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Severely injured patients benefit from in-house attending trauma surgeons

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ABSTRACT

Introduction: There is continuous drive to optimize healthcare for the most severely injured patients. Although still under debate, a possible measure is to provide 24/7 in-house (IH) coverage by trauma surgeons. The aim of this study was to compare process-related outcomes for severely injured patients before and after transition of attendance policy from an out-of-hospital (OH) on-call attending trauma surgeon to an in-house attending trauma surgeon.
Methods: Retrospective before-and-after study using prospectively gathered data in a Level 1 Trauma Center in the Netherlands. All trauma patients with an Injury Severity Score (ISS) >24 presenting to the emergency department for trauma before (2011–2012) and after (2014–2016) introduction of IH attendings were included. Primary outcome measures were the process-related outcomes Emergency Department length of stay (ED-LOS) and time to first intervention.
Results: After implementation of IH trauma surgeons, ED-LOS decreased ($p = 0.009$). Time from the ED to the intensive care unit (ICU) for patients directly transferred to the ICU was significantly shorter with more than doubling of the percentage of patients that reached the ICU within an hour. The percentage of patients undergoing emergency surgery within 30 min nearly doubled as well, with a larger amount of patients undergoing CT imaging before emergency surgery.
Conclusions: Introduction of a 24/7 in-house attending trauma surgeon led to improved process-related outcomes for the most severely injured patients. There is clear benefit of continuous presence of physicians with sufficient experience in trauma care in hospitals treating large numbers of severely injured patients.

Introduction

Improved outcomes for severely injured patients treated at designated trauma centers within an inclusive trauma system are well established [1–3]. One of the cornerstones of designated trauma centers has been timely involvement of trauma surgeons in the management of severely injured patients. With ongoing centralization of patients and further differentiation of hospitals, the question arises if trauma surgeons should be in house at all times in centers treating severely injured patients. However, there is ongoing debate regarding the value of such an in-house (IH) attending trauma surgeon [4–6].

In several Level 1 Trauma Centers, an IH attending trauma surgeon is available 24/7, whereas other institutions maintain an out-of-hospital (OH) on-call attending schedule with a reasonable response time [7,8]. In practice, OH on-call attending schedule means that a (senior) resident may serve as an in-house surgeon, while the attending surgeon participates in all major therapeutic decision-making and attends surgical procedures when needed.

Several studies have examined the effects of IH attending surgeons on process- and patient-related outcomes. On one side,

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there are studies that provide arguments that an IH attending improves efficiency of processes, such as faster decision-making, fewer errors, decrease of time to disposition and reduction in preventable deaths [6,9–11]. On the other side, there is no true consensus on the added value of 24/7 presence of an attending trauma surgeon in terms of overall mortality or hospital length of stay [12,13]. These latter outcomes are subject to the efficiency of the complete trauma care chain. Thus, when attempting to optimize the resuscitation process by introducing IH trauma surgeons, focus should be on process-related outcomes for this specific part of the chain. As stated by Durham et al, aggregate statistics and the use of surrogate markers to determine outcomes may not accurately portray the impact of attending surgeons on the quality of care [6].

Recently, an IH attending schedule with two experienced trauma surgeons available 24/7 has been introduced in our hospital. The aim of the present study was to compare process-relatedoutcomes before and after the introduction of an institutional IH attending trauma surgeon schedule in a single large volume Level 1 Trauma Center in the Netherlands.

Methods

The University Medical Center of Utrecht is a Joint Commission International (JCI) accredited tertiary care facility with 1000 beds. Our hospital complies with all requirements as defined by the American College of Surgeons' Committee on Trauma (ACS-COT) for a Level 1 Trauma Center with the CT scan located nearby the Emergency Department (ED), thus not in the resuscitation bay [7]. Trauma team composition and tasks in our institution are described in detail by Kreb et al [14]. In July 2013, a shift from an out-of-hospital (OH) on-call to an in-house (IH) schedule for attending trauma surgeons took place. Before this change, trauma surgeons were available for consultation on-call with a senior resident in general surgery acting as house officer. Trauma surgeons were present during daytime trauma team activations and a selected amount of 'off hours' presentations. After July 2013, there was continuous presence of an IH trauma surgeon together with a resident of no specified level of experience (varying from junior to senior residents in general surgery). In case of a trauma team activation, this IH trauma surgeon was present at the bedside upon presentation of the patient. In addition, a second trauma surgeon was available on-call to perform or assist in surgical procedures or lead resuscitation at the ED if multiple victims arrived simultaneously. Hence, two trauma surgeons were present during surgery if needed. In the Dutch trauma model, trauma surgeons perform surgical procedures for both truncal (i.e. visceral) and extremity (i.e. osseous, including pelvic) injuries, but do not perform vascular reconstructions [15]. There were no other major changes after implementation of the in-house schedule (especially the location of the CT scan and operating room (OR) remained similar) except for 24/7 availability of an ICU bed for trauma patients, even in case of severe bed shortage, from the second year in the IH period onwards.

