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A comparison of severely injured trauma patients admitted to level 1 trauma centres in Queensland and Germany

Johanna M. M. Nijboer,*† Martin E. Wullschleger,* Susan E. Nielsen,* Anitia M. McNamee,* Rolf Lefering,‡ Hendrik-Jan ten Duis† and Michael A. Schuetz*

*Department of Surgery – Trauma Service, Princess Alexandra Hospital, Brisbane, Australia

†Department of Surgery, University Medical Center Groningen, University of Groningen, the Netherlands

‡Trauma Registry of the German Society for Trauma Surgery (DGU), c/o Institute for Research in Operative Medicine, University Witten/Herdecke, Cologne, Germany

Key words
multiple trauma, outcome, trauma, trauma network, trauma registry.

Correspondence
Susan E. Nielsen, Department of Surgery – Trauma Service, Princess Alexandra Hospital, 199 Ipswich Road, Woolloongabba QLD 4102, Australia. Email: susan_nielsen@health.qld.gov.au

J. M. M. Nijboer MD; **M. E. Wullschleger** MD; **S. E. Nielsen** CNC; **A. M. McNamee** MD; **R. Lefering** PhD; **H. J. ten Duis** MD, PhD; **M. A. Schuetz** MD, PhD

Accepted for publication 4 March 2009.

doi: 10.1111/j.1445-2197.2010.05210.x

Abstract

Background: The allocation of a trauma network in Queensland is still in the developmental phase. In a search for indicators to improve trauma care both locally as state-wide, a study was carried out comparing trauma patients in Queensland to trauma patients in Germany, a country with 82.4 million inhabitants and a well-established trauma system.

Methods: Trauma patients ≥15 years of age, with an Injury Severity Score (ISS) ≥ 16 admitted to the Princess Alexandra Hospital (PAH) and to the 59 German hospitals participating in the Trauma Registry of the German Society for Trauma Surgery (DGU-G) during the year 2005 were retrospectively identified and analysed.

Results: Both cohorts are comparable when it comes to demographics and injury mechanism, but differ significantly in other important aspects. Striking is the low number of primary admitted patients in the PAH cohort: 58% versus 83% in the DGU-G cohort. PAH patients were less physiologically deranged and less severely injured: ISS 25.2 ± 9.9 versus 29.9 ± 13.1 ($P < 0.001$). Subsequently, they less often needed surgery (61% versus 79%), ICU admission (49% versus 92%) and had a lower mortality: 9.8% versus 17.9% of the DGU-G cohort.

Conclusions: Relevant differences were the low number of primary admissions, the lesser severity of injuries, and the low mortality of the patients treated at the PAH. These differences are likely to be interrelated and Queensland's size and suboptimal organization of trauma care may have played an important role.

Introduction

Trauma remains a major health and social problem in every part of the world. It constitutes the main cause of death in people between the ages of 1 and 35 years in Australia and Western Europe.[1] Possibly, a large percentage of deaths are needless and preventable if better treatment and prevention programs would be available. Queensland is known to have the highest incidence of trauma of all Australian states and is the most decentralized, with only 51% of its population located within Brisbane's metropolitan area.[2] Nevertheless, its trauma death rate is comparable to most other states (Table 1): 36.1 per 100 000 inhabitants in 2005. The three main causes were suicide, traffic incidents and accidental falls.[2]

Various initiatives have been undertaken to improve trauma care in Queensland, but the allocation of a trauma network and subsequent trauma centres is still in the developmental phase.[3] Because of the state's geographical size (1.7 million km^2), it has been divided into three zones (i.e. catchment areas) to facilitate the organization of medical care. Queensland's first recognized adult Major Trauma Service (comparable to a level 1 trauma centre), the Princess Alexandra Hospital (PAH) in Brisbane, constitutes the only adult tertiary referral hospital for the southern zone, with a geographical size of almost 375 000 km^2 and 1.8 million inhabitants.[2] When necessary, six local hospitals (Gold Coast Hospital, Ipswich Hospital, Logan Hospital, Mater Hospital, Redcliffe and Caboolture Hospitals, Toowoomba Hospital) can provide initial trauma care while awaiting the

Table 1 Death rate due to accidents and self-harm in Australia and Germany, year 2005

