Effective treatment at a Danish trauma centre

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ABSTRACT
INTRODUCTION: The trauma centre at Aarhus University Hospital, Denmark was established in 1999 and has continuously tried to improve its efficiency through regular training of personnel and auditing of selected trauma cases. The purpose of the present study was to assess the efficiency of the trauma teams to perform the initial evaluation using the time spent in the emergency room after arrival and the time to the first chest X-ray as measures for effectiveness.
MATERIAL AND METHODS: This was a prospective cohort study conducted from January 2000 to December 2008 and which included all trauma patients admitted to the hospital.
RESULTS: The results are based on 4,493 admissions, of which 1,102 patients (24%) had an injury severity score > 15. The median time spent in the trauma room was 50 minutes in 2000, which was steadily reduced throughout the period reaching a median time of 27 minutes in 2008 ($p < 0.0001$, Kruskal-Wallis test). The median time to the first chest X-ray was reduced from seven minutes in 2001 to five minutes in 2008 ($p < 0.024$, Kruskal-Wallis test).
CONCLUSION: Utilisation of a standardised protocol for initial evaluation and treatment of trauma patients and continuous training of trauma teams may considered some of the main factors responsible for these findings.
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The four regional trauma centres in Denmark are of recent origin and together they serve a population of approximately 5.5 million inhabitants. Aarhus University Hospital (AUH), Aarhus, Denmark is the trauma hospital of 350,000 inhabitants and the referral trauma centre for a region comprising 1.2 million inhabitants. The trauma centre was formally established in 1999 with organised trauma teams and an initial patient evaluation and treatment that follow advanced trauma life support (ATLS) guidelines [1]. Since its opening, the trauma centre has acquired experience through more than 5,500 calls.

Historical experience has shown that time is an important factor for the survival of trauma victims [2]. Santy reported that the mortality of injured individuals in World War I was only 10% when treatment took place within one hour after the injury, but increased to 75% when treatment was delayed eight hours or more [3]. More recent studies have indicated that the time required to complete the primary survey of trauma patients in a trauma centre is directly related to patient outcome [4]. The time spent in the trauma room after admission is therefore a key parameter for survival. Diagnostic imaging is an important part of the initial evaluation of trauma patients because swift answers are essential to subsequent treatment [5]. Given this background, it is essential to have an effective primary set-up in a hospital when a severely injured patient arrives to perform a quick initial evaluation and achieve damage control [6].

The purpose of the present study was to assess the efficiency of the trauma teams with regard to the initial evaluation using the overall time spent in the emergency room after arrival and the time to the first chest X-ray as measures of effectiveness.

MATERIAL AND METHODS

The study was a prospective cohort study including all patients admitted to the regional trauma centre at AUH during the time period from January 2000 to December 2008. The composition of the trauma teams was kept constant throughout the study period. Trauma teams had the following members: a specialist of orthopaedic surgery, who headed the team, a specialist of anaesthesiology, a nurse specialized in anaesthesiology, a nurse from the emergency department, a laboratory technician, a radiographer and two support staff. All teams

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followed a standardised protocol describing the theoretical and practical methodology for resuscitation and clinical evaluation with a primary and a secondary survey in accordance with the ATLS system [1]. Teams can be activated directly from the scene of the accident to ensure that they are present when the patient arrives in hospital. The organisation and the protocol used underwent no important modifications during the study. Trauma team training and auditing of individual trauma cases are organised at regular intervals throughout the year to keep all involved personnel updated and to retain a high level of effective communication and coordination of tasks.

We used the following processing times as surrogate end-points for the efficacy of a trauma team:

– The overall processing time: the time elapsed (in minutes) from arrival in the trauma room until the patient left the room for diagnostic evaluation by means of computed tomography (CT), immediate surgical treatment in the operating room (registered since 1 January 2000) or transport to the intensive care unit.
– The time (in minutes) between arrival in the trauma room and the hour indicated on the first chest X-ray (registration started 1 January 2001).

The time usage is routinely registered for all trauma patients using a single watch located in the trauma room. The watch automatically synchronises with the atomic clock in Frankfurt, Germany.

All injuries were scored according to the Abbreviated Injury Scale (AIS) using the 1998 version (AIS98) [7].

Statistical evaluation

Data not normally distributed were summarised using their median and interquartile range (IQR) (the 25th-75th percentiles). All processing time differences between study years were tested with the Kruskal-Wallis test and one-way ANOVA for both the overall processing time and for the time elapsed until the first chest X-ray was performed. The data were evaluated statistically using STATA 9.0 with a level of significance of $p < 0.05$.

Trial registration: not relevant.