Study design and participants

After a waiver for approval by our institutional review board was achieved, we conducted a retrospective before-and-after study using prospectively gathered data from the Dutch National Trauma Database (DNTD) and the local emergency department, radiology, operating theatre and hospital logistics databases. Data embedded in these databases were prospectively gathered as required for national and local quality improvement programs. All severely injured patients presented to the ED with pre-notification of trauma between August 2011 (introduction of new electronic patient documentation system) and December 2012 and from January 2014 through December 2016 were included in the study. Patients presenting six months prior to or six months after the transition to the IH schedule (June 2013) were excluded to minimize possible effects of anticipation on and first implementation of the new schedule. Severely injured patients were defined as patients presenting with trauma resulting in Injury Severity Scores (ISS) >24 only, as we hypothesized that this group would benefit most from the new management model [16]. Children were enrolled in this cohort as well, since the same surgical trauma team performed the initial assessment of both adult and pediatric patients. Eligible patients were divided into two groups based on

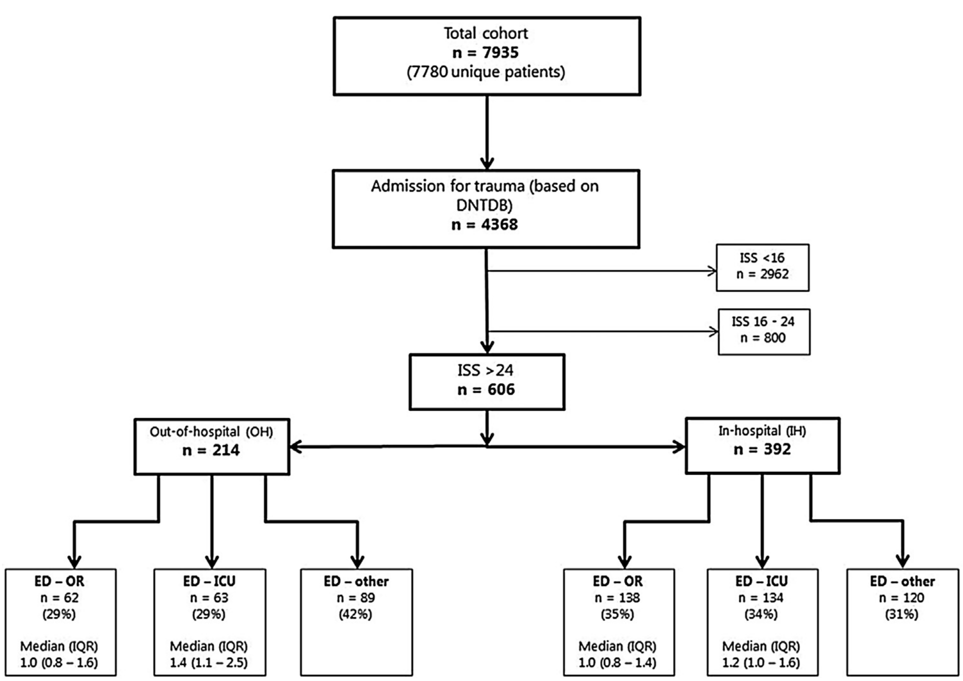

Fig. 1. Flowchart of cohort.

their dates of presentation; one group of patients who presented before the introduction of the IH system (2011–2012) and one group who suffered trauma in the time period after the introduction of the IH system (2014–2016).