	Number of inhabitants (million)	Death rate*†
New South Wales	6.77	31.8
Victoria	5.02	34.5
Queensland	3.96	36.1
West Australia	2.01	34.9
South Australia	1.54	41.5
Tasmania	0.49	47.9
Northern Territory	0.20	83.3
Australian Capital Territory	0.33	34.6
Germany	82.44	35.7

*ICD 10 codes V01-X59, X60-X84 (assault excluded),
†per 100 000 inhabitants.
Source: The Australian Bureau of Statistics and World Health Organisation.

proper timing for transport to the PAH. Additionally, the PAH receives patients from the neighbouring state of New South Wales, given that the next closest level 1 trauma centre is 800 km to the south.

In a search for indicators to improve trauma care both locally as well as state-wide, we compared trauma patients admitted to the PAH to trauma patients admitted to a trauma centre in 'an area' of almost identical size as the PAH's catchment area, but with a well-established trauma system: the country of Germany, with 82.4 million inhabitants. In 2005, the trauma death rate was 35.7 per 100 000 inhabitants (Table 1).[1] The causes of death were comparable to Queensland. Its trauma system consists of approximately 90 level 1 trauma centres and numerous local hospitals, scattered over the country depending on the density of population. Besides the vast geographical differences, the pre-hospital rescue systems differ greatly as well. Queensland possesses four physician-staffed helicopters and numerous paramedic-staffed ambulances, in contrast to the German system that consists of 52 physician-staffed helicopters, almost 1000 physician-staffed ambulances and numerous paramedic-staffed ambulances.[4] In both Queensland and Germany, trauma care is performed according to the Advanced Trauma Life Support (ATLS) guidelines. Therefore, the indications for pre-hospital treatment (i.e. fluid replacement, intubation and ventilation, intercostal drainage) are similar. In-hospital treatment (i.e. indications for the transfusion of red blood cells, surgical procedures and admission to an Intensive Care Unit (ICU)) may vary slightly. One major difference lies in the resuscitation in the Emergency Department. In Queensland, this is performed by emergency physicians, whilst in Germany, this is performed by a trauma team lead by surgeons. These are general surgeons with an extensive experience in trauma care including fracture management. Therefore, the number of involved specialties, and subsequently doctors, is often lower than in Queensland.

This study analysed the trauma care of severely injured trauma patients, from the trauma scene to discharge from the hospital. To gain insight in the consequences of Queensland's geographic features and current design of trauma care on severely injured trauma patients, the following two questions were addressed: (i) In what way do the pre-hospital, in-hospital and injury characteristics differ in trauma patients admitted to the PAH and German trauma centres?; and (ii) Does a difference in outcome exist?

Methods

The study cohorts were retrospectively identified and extracted from the database of the Queensland Trauma Registry and the Trauma Registry of the German Society for Trauma Surgery (Traumaregister der Deutsche Gesellschaft für Unfallchirurgie (DGU).[5,6] The latter consists of 126 voluntary participating trauma centres in Germany, Switzerland, Austria, the Netherlands, Belgium and Slovenia. For this study, only data concerning the 59 German trauma centres that contributed patient data in 2005 were included.

Both databases contain all primary (transported directly to trauma centre from trauma scene) and secondary admitted (transported to trauma centre after admission to other hospitals) trauma patients of all ages, with an Injury Severity Score (ISS) ≥ 16 and positive signs of life on arrival at the trauma centre. One cohort was treated in the Princess Alexandra Hospital in Brisbane from January to December 2005 (PAH cohort). The second cohort consisted of patients treated in anyone of the German hospitals during the same time period (DGU-G cohort). No burn patients or patients <15 years of age are treated at the PAH and therefore not included in this study. The quality of data was enhanced by multiple plausibility checks implemented in the online data collection software of the DGU Trauma Registry. The same plausibility checks were performed within the PAH data set.

The collected patient data included gender, age, mechanism of injury, duration of pre-hospital phase and mode of transport, physiological parameters on arrival, diagnosis, ISS, Trauma and Injury Severity Score (TRISS), treatment, details on ICU stay, duration of in-hospital-stay and in-hospital mortality.[7] The ISS was based on the Abbreviated Injury Scale (AIS) codes for each body region.[8] An injury to a body region was considered severe in case of an assigned AIS severity score ≥ 3. Severe isolated head and neck injury was diagnosed in cases with an AIS severity score ≥ 3 concerning the head and neck region and an AIS severity score ≤ 1 for other regions.

