attended by trauma surgeons. There was no significant difference in mortality between the two groups ( $P = 0.35$ ). However, patients attended by trauma surgeons were significantly more likely to be intubated, admitted to the ICU and undergo operative interventions ( $P < 0.01$  each). The average length of hospital stay in both groups was similar (2.6 versus 2.8 days;  $P = 0.81$ ). **Conclusion:** No difference in mortality was observed between multi-trauma RTC patients attended by trauma surgeons in comparison to those cared for by non-trauma surgeons at a tertiary centre in Oman.

**Keywords:** Multiple Trauma; Resuscitation; Patient Outcome Assessment; Surgeons; Trauma Centers; Oman.

**المخلص: الهدف:** يعد وجود جراحي الرضوح أمرا لازما في المستشفيات التي بها أنظمة رعاية للرضوح. غير أنه لا تتوفر معلومات كافية عن مدى تأثير وجودهم على نتائج المرضى المصابين برضوح متعددة. وتهدف هذه الدراسة لتقويم نتائج حوادث المرور على الطرق التي يقوم عليها جراحو الرضوح مقارنة مع تلك التي يقوم عليها غيرهم من الجراحين في مستشفى ثالثي عمان. **الطريقة:** أجريت هذه الدراسة الإستيعادية في ديسمبر من عام 2015م، وتمت مراجعة المعلومات المخزنة الخاصة بالديمغرافيا والإصابة والاستشفاء لحالات 821 مريضا أدخلوا لمستشفى جامعة السلطان قابوس في مسقط عمان بين يناير وديسمبر 2011م. وكانت الوفاة في المستشفى هي النتيجة الرئيسية، أما النتائج الثانوية فكانت هي الإدخال في العناية المركزة، والعلاج الجراحي، والتنبيب، ومدة البقاء بالمستشفى. **النتائج:** بلغ عدد المصابين برضوح متعددة في حوادث المرور على الطرق في فترة الدراسة 821 مريضا، قام على رعاية 60 منهم (7.3%) جراحو رضوح. ولم يكن هنالك فرق إحصائي معنوي (معنوي) في معدل الوفاة بين هذه المجموعة وغيرها ( $P = 0.35$ ). إلا أن معدل المرضى الذين قام على رعايتهم جراحو الرضوح كانوا أكثر تنبيبا وإدخالاً للعناية المركزة وخضوعاً للتدخلات الجراحية من غيرهم ( $P < 0.01$  في كل حالة). ولم يكن هنالك فرق إحصائي معنوي في فترة البقاء في المستشفى بين المجموعتين (2.6 يوما في مقابل 2.8 يوما،  $P = 0.81$ ). **الخلاصة:** لم يكن هنالك فرق إحصائي معنوي في معدل الوفاة عند المصابين الذين قام على رعايتهم جراحو الرضوح مقارنة بالمصابين الذي قام على رعايتهم جراحو آخرين في مستشفى رعاية ثالثة بعمان.

**الكلمات المفتاحية:** رضوح متعدد؛ إنعاش؛ تقويم نتائج المرضى؛ الجراحون؛ مراكز الرضوح؛ عمان.

#### ADVANCES IN KNOWLEDGE

- In Oman, multi-trauma road traffic crash (RTC) cases attended by non-trauma surgeons were found to have similar outcomes to those cared for by trauma surgeons.

#### APPLICATION TO PATIENT CARE

- Many of the multi-trauma RTC cases in the current study were attended by non-trauma surgeons. As such, non-trauma surgeons in Oman should be trained in the management and resuscitation of multi-trauma patients in order to strengthen overall trauma care services in the country.