Outcome measures and explanatory variables

The process-related outcomes were duration of emergency department length of stay (ED-LOS) and time to first intervention. ED-LOS was calculated utilizing ED arrival- and departure times as registered by ED staff members, which included finishing administration. Time to first intervention was based on emergency department disposition and categorized into the time between arrival at the ED and arrival at the CT scan, the operating room (OR) or the ICU. Secondly, we assessed in-hospital mortality, hospital length of stay (H-LOS), ED disposition, ICU admission and time to surgical procedures performed within 24 h. Demographic and explanatory variables were extracted from the databases. Stability of trauma was defined according to triage by ED nurses. Triage color was scored based on the Emergency Severity Index and ranges from red to green, with red demanding immediate intervention and green indicating a low level of emergency [17]. Emergency surgeries, defined as any surgical procedure performed directly after ED departure, were categorized into anatomical region and level of emergency. Surgical emergency procedures included laparotomies, thoracotomies, pelvic packing and emergent vascular procedures, neurosurgical emergency procedures comprised all types of neurosurgical interventions (e.g. trepanation), orthopedic emergency procedures included fasciotomies and stabilization of the vertebral column, major pelvic and long-bone fractures, non-emergent orthopedic procedures consisted of stabilization of minor fractures and other non-emergent procedures encompassed all other procedures for non-life threatening conditions (e.g. wound treatments, oral and maxillofacial procedures).

Statistical analyses

Categorical and dichotomous variables were reported as numbers with percentages, continuous variables as medians with interquartile ranges (IQR). Bivariate analyses using chi-squared with continuity correction according to Yates' correction and Mann-Whitney U tests, as appropriate, were carried out in order to compare demographic, explanatory, and outcome variables between groups. All statistical analyses were performed using STATA® 13.1 (StataCorp LP, TX, USA). A *p*-value of <0.05 was considered statistically significant.

Results

Population

A total of 7780 patients presented for 7935 unique traumas during the study period. An overview of the patients presenting and their dispositions are shown in Fig. 1. In supplementary Table 1, triage characteristics for all patients admitted for trauma are provided. Emergency Department length of stay (ED-LOS) and time to CT scan for the entire cohort are depicted in supplementary materials 2 and 3.

The population of patients presenting with ISS > 24 consisted of 606 patients presenting for 606 unique traumas. Baseline characteristics of these patients are presented in Table 1. There were no significant differences between patients presenting before and after the IH schedule with respect to baseline characteristics. In both groups, the majority of patients were male and nearly all patients suffered blunt trauma.

Process-related outcomes

Outcome variables are presented in Table 2. ED-LOS was significantly shorter after implementation of the IH schedule (2.7 versus 2.1 h; $p = 0.009$). There was no difference with respect to time to CT imaging, with a larger percentage of patients undergoing CT scanning after the introduction of in-hospital attendings (95% versus 90%; $p = 0.018$) (Fig. 2). After introduction of the IH surgeon, time from the ED to the intensive care unit (ICU) for patients directly transferred to the ICU was significantly shorter, with a decrease from a median time of 1.4 h (IQR 1.1–2.5) to a median time of 1.2 h (IQR 1.0–1.6) ($p = 0.004$). In addition, the percentage of patients who reached the ICU within 60 min increased from 15% to 33%. Fig. 3 shows time to the intensive-care unit graphically.

Overall time from presentation at the ED to emergent surgical intervention (surgical intervention directly from the ED) did not change significantly (1.0 versus 1.0 h, $p = 0.92$). However, the percentage of patients who had emergency surgery within 30 min of presentation increased from 4.8% to 8.0%. Of all patients demanding surgery within the initial 24 h, a significantly larger

Table 1
Baseline characteristics for patients with ISS > 24 (n = 606).

	Out-of-hospital period (n = 214) Median (IQR)	In-hospital period (n = 392) Median (IQR)	*p*-value
Age at presentation (years)	47 (26 – 66)	50 (26 – 69)	0.53
Injury Severity Score	29 (26 – 34)	29 (26 – 35)	0.46
Glasgow Coma Scale[a]	14 (11 – 15)	14 (10 – 15)	0.46
	n (%)	n (%)	*p*-value
Male gender	150 (70)	254 (65)	0.22
Unstable trauma	137 (64)	254 (65)	0.92
Triage color[b]			
Red	131 (61)	270 (69)	0.26
Orange	77 (36)	118 (30)	
Yellow	2 (1)	4 (1)	
Green	0 (0)	0 (0)	
Missing	4 (2)	0 (0)	
Blunt trauma	206 (96)	385 (98)	0.23

n = number; IQR = interquartile range.
[a] Glasgow Coma Scale available for 123 patients (57%) pre in house surgeon and 225 (57%) after.
[b] Triage color ranges from most emergent (red) to least emergent (green).

Table 2
Outcome variables for patients with ISS > 24 (n = 606).