Statistical analysis

Data was expressed as mean ± standard deviation (SD) or as median and interquartile range (IQR) in the case of a skewed distribution. Differences between groups were assessed with the Student's *t*-test or Mann-Whitney U test for data presented as means or medians, respectively. Differences in counts or percentages were evaluated with the chi-square test. Differences were considered significant for a two-tailed P value < 0.01. The significance level was set lower than usual because of multiple comparisons and the large sample size at least in one group. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) version 15 for Windows.

Results

Demographics

During 2005, 305 trauma patients with ISS ≥ 16 were admitted to the PAH (Table 2). In the same period, 2086 patients were admitted

Table 2 Demographics and pre-hospital characteristics

	PAH (*n* = 305)	DGU-G (*n* = 2086)	*P* value
Age (years, mean ± SD)	43.2 ± 20.6	45.1 ± 19.9	0.110
	n (%)	*n* (%)	
Age ≥60 years	66 (22)	565 (26)	0.044
Gender: male	233 (73)	1501 (72)	0.673
Trauma mechanism: blunt	284 (93)	2002 (96)	0.004
Cause of injury:			
Traffic	155 (51)	1224 (59)	0.002
Fall ≥3 m height	42 (14)	337 (16)	
Fall <3 m height	50 (16)	242 (12)	
Other	58 (19)	283 (14)	
During night hours (8 pm–6 am)	86 (32)	745 (36)	0.197
Primary admissions			
Number of patients	174 (57)	1730 (83)	<0.001
Time injury – arrival ED* (min, mean ± SD)	69 ± 45	72 ± 44	0.570
Secondary admissions			
Number of patients	131 (43)	356 (17)	<0.001
Arrival trauma centre <24 h	120 (92)	304 (85)	<0.001

*Quick's value is the PT expressed as a percentage of pooled normal plasma, with a normal range of 70–130%. This corresponds to a PT of 10–14.5 s.

Table 3 Psychological and blood parameters of PAH and DGU-G patients

	PAH (*n* = 305) Mean ± SD	DGU-G (*n* = 2086) Mean ± SD	*P* value
Glasgow Coma Scale on trauma scene	11.8 ± 4.2	10.6 ± 4.8	<0.001
Pre-hospital intubation (*n* (%))	70 (23)	1203 (58)	<0.001
On admission to trauma centre:			
Glasgow Coma Scale ≤8 (*n* (%))	83 (29)	772 (37)	<0.001
Systolic blood pressure (mm Hg)	132 ± 28	121 ± 32	<0.001
Systolic blood pressure <90 mm Hg (N (%))	15 (5)	292 (14)	<0.001
Respiratory rate (/min)	18.4 ± 7.7	13.3 ± 6.9	<0.001
Heart rate (/min)	88 ± 22	88 ± 21	0.846
Base excess	–4.4 ± 6.1	–3.9 ± 5.1	0.413
Temperature (°C)	36.3 ± 1.1	35.8 ± 1.3	<0.001
Haemoglobin (g/dl)	13.2 ± 2.0	11.6 ± 2.8	<0.001
Platelets (×1000/L)	231 ± 78	197 ± 79	<0.001
Quick's value (%)[1]	89.9 ± 22.6	78.0 ± 23.2	<0.001
Insertion intercostal drainage catheter (*n* (%))	42 (14)	419 (20)	<0.001

to the participating German trauma centres. The demographics of the cohorts were comparable: a mean age of 43 ± 21 years (PAH) and 45 ± 20 years (DGU-G), approximately one-quarter of both cohorts was 60 years or older, and three-quarters of all patients were male. The differences in trauma mechanism was not clinically relevant (Table 2). Ninety-three percent of the PAH cohort suffered blunt injury compared to 96% of the DGU-G cohort. Most patients sustained their injury in traffic or due to a fall: 51% and 30% (PAH) compared to 59% and 28% (DGU-G), respectively. In both cohorts, approximately one-third of injuries occurred during the night hours, from 8 pm to 6 am.