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**T**RAUMA INJURIES REPRESENT A SIGNIFICANT global burden, particularly in middle- and low-income countries; the World Health Organization (WHO) has estimated that approximately five million people die every year from injuries, most often due to road traffic crashes (RTCs), violence or burns.<sup>1</sup> The physical effects of such injuries can be classified as either immediate, secondary (i.e. within hours of the event) or delayed (i.e. long-term complications). Most trauma-related deaths occur either at the scene of the injury or *en route* to or within hours of arrival at a healthcare facility.<sup>1</sup> Therefore, pre-hospital and initial hospital-based trauma systems focus on reducing the immediate effects of injuries on mortality and morbidity by promptly providing essential life-saving trauma interventions, such as securing a patient's airway, maintaining adequate ventilation and controlling bleeding.<sup>1</sup> The WHO has advocated for the establishment of trauma care systems globally in order to mitigate the mortality and morbidity of trauma injuries.<sup>2</sup> Moreover, the American College of Surgeons recommend that trauma surgeons be present upon the initial arrival of a seriously injured patient to the emergency department.<sup>3</sup>

Oman has one of the highest rates of RTCs globally; in 2015, there were approximately 6,279 RTCs and this type of accident was the direct cause of 675 deaths and 3,624 injuries.<sup>4</sup> Moreover, the RTC-related fatality rate in 2013 was 30.4 per 100,000 people annually compared to the global yearly average of 18 per 100,000 people.<sup>5</sup> An increase in car ownership as a result of rapid modernisation and the development of new roads and highways due to urbanisation processes have contributed to a dramatic increase in RTCs.<sup>6-8</sup> Other complex behavioural issues related to modernisation, such as increased use of mobile phones while driving, may also be partially responsible for the high rate of RTCs in Oman.<sup>6,9</sup> In some cases, traffic enforcement and legal authorities have failed to keep up with rapid modernisation, resulting in more lenient and less than optimal law enforcement. The trauma system in Oman consists of a pre-hospital emergency system and the Emergency Medical Services (EMS) run by the Public Authority of Civil Defence and Ambulances.<sup>10,11</sup> Hospitals in Oman vary in size and resources, ranging from rural health centres staffed by junior non-specialist doctors to tertiary hospitals with qualified trauma and non-trauma surgeons.

The Sultan Qaboos University Hospital (SQUH) in Muscat is the only national tertiary hospital in the country which has board-certified trauma surgeons with training in trauma and critical and acute care surgeries, excluding emergency craniotomies.<sup>10,11</sup> At SQUH, the Emergency Department receives an average

of 900 trauma patients annually.<sup>11</sup> Trauma teams consist of a team leader (either a trauma or non-trauma surgeon), an anaesthetist, an emergency physician, residents in emergency or general surgery and allied health personnel. However, while some of the trauma teams are led by board-certified trauma surgeons, others are led by non-trauma surgeons for whom the scope of emergency procedures is limited to abdominal damage control. It is therefore not clear whether the presence of board-certified trauma surgeons affects the outcome of injured patients. This study aimed to assess differences in outcomes among multi-trauma patients injured in RTCs who were attended by board-certified trauma surgeons compared to those attended by non-trauma surgeons.

## Methods

This retrospective study took place in December 2015 and utilised the same cohort as that of a previously published study.<sup>11</sup> The electronic medical records of all RTC multi-trauma patients admitted to the Emergency Department of SQUH between January and December 2011 were reviewed. Data for all cases were collected, including the demographic characteristics of the patient and whether they were attended by a board-certified trauma surgeon or a non-trauma surgeon.<sup>11</sup> Additionally, information regarding patient outcome, length of hospital stay and injury details, severity and management was recorded.<sup>11</sup> The primary outcome was in-hospital mortality, with secondary outcomes constituting of admission to the Intensive Care Unit (ICU), surgical interventions and length of hospital stay.

Data were analysed using the Statistical Package for the Social Sciences (SPSS), Version 22.1 (IBM Corp., Armonk, New York, USA). Differences between variables were initially determined using a univariate analysis. For continuous variables, a Student's t-test or Mann-Whitney U test was used whereas a Yates' Chi-squared test or Fisher's exact test was used for categorical variables, as appropriate.<sup>12</sup> A *P* value of <0.05 was considered statistically significant. A general linear multivariate regression analysis was performed to determine if the primary and secondary outcomes were the same between the two groups, after controlling for variables with potential confounding effects, such as age, gender, ethnicity, time of injury, admissions over the weekend, triage status, Injury Severity Score (ISS) and the presence of a head injury. This study received ethical approval from the Ethics Committee of the Ministry of Health in Oman.