	Out-of-hospital period (n = 214) Median (IQR)	In-hospital period (n = 392) Median (IQR)	*p*-value
ED length of stay (hours)	2.7 (1.6 – 4.0)	2.1 (1.5 – 3.7)	**0.009**
Time to CT < 24 hours (hours) (n = 565)*	0.4 (0.3 – 0.8)	0.5 (0.3 – 0.6)	0.59
Time to immediate ICU admission (hours) (n = 196)*	1.4 (1.1 – 2.5)	1.2 (1.0 – 1.6)	**0.004**
Time to emergency surgery (hours) (n = 200)	1.0 (0.8 – 1.6)	1.0 (0.8 – 1.4)	0.90
Without pre-operative CT (hours) (n = 38)	0.7 (0.6 – 0.9)	0.5 (0.4 – 0.7)	**0.016**
Duration of emergency surgery (hours) (n = 199)[a]	1.5 (1.0 – 2.2)	1.7 (1.2 – 2.2)	0.37
With emergent surgical procedure (hours) (n = 62)	1.4 (1.0 – 1.9)	1.5 (1.0 – 2.3)	0.96
	n (%)	n (%)	*p*-value
ED disposition			
Operating room	62 (29)	138 (35)	0.25
Death in operating room	4 (6)	1 (1)	
Intensive care unit	63 (29)	134 (34)	
Medium care unit	48 (22)	66 (17)	
Ward	32 (15)	41 (10)	
Deceased at emergency department	4 (2)	7 (2)	
Death on arrival	3 (1)	3 (1)	
Transfer	2 (1)	3 (1)	
Intensive care unit admission	133 (62)	266 (68)	0.18
Emergency surgery (OR from ED)	62 (29)	138 (35)	0.14
Emergency surgery without pre-operative CT	18 (29)	20 (14)	**0.026**
Emergent surgical procedure	25 (40)	38 (28)	0.10
Emergent neurosurgical procedure	26 (42)	66 (48)	0.54
Emergent orthopedic procedure	6 (10)	16 (12)	0.88
Non-emergent orthopedic procedure	16 (26)	36 (26)	0.89
Non-emergent other procedure	3 (5)	10 (7)	0.74
Combined surgical types	13 (21)	21 (15)	0.43
Operation <48 hours of presentation	115 (54)	209 (53)	0.99
Operation during night/weekend shift	69 (60)	119 (57)	0.53
In-hospital mortality	52 (24)	107 (27)	0.48
	Median (IQR)	Median (IQR)	*p*-value
Hospital length of stay for admitted patients (days) (n = 579)	14 (6 – 25)	13 (5 – 26)	0.33

n = number; IQR = interquartile range; ED = Emergency Department; OR = Operating Room; ICU = Intensive Care Unit.
Bold indicates statistically significant difference.
[a] No CT imaging <24 h after arrival performed in 46 (8%); time to CT, time to immediate ICU admission and duration of emergency surgery missing in1 patient (0%).

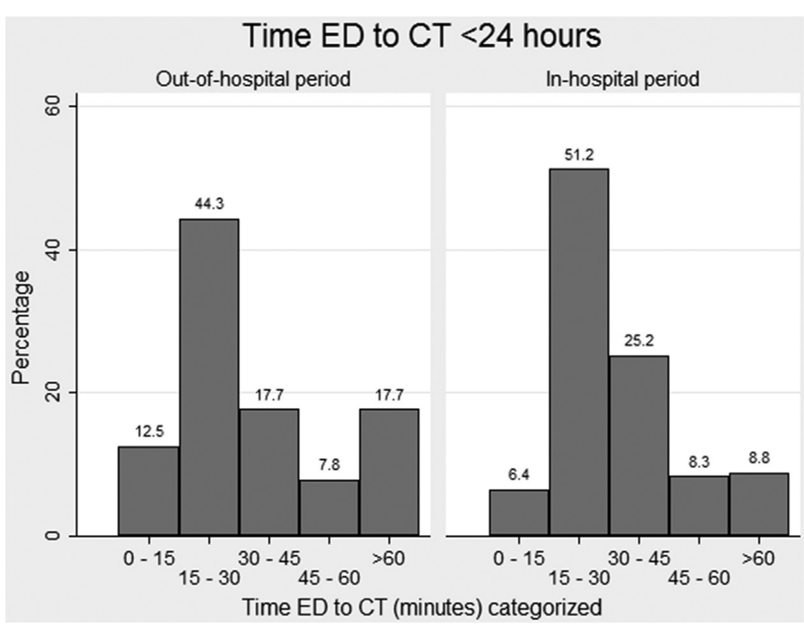

Fig. 2. Time to CT < 24 h for patients with ISS > 24 (n = 565).