Data on pre-hospital phase and emergency department

In the PAH cohort, 57% of patients was directly referred to the PAH from the trauma scene. This is significantly lower than in the DGU-G cohort, where 83% were directly referred. The time between the trauma incident and arrival at the hospital of primary admitted patients was comparable; in both cohorts, it took approximately 70 min (PAH 69 ± 45 min; DGU-G 72 ± 44 min). However, the mode of transport differed: 7% of PAH patients were transported by air, compared to 40% of DGU-G patients. Unfortunately, no data on geographic distances between the trauma scene and hospital was available. Ninety-two percent of the secondary admitted PAH patients and 85% of the secondary admitted DGU-G patients arrived at the trauma centres within 24 h.

Upon arrival at the hospital, primary and secondary admitted PAH patients were significantly less severely physiological deranged than their DGU-G counterparts: blood pressure, respiratory rate and GCS were higher, numbers of mechanically ventilated patients and patients with intercostal drainage catheters were lower, and the average values of haemoglobin, platelets and coagulation tests were more within normal range (Table 3).

Injuries

According to the ISS, PAH patients were less severely injured than DGU-G patients: 25.2 ± 9.9 versus 29.9 ± 13.1 (Table 4). However, PAH patients more often suffered from severe head and neck injury:

Table 4 Injury severity score and injured body regions for PAH and DGU-G patients

	PAH (n = 305) n (%)	DGU-G (n = 2086) n (%)	P value
Injury Severity Score (mean ± SD)	25.2 ± 9.9	29.9 ± 13.1	<0.001
Severe injury (Abbreviated Injury Scale (AIS) ≥ 3) to:			
Head/neck	201 (66)	1175 (56)	0.002
AIS 3	33 (16)	202 (17)	
AIS 4	101 (50)	527 (45)	<0.001
AIS 5	66 (33)	404 (34)	
AIS 6	1 (1)	42 (4)	
Thorax	135 (44)	1250 (60)	<0.001
Abdomen	46 (15)	430 (21)	0.024
Extremities	72 (24)	774 (37)	<0.001

Table 5 In-hospital mortality analysis of PAH and DGU-G patients

	PAH (n = 305) n (%)	DGU-G (n = 2086) n (%)	P value
In-hospital mortality			
Total cohort	30 (9.8)	374 (17.9)	<0.001
Primary admitted patients	20 (11.5)	323 (18.7)	0.019
Secondary admitted patients	10 (7.7)	51 (14.3)	0.048
Trauma and Injury Severity Score analysis			
Number of cases included	152 (87)	969 (56)	
Observed mortality	19 (12.5)	177 (18.3)	
Expected mortality	14.1%	23.3%	
Standardized mortality ratio (95% CI)	0.89 (0.51–1.26)	0.79 (0.68–0.89)	
Non-survivors	30	374	
Time to death (h, median ± IQR)	23.7 (2.6–55.7)	24.2 (3.2–128.6)	0.897
Early mortality (<24 h)	16 (53.3)	188 (50.3)	0.747
Non-survivors			
Age (years, mean ± SD)	53.0 ± 25.1	54.1 ± 23.0	0.931
Gender: male	20 (67)	235 (63)	0.676
Injury Severity Score (mean ± SD)	30.8 ± 14.9	39.5 ± 17.8	0.007
Severe injury (Abbreviated Injury Scale ≥ 3) to:			
Head/neck	27 (90)	287 (77)	0.093
Chest	11 (37)	196 (52)	0.097
Abdomen	8 (27)	75 (20)	0.388
Extremity	5 (17)	130 (35)	0.043

66% versus 56%. A slight difference in distribution of AIS severity score of severe head and neck injuries was found. The PAH cohort scored AIS severity score ≥5 in 34% of the patients suffering from severe head and neck injury compared to 38% of their DGU-G counterparts. Severe *isolated* head and neck injury was diagnosed in respectively 34% and 16% of the cohorts ($P < 0.001$). PAH patients less often suffered from severe chest and extremity injuries (44% and 24%), compared to 60% and 37% of DGU-G patients, respectively.