**Table 1:** Demographic and injury characteristics of multi-trauma road traffic crash cases admitted to the Sultan Qaboos University Hospital, Muscat, Oman (N = 821)

Characteristic	n (%)		P value
	Patients attended by trauma surgeons (n = 60)	Patients attended by non-trauma surgeons (n = 761)	
Mean age in years (range)	29.8 (1–67)	27.6 (2–79)	0.20
Male gender	51 (85.0)	521 (68.5)	0.01
Omani ethnicity	40 (66.7)	495 (65.0)	0.20
Admitted during the weekend	19 (31.7)	220 (28.9)	0.05
Transported to hospital by EMS	40 (66.7)	508 (66.8)	0.60
<b>Time of arrival to ED</b>			
12 a.m. to 7 a.m.	16 (26.7)	176 (23.1)	0.05
8 a.m. to 3 p.m.	21 (35.0)	193 (25.4)	0.04
4 p.m. to 11 p.m.	23 (38.3)	392 (51.5)	0.03
<b>Triage category</b>			<b>&lt;0.01</b>
Urgent	30 (50.0)	625 (82.1)	
Emergency	20 (33.3)	73 (9.6)	
Resuscitation	10 (16.7)	63 (8.3)	
<b>ISS</b>			<b>0.12</b>
0–15	53 (88.3)	665 (87.4)	
16–30	6 (10.0)	43 (5.7)	
31–75	1 (1.7)	53 (7.0)	
<b>Presence of a head injury</b>	<b>16 (26.7)</b>	<b>66 (8.7)</b>	<b>&lt;0.01</b>

EMS = Emergency Medical Services; ED = emergency department; ISS = Injury Severity Score.

## Results

A total of 821 multi-trauma RTC cases were admitted during the study period.<sup>11</sup> Of these, 60 (7.3%) were attended by trauma surgeons and 761 (92.7%) were attended by non-trauma surgeons. The average age of patients attended by trauma surgeons was similar to that of patients attended by non-trauma surgeons; however, significantly more of the trauma patients attended by trauma surgeons were male compared to those attended by other surgeons (85.0% versus 65.8%;  $P = 0.01$ ). A similar proportion of patients in both groups were of Omani ethnicity. Almost one-third of the patients in both groups were admitted to the hospital during weekends and approximately two-thirds were transported to the hospital by the EMS.

Patients admitted between 8 a.m. and 3 p.m. were significantly more likely to be attended by trauma surgeons (35.0% versus 25.4%;  $P = 0.04$ ) while those admitted between 4 p.m. and 11 p.m. were significantly more likely to be seen by non-trauma surgeons (51.5% versus 38.3%;  $P = 0.03$ ). In terms of triage status, significantly more patients in the ‘resuscitation’ (16.7% versus 8.3%) and ‘emergency’ (33.3% versus 9.6%) triage categories were attended by trauma surgeons ( $P < 0.01$ ) [Table 1].

The majority of cases in both groups had an ISS of 0–15. However, 26.7% of cases attended by trauma surgeons had head injuries compared to 8.7% of cases attended by non-trauma surgeons ( $P < 0.01$ ). Nevertheless, when patients with severe head injuries were compared using the Abbreviated Injury Score (AIS) for injuries of  $>3$  AIS severity, there was still no difference in outcome between the two groups. After controlling for potential confounders in the regression analysis, no significant differences were noted with regards to in-hospital mortality between patients attended by trauma surgeons and those attended by non-trauma surgeons ( $P = 0.35$ ), even when stratified by head trauma AIS or ISS scores ( $P = 0.42$  and  $0.50$ , respectively). In addition, no significant difference was observed with regards to the length of stay between the two groups (2.8 versus 2.6 days;  $P = 0.81$ ) However, patients attended by trauma surgeons were significantly more likely to be intubated (relative risk [RR]: 13.3; confidence interval [CI]: 7.76–22.7;  $P < 0.01$ ), admitted to the ICU (RR: 7.2; CI: 4.16–12.62;  $P < 0.01$ ) and undergo surgical interventions (RR: 3.5; CI: 2.64–5.48) [Table 2].