RESULTS

Consecutive data were available from 4,493 admissions to the trauma centre between 2000 and 2008. A total of 548 patients were referred from other hospitals after primary resuscitation there, and the annual proportion varied between 3.1% and 16% ($p < 0.001$). **Table 1** presents the annual sex and age distributions and the total number of patients arriving at the trauma centre during the study period. A total of 3,027 patients were male and 1466 were female, and the median patient age was 31 (IQR 20-48) years for the cohort as a whole. There were no statistically significant differences between the patients in terms of sex or age distribution during the study period. The total number of patients arriving varied from 259 in the year 2000 to 597 in 2008, with a maximum of 637 in 2004. The median time spent in the trauma room per patient during the entire observation period was 33 (IQR 24-48) min. for the group as a whole, 30 (IQR 21-42) min. and 34 (IQR 24-49) min., respectively, for patients referred from other hospitals and for primarily admitted patients. Overall, 1,102 patients (24.5%) had an Injury Severity Score (ISS) > 15 with an annual variation ranging from 31.2% in 2000 to 22.3% in 2008 ($p < 0.001$); 350 of these patients (7.8%) were referred from other hospitals (Table 1).

Figure 1 shows a box plot of the overall processing

TABLE 1

The total number of patients, sex distribution, median age, number of patients with ISS > 15, number of patients with penetrating trauma and number of patients referred by other hospitals, arriving to the Trauma Centre at Aarhus University Hospital every year between 2000 and 2008.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	p-value, Pearsons χ^2 test
Patients, n	259	270	451	580	637	594	547	558	597	
Gender, n (%)[a]										0.187
Male	168 (64.9)	187 (69.3)	316 (70.1)	403 (69.5)	402 (63.1)	413 (69.5)	367 (67)	379 (67.5)	392 (65.7)	
Female	91 (35.1)	83 (30.7)	135 (29.9)	177 (30.5)	235 (36.9)	181(30.5)	180 (33)	179 (32.5)	205 (34.3)	
Median age, years	29	30	30	32	30	31	31	32	32	0.982
Patients with an ISS > 15, n (%)[a]	81 (31.2)	61 (22.6)	144 (31.9)	176 (30.3)	149 (23.3)	116 (18.5)	106 (19.4)	136 (24.4)	133 (22.3)	< 0.001
Patients with penetrating trauma, n (%)[a]	16 (6.1)	14 (5.2)	11 (2.4)	12 (2.1)	22 (3.5)	14 (2.4)	16 (2.9)	9 (1.6)	19 (3.2)	< 0.001
Patients referred by other hospital, n (%)[a]	10 (3.9)	8 (3.0)	92 (20.4)	87 (15.0)	79 (12.4)	72 (12.1)	57 (10.4)	63 (11.3)	80 (13.4)	< 0.001
Patients referred by other hospital with an ISS > 15, n (%)[a]	8 (3.1)	2 (0.7)	72 (16.0)	64 (11.0)	56 (8.8)	41 (6.9)	33 (6.0)	39 (7.0)	35 (5.9)	< 0.001

ISS = Injury Severity Score.
a) Percentage of year total.

times from arrival in the trauma room to departure for CT evaluation or treatment each year for all patients irrespective of their ISS. The median time spent was 50 (IQR 35-65) min. in the year 2000 and time was steadily reduced through each of the following years to a median of 27 (IQR 20-37) min. in 2008 ($p < 0.0001$, Kruskal-Wallis test). For patients with an ISS > 15, the overall annual processing times were also significantly reduced from 50 (IQR 35-72) min. in the year 2000 to 28 (IQR 21-40) min. in 2008 ($p < 0.0001$, Kruskal-Wallis test). In 2001, the median time elapsed from arrival in the trauma room until performance of the first chest X-ray was 7 (IQR 4-10) min. for all patients irrespective of ISS; it was reduced to 5 (IQR 4-8) min. in 2008 ($p < 0.0001$, Kruskal-Wallis test) (**Figure 2**). For patients with an ISS > 15, the median time elapsed from arrival in the trauma room until performance of the first chest X-ray was reduced from 6 (IQR 4-8.5) min. in 2001 to 5 (IQR 3-8) min. in 2008 ($p < 0.024$, Kruskal-Wallis test).

DISCUSSION

This study demonstrated that the time intervals from arrival in the trauma room until CT or other treatment and the time elapsed from arrival until the first chest X-ray were significantly reduced with a tendency to decrease constantly over the entire study period independently of trauma severity. We regard these time intervals as surrogate endpoints for efficiency and our interpretation of these findings is therefore that practice does increase efficiency in trauma resuscitation. We believe that the internal validity of the results is high, as the variables we have chosen to represent processing times and effectiveness of the trauma resuscitation were registered routinely whenever a trauma patient entered the trauma centre. However, the purpose of the study was not to identify specific factors responsible for the increased efficiency, but simply to note that it has been possible to influence a key variable in trauma resuscitation.