Clinical course

PAH patients were less often operated on: 61% of the patients underwent one or more surgical procedures as compared to 79% of the DGU-G patients. PAH patients were less often admitted to the ICU (49% versus 92% of the DGU-G patients), and the length of ICU stay was shorter (7.6 ± 8.9 d versus 13.0 ± 13.6 d). Data on multiple organ failure, sepsis or other complications were unavailable for analysis. Fourteen percent of PAH patients received transfusion of red blood cells versus 28% of DGU-G patients, and the mean number of units given was 2.5 ± 1.5 versus 7.4 ± 7.5 in DGU-G patients. All these differences were highly significant ($P < 0.001$).

Outcome

The in-hospital mortality rate was significantly lower in the PAH cohort: 9.8% versus 17.9% in the DGU-G cohort (Table 5). Analysis of the mortality of primary and secondary patients separately, did not identify significant differences. The small number of PAH non-survivors only allowed for limited analysis. Over half of the in-hospital deaths occurred within 24 h after the trauma: 57.1% of the PAH non-survivors and 50.3% of the DGU-G non-survivors. The causes of death were unavailable for analysis. The mean age of the non-survivors (53–54 years) was about 10 years higher than the mean age of survivors in both cohorts. PAH non-survivors were less severely injured than DGU-G non-survivors according to the ISS (mean 30.8 ± 14.9 versus 39.5 ± 17.8), but the distribution of injuries did not differ significantly.

Additionally, TRISS analysis of primary admitted patients was performed. Only the data from 152 (87%) PAH and 969 (56%) DGU-G patients were available for this analysis. Results showed expected mortality rates of 14.1% of the PAH patients and 23.3% of the DGU-G patients. The observed mortality rates in these cohorts were 12.5% ($n = 19$) and 18.3% ($n = 177$), respectively. Combining observed and expected mortality resulted in a standardized mortality ratio of 0.89 (95% CI (0.51–1.26)) for the PAH patients and 0.79 (95% CI (0.68–0.89)) for their DGU-G counterparts. It means that the observed mortality is lower than the expected mortality in both cohorts.

The length of hospital stay (survivors only) was shorter in the PAH cohort: 23.2 ± 22.8 d versus 28.5 ± 33.4 d in the DGU-G cohort ($P < 0.001$). The discharge destinations differed significantly as well. The most interesting differences lied in the patients who went home after hospital discharge, or to a rehabilitation centre; 71% and 15% of the PAH survivors compared to 35% and 41% of the DGU-G survivors ($P < 0.001$), respectively.

Discussion

This study disclosed valuable insights in trauma care in Queensland. Relevant differences were the low number of primary admissions, the lesser severity of injuries and subsequent favourable condition and the low mortality of the PAH cohort. No differences in the quality of in-hospital trauma care were identified in this study.

Most striking is the difference in outcome, with the mortality of the PAH cohort almost being half of the DGU-G mortality. This finding requires careful evaluation. Both cohorts were comparable in demographics and injury mechanism but differ significantly in other important aspects: distribution of primary and secondary admissions, physiological derangement and injury patterns (especially head and neck injuries). Calculation of the expected mortality using the TRISS analysis adjusts for injury severity and physiological aspects and proved more valuable in this study.[7,9] The shortcoming of this method is the fact that the expected mortality rates are based on the TRISS score, which was derived from data of the 81 000 trauma patients included in the American Major Trauma Outcome Study almost 20 years ago, and should only be applied to primary admitted patients.[10] Nonetheless, both the PAH and the DGU-G showed a better outcome than expected. Unfortunately, data on pre-hospital deaths is unavailable for both Queensland and Germany. Taking Queensland's death rate into account, we assume that a considerable percentage of people died outside of the trauma centre; at the trauma scene, during transport or at a local hospital before referral to the PAH. There is no reason to believe that trauma incidents in Queensland are more severe and result in more immediate deaths than in Germany. Therefore, our assumption is in accordance with the findings by Rogers *et al.*, who concluded that non-survivors in a rural area without a formal trauma system are more likely to die at the scene due to longer discovery and transport times than urban non-survivors.[11] In 2005, the conditions may have been disadvantageous to the extent that not only the first peak (50%) of Trunkey's trimodal distribution of deaths after trauma occurred in the pre-hospital phase, but the second peak (30%, up to 4 h post-trauma) as well.[12]