## Discussion

The burden of trauma in Oman has been steadily rising over the last few decades, thus highlighting the need for a well-established trauma system.<sup>6,11</sup> A well-resourced trauma system is known to improve mortality rates.<sup>13–17</sup> However, the trauma system in Oman has not kept pace with modernisation and rapid population growth in the country. Furthermore, a non-holistic approach has led to a lack of integration of trauma care services within the existing healthcare system; for example, as the pre-hospital trauma care system has developed faster than existing hospital systems, there can be a decline in care once the patient is transferred to a medical facility. At present, SQUH is the only facility in the country with qualified trauma surgeons who have undergone structured training. However, within established hospital trauma systems, it remains to be seen whether all trauma cases require

**Table 2:** Outcomes of multi-trauma road traffic crash cases admitted to the Sultan Qaboos University Hospital, Muscat, Oman (N = 821)

Outcome	n (%)		RR (CI)	P value
	Patients attended by trauma surgeons (n = 60)	Patients attended by non-trauma surgeons (n = 761)		
<b>Mortality</b>	2 (3.3)	49 (6.4)	0.5 (0.13–2.10)	0.35
Head injury AIS >3	1 (1.7)	24 (3.2)	0.2 (0.03–1.12)	0.42
ISS >15	1 (1.7)	40 (5.3)	0.2 (0.02–1.02)	0.50
<b>Intubation</b>	22 (37)	21 (2.8)	13.3 (7.76–22.7)	<0.01
Head injury AIS >3	10 (46)	1 (0.6)	76.6 (82.3–41.2)	<0.01
No TBI	12 (54)	20 (94)	0.7 (1.3–0.34)	0.56
<b>ICU admission</b>	16 (27)	28 (3.7)	7.2 (4.16–12.62)	<0.01
Head injury AIS >3	3 (15.8)	3 (1.2)	13.2 (17.3–4.9)	<0.01
No TBI	13 (84.2)	25 (98.8)	0.9 (1.9–0.43)	0.34
<b>Surgical interventions</b>	25 (41.7)	88 (11.8)	3.5 (2.64–5.48)	<0.01
<b>Transferred from hospital</b>	4 (6.7)	49 (6.4)	1.1 (0.39–2.77)	0.94
<b>Mean LOS in days (range)</b>	2.8 ± 5.4 (1–75)	2.6 ± 5.5 (1–83)	-	0.81

RR = relative risk; CI = confidence interval; AIS = Abbreviated Injury Score; ISS = Injury Severity Score; TBI = traumatic brain injury; ICU = intensive care unit; LOS = length of stay.

a trauma surgeon. In settings where a trauma system is still in its infancy, such as Oman, determining whether this factor affects outcomes can potentially guide policy-makers in the hiring of additional human resources, if necessary, and to anticipate training requirements.

In the current study, the outcomes of multi-trauma RTC patients attended by trauma surgeons were compared with those of patients cared for by non-trauma surgeons at SQUH. The primary practice of the non-trauma surgeons was elective general surgery and subspecialties other than trauma; however, they were all certified in the Advanced Trauma Life Support® (American College of Surgeons, Chicago, Illinois, USA) training course and were aware of the written resuscitative protocols for trauma care set by the hospital’s trauma committee. In addition, all non-trauma surgeons were included within the trauma case schedule and had a similar amount of exposure to trauma patients. No criteria currently exist at SQUH to decide which trauma patients should be attended by trauma surgeons; the presence of a trauma surgeon is instead determined by their call schedule, which covers a minimum of two days a week.

The findings of the present study indicated that multi-trauma RTC patients attended by trauma surgeons at SQUH had similar mortality rates to those cared for by non-trauma surgeons. In addition, the severity of injuries was similar between the two groups. These findings would suggest that—in

hospitals with established trauma systems—trauma patients may not always require a trauma surgeon, as this factor did not play a significant role in improving patient outcomes. However, an interesting finding of the present study was that trauma patients attended by trauma surgeons were significantly more likely to undergo surgical interventions than those attended by non-trauma surgeons. This finding is probably a reflection of the confidence of trauma surgeons in operative trauma management compared to a potentially more conservative approach among non-trauma surgeons.