During the nine-year study period, the overall time consumption was cut by half from a median of 50 min. in 2000 to 27 min. in 2008. The reduction in processing time was also observed in cases with an ISS > 15, which would be expected to require more time resources. Driscoll observed similar process times as those observed in our study in two Level 1 trauma centres in North America and two in South Africa, with time intervals between 15 min. and 102 min. spent in the resuscitation room in his study [4]. Driscoll observed that the fastest unit also had the largest trauma team; however, when correcting for other co-variables, he found that differences in time between the centres could not be explained by either the number of team members or the seniority of the members. Driscoll stated that if a team is inefficient, it remains inefficient when more staff is added. However, a retrospective study from a teaching hospital and a Level 1 trauma centre in Vancouver concluded that implementation of trauma teams had only minimal effect on the time spent for the initial assessment in the trauma room [8].

It is difficult to point out specific factors that have made the processes in the trauma room more effective. Trauma resuscitation must be considered a complex

FIGURE 1

Box-and-whisker plot showing the overall processing times spent every year during the study period from arrival in the trauma room until the patient left for further diagnostic evaluation and treatment. Median (line in box), quartiles (box), 95% of observations (whiskers).

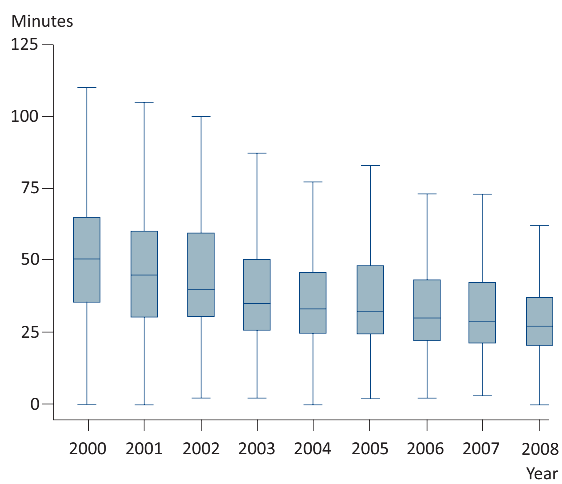
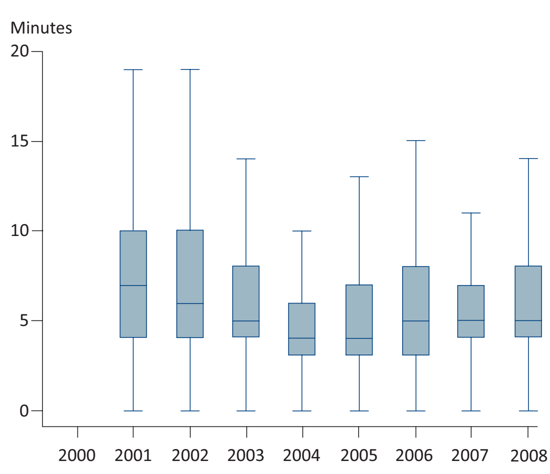


FIGURE 2

Box-and-whisker plot showing the time spent every year during the study period from arrival in the trauma room until the first chest X-ray was performed. Median (line in box), quartiles (box), 95% of observations (whiskers).



process with many contingency factors. Every time a new patient arrives, a new trauma team is constituted. The skills and technology needed and the available resources may differ from case to case, and what works best in one situation may be detrimental in another. If we affect one single component in the process or change the organization, we cannot predict the outcome. Of course this does not mean that we cannot change anything within the organization; it means that we must be cautious not to draw exceedingly rigid conclusions. However, we can conclude from this study that it has been possible to continuously make improvements, and we may not yet have reached the upper limit of possible improvements.

Yun et al studied a Level 1 trauma centre in the United States from a contingency viewpoint and observed that the quality of leadership influenced team effectiveness and varied depending on the situation and goal [9]. In the less severe trauma cases and when team experience was high, empowering leadership was most effective; however, direct leadership was most efficient in severe cases and with an inexperienced trauma team. These observations may also explain the difference in effectiveness and the above mentioned findings by Driscoll [8].

Our results demonstrate that we were able to significantly reduce the processing times in severe cases with an ISS above 15 as well as in less-severe cases, which is somewhat controversial compared with other reports. One explanation for this could be that our trauma team leader is always an orthopedic surgeon, and that there is also always a specialist in anaesthesiology on the team.