The less deranged clinical condition of the PAH cohort remained noticeable all through the hospital stay: lower rates of intubation/ventilation, blood transfusions, ICU admissions (as well as shorter ICU stays), surgical interventions, shorter hospital stays and more favourable discharge destinations. The latter is additionally the result of a different organization of health care. Rehabilitation services are limited in Queensland and patients often rehabilitate whilst at home or in a local hospital, while German patients were transferred to a rehabilitation center.[3]

The low percentage of primary admissions is most likely the consequence of the fact that in 2005, in Queensland, patient triage protocols were not yet implemented. Instead of transporting the severely injured patients directly to the PAH for definitive treatment, they were more often first transported to a local hospital. The relatively short pre-hospital phase of primary patients may also be a reflection of this; possibly only patients from a relatively nearby trauma scene were directly transported to the PAH. Once again, the difficulty is the state's unparalleled vastness that makes developing adequate triage protocols no sinecure, as confirmed by a study performed in Western Australia.[13] Overseas evidence that bypassing local hospitals and directly referring severely injured patients to a level 1 trauma centre leads to a better outcome did not include areas as vast and remote as Queensland.[14–16] Further analysis should clarify this. A possible explanation for the relatively long pre-hospital phase of the DGU-G patients, despite relatively short distances, may be the frequent involvement of physicians and subsequently the delivery of high care to the trauma scene ('stay and play') instead of the 'scoop and run' tactics in previous decades. A similar trend of prolonged pre-hospital phases was seen in the United Kingdom and the Netherlands.[17,18]

Future prospects

In addition to the aforementioned results, Queensland's prospects are hopeful. In the early 2000s, it was recognized that improved coordination of trauma care could reduce the impact of injury on the community. To illustrate: an estimated 10% of the population suffers an injury in any given year, leading to an estimated cost of AUD$2.6 billion per annum. Ever since, there have been numerous initiatives that resulted in improved management of the trauma patient. A 5-year project to produce an evidence based approach to enhance trauma care in Queensland has culminated in the development of a trauma plan for Queensland, to which the Queensland government assigned AUD$30 million additional funding.[3] Among several strategies, it includes the development of a trauma network with trauma services based around three level 1 trauma centres for adults (PAH, Royal Brisbane Hospital, Townsville Hospital) and one level 1 trauma centre for children (Royal Children's Hospital in Brisbane). Additional main scopes of the trauma plan include injury prevention, research, education and the development of rehabilitation facilities. For quality control purposes, the Queensland Trauma Registry will be adjusted to facilitate statewide analysis of trauma care and will be used to review the effect of protocols, for example the in 2008 implemented bypass rules for the pre-hospital sector. This study showed that the consequences of Queensland's geographic features are even further-reaching than perhaps expected which makes the development of the trauma network even more challenging.

Limitations

Our study has several limitations, mostly due to its retrospection. In general, retrospective analyses from registries have a lower level of quality and completeness than data from clinical trials. Previous analysis showed that hospitals participating in the DGU Trauma Registry include approximately 90% of their suitable cases. Missing cases are usually due to organizational problems (i.e. the data collector being unavailable). The number of missing PAH cases is expected to be low but the exact number is unknown.

Only data regarding patients admitted to the trauma centres was analysed, no data was available on casualties that were not treated in the included facilities. Additionally, it would have been interesting to focus more on secondary referred patients or study outcome in relation to geographic distance from trauma scene to trauma centre. Unfortunately, no data was available on pre-hospital deaths, which would be quite helpful in the development of the trauma network. Another shortcoming is that some relevant items (e.g. cause of death, complications) could not be analysed because they had not been scored. Nonetheless, our data disclose valuable insights in severely injured trauma patients in Queensland's southern zone.

Conclusion

Numerous differences were identified between trauma (care) in Queensland and Germany. Relevant differences were the low number of primary admissions, the lesser severity of injuries and the low mortality of the patients treated at the Princess Alexandra Hospital. These differences are likely to be interrelated and Queensland's size and suboptimal organization of trauma care may have played an important role.

Acknowledgements

This study was supported by the Centre of National Research on Disability and Rehabilitation Medicine – Royal Australasian College of Surgeons Trauma Fellowship for 2007. Special thanks to Dr J. van Bastelaar for editing the manuscript. We thank Mr H. Sarai for his assistance with data collection.

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