The findings of the present study are in line with some of those reported in the literature. A recent study from a rural trauma centre in the USA similarly found no difference in the mortality rate of trauma patients attended by trauma surgeons versus those attended by other surgeons.<sup>18</sup> Podnos *et al.* also reported no difference in mortality among 1,427 patients at a level I trauma centre cared for either by trauma specialists or general surgeons.<sup>19</sup> However, other researchers have obtained different results; Haut *et al.* reported significantly better outcomes among patients with severe head injuries treated by full-time trauma surgeons compared to those cared for by part-time trauma surgeons.<sup>14</sup> In the present study, analysis of the outcomes of patients with head injuries did not indicate statistically significant differences. This finding may have been the result of grouping together all types of head injuries, including moderate head

injuries. In addition, no significant results were found when stratifying patients by ISS category.

Employing full-time surgeons dedicated exclusively to trauma surgery and surgical critical care, such as those employed in the setting described by Haut *et al.*, is not yet feasible in Oman.<sup>14</sup> Currently, there are no centres in Oman busy enough to support a surgical practice dedicated exclusively to trauma care; this could account for the differences in findings reported by this study. Moreover, it may be that the volume of multi-trauma patients seen by non-trauma surgeons at SQUH allows them sufficient opportunities to improve their skills to the level of that of specialised trauma surgeons. Indeed, Smith *et al.* have demonstrated an inverse relationship between patient volume and mortality rates at trauma centres in the USA.<sup>20</sup> Konvolinka *et al.* also affirmed that increased surgeon experience with seriously injured patients was associated with improved outcomes while Haut *et al.* reported that surgeons with vastly different levels of training could safely provide trauma care and obtain equivalent patient outcomes.<sup>15,21</sup>

Based on these findings, it seems that more emphasis should be placed on building a cohesive trauma system rather than focusing on capacity-building individual components within the system. As such, all components in a hospital trauma system require equal development to assure that a satisfactory level of trauma care is provided, including institutional policies governing clinical and operational processes, round-the-clock availability of a structured trauma team, a dedicated trauma admitting unit and adequate training and qualification standards for healthcare providers involved in trauma care and the provision of essential equipment and services. Education and the application of evidence-based protocols and guidelines should also be prioritised among non-trauma surgeons in Oman. Another important component is the expansion of the available pool of trauma surgeons; however, the extent to which this is needed remains debatable. Nevertheless, trauma surgeons may act as advocates for better trauma care at the national level.

The current study has several limitations which may have affected the results. First, the study design was retrospective and the cohort was from a single institution. Second, the Glasgow Coma Scale of the patients at admission was not assessed, thus precluding further analysis of patients with severe head injuries. This limitation was minimised as much as possible by stratifying outcomes based on AIS categorisation; nevertheless, patients with head injuries may still have significantly improved outcomes when cared for by trauma surgeons. Third, the low rate of penetrating trauma injuries in the present study population may

have resulted in a less defined outcome difference between the two groups. As such, it is possible that a more significant difference would have been evident had the study population been larger and included more severe trauma cases. A multicentre study is recommended for more accurate results. Finally, this study focused primarily on mortality and did not investigate morbidity, for which the presence of an attending trauma surgeon may potentially affect patient outcomes.

## Conclusion

No significant difference was noted in the mortality rates of multi-trauma RTC cases attended by trauma surgeons compared to those attended by non-trauma surgeons. These findings indicate that addressing only one component of a trauma system (i.e. the presence of trauma surgeons) is not sufficient to achieve better patient outcomes. As such, better outcomes for trauma patients in Oman may potentially be achievable by developing all components of a trauma system to ensure that it is both effective and cohesive.

## CONFLICT OF INTEREST

The authors declare no conflicts of interest.

## FUNDING

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