This standard representation of experienced specialists probably renders the team capable of solving even complex tasks as routine matters and therefore there is no great need for direct leadership. These observations are consistent with theories and experiences from the organization theory by Mintzberg, who has shown that complex tasks are performed most efficiently when standardized [10].

Wurmb et al also measured the time required for resuscitation and total stay in the trauma room as markers of trauma team performance before and after the introduction of standardized processes in trauma treatment [11]. After implementation of the system, a significant reduction in resuscitation time was observed and total time spent in the trauma room was also reduced. Similarly to our study, it was difficult to point out one specific factor that resulted in faster processing times, even though it was possible to determine that organizational factors are important.

In recent years, there has been more focus on damage control with staged surgical procedures, protocols for transfusion strategy, prevention of acidosis, hypothermia and coagulopathy. Damage control starts in the prehospital setting and continues in the trauma room. The indication and the extent of damage control in the trauma room can vary between trauma centres, which can be attributed to the lack of consensus and the relatively few studies documenting efficacy [12].

During the observational period of the present study, we saw an increased use of damage control surgery in the form of pelvic packing, thoracotomy, labarotomy and external fracture fixation in our trauma room. However, in the study the time spent on damage control procedures is also included in the overall processing times, which tends to prolong the patient's stay in the trauma room and thus enhances the conclusion that we saw an increasing efficacy through the entire study period.

The focus on only two processing times is a potential weakness of this study because these two variables are not necessarily representative of how quickly all processes in trauma resuscitation are performed. It is not simple processes that create the overall result, but rather a series of processes. However, we strongly believe that a 50% overall reduction in process time can be correlated with increased efficiency overall. Our material is based on more than 4,000 arrivals over a period of nine years, which increased the strength of our observations.

Although we have demonstrated that standard procedures and team training seem to improve trauma team efficiency, the specific impact on patient survival remains controversial [13, 14]. We still have no clear evidence of what works, and ethical controversies may limit the opportunity to conduct randomised trials. However, these factors should not stop us from continuing to challenge, refine, and evaluate the sub-processes of trauma receipt, which should be regarded as a constant dynamic process. Only in this way can we challenge the limits of what is possible.

CONCLUSION

We have observed a significant reduction in the time spent on resuscitation after the patient's arrival in the trauma room in the nine-year time period from 2000 to 2008. Utilisation of a standardised protocol for initial evaluation and treatment of trauma patients, continuous training of trauma teams and regular auditing of individual trauma cases may be considered some of the main factors responsible for this finding.

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LITERATURE

1. Resources for optimal care of the injured patient. Chicago: American College of Surgeons Committee on Trauma, 2006.
2. Tscherne H, Kalbe PM. Pre-hospital care of the polytrauma patient. The role of the physician. In: Border J, Allgöwer M, Hansen SJ et al, eds. Blunt multiple trauma. Comprehensive pathophysiology and care. New York: Marcel Dekker Inc., 1990:295-309.
3. Santy PMM. Da Shock Tramatique dans les blessures de Guerre. Analysis d'observations. Bull Med Soc Chir 1918;44:205.
4. Driscoll PA, Vincent CA. Variation in trauma resuscitation and its effect on patient outcome. Injury 1992;23:111-5.
5. Ewertsen C, Hansen KL, Nielsen MB. Aspects of imaging modalities in relation to damage control surgery. Ugeskr Læger 2011;173:1267-70.
6. Larsen MS. Orthopedic surgical aspects of damage control surgery. Ugeskr Læger 2011;173:1273-6.
7. The Abbreviated Injury Scale 1990 revision – update 98. Barrington, Illinois: Association for the Advancement of Automotive Medicine, 1998.
8. Dodek P, Herrick R, Phang PT. Initial management of trauma by a trauma team: effect on timeliness of care in a teaching hospital. Am J Med Qual 2000;15:3-8.
9. Yun S, Faraj S, Sims HP Jr. Contingent leadership and effectiveness of trauma resuscitation teams. J Appl Psychol 2005;90:1288-96.
10. Mintzberg H. Structure in fives: designing effective organizations. Englewood Cliffs, New Jersey: Prentice-Hall International, 1983.
11. Wurmb TE, Fruhwald P, Knuepffer J et al. Application of standard operating procedures accelerates the process of trauma care in patients with multiple injuries. Eur J Emerg Med 2008;15:311-7.
12. Steinmetz J. Anaesthesiological considerations in damage control surgery. Ugeskr Læger 2011;173:1276-9.
13. Gross T, Messmer P, Amsler F et al. Impact of a multifunctional image-guided therapy suite on emergency multiple trauma care. Br J Surg 2010;97:118-27.
14. Rainer TH, Cheung NK, Yeung JH et al. Do trauma teams make a difference? A single centre registry study. Resuscitation 2007;73:374-81.