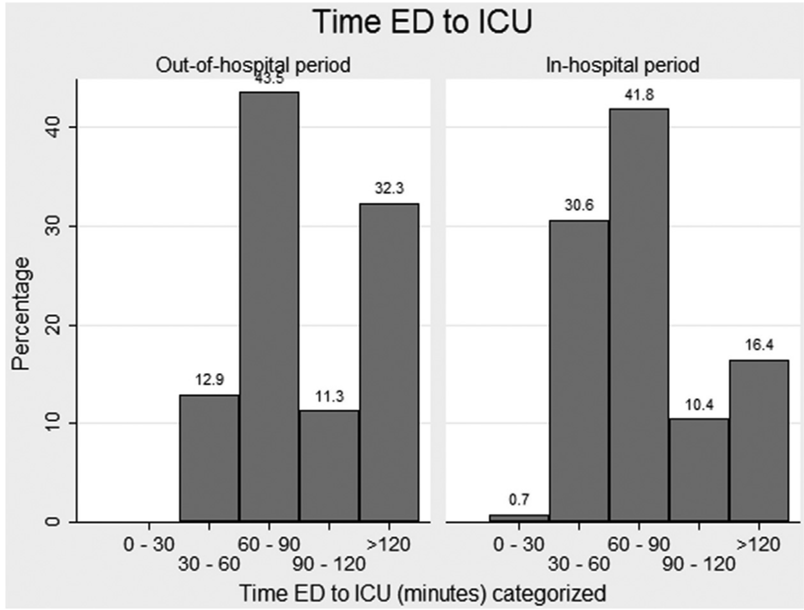

Fig. 3. Time to ICU for patients with ISS > 24 (directly from ED) (n = 196).

amount had surgery within 1.5 h of presentation in the second period (43% versus 58%; $p = 0.021$). Time to the OR for patients without pre-operative CT imaging decreased significantly (25% faster; 0.7 versus 0.5 h; $p = 0.017$), whereas the percentage of patients who had surgery without prior CT scanning decreased (29% versus 14%; $p = 0.026$). Times to surgical intervention for all severely injured patients who demanded emergent surgical intervention are presented graphically in Fig. 4a. With IH attendings, the duration of emergency surgeries did not change significantly (1.5 versus 1.7 h; $p = 0.37$) (Fig. 4b).

Patient-related outcomes

In-hospital mortality was comparable between both groups (24% versus 27%; $p = 0.48$). Median hospital length of stay did not differ between the two periods (14 versus 13 days; $p = 0.33$).

Discussion

After introduction of an in-house (IH) attending trauma surgeon schedule at our institution, there was significant acceleration of care-processes for severely injured patients, with a significant decrease in emergency department length of stay, a doubling in the percentage of patients that reached the ICU within an hour and a doubling in percentage of patients that arrived at the OR within 30 min.

At our institution, improving care for the most severely injured patients has always been of high priority. For example, video registration has been used to improve functioning of trauma teams [18]. With the recent introduction of an IH attending, process-related quality of care, based on disposition times, improved. It may very well be that the decreased ED-LOS and times to first disposition are the result of improved decision-making and leadership. Although residents may become proficient in the initial evaluation and treatment of trauma patients, the “big picture” and accompanying treatment necessities may be visible for attending surgeons more quickly. Non-technical skills such as leadership, decision-making and situation awareness have been reported to be of utmost importance in the context of resuscitation in trauma patients [19,20]. As those non-technical skills typically develop with experience, one can imagine that presence of an experienced surgeon (attending) is necessary for optimal care of the injured. Positive effects of in-house trauma surgeons on resuscitation times and times to intervention have been described previously [8–10,21]. Interestingly, emergency disposition length of stay increased for patients with less severe trauma after introduction of IH surgeons. This reflects less efficient overall processes at de ED, such as prolonged administrative times and fewer availability of hospital beds. In the light of this, the shorter ED-LOS for severely injured patients emphasizes the contribution of trauma surgeons to the acute care of this vulnerable population even more.

With implementation of the in-house schedule, time to the OR for patients without pre-operative CT imaging (most often due to severe instability) as well as the percentage of patients undergoing emergency surgery without prior CT scan, significantly decreased. This may be a reflection of faster decision-making as caused by presence of experienced surgeons, but is also likely to be the result of improved resuscitation processes in the last years. When a patient appears unresponsive, but becomes a transient responder, a CT-scan is deemed feasible in our institution. We expect the lower percentage of emergency procedures without previous imaging to be beneficial in terms of operative planning, higher amount of non-operative management and more accurate interventions, potentially leading to improved outcomes.

When comparing the IH and OH period, no changes in clinical decision making for interventions that require attending staff, such as nighttime surgeries, could be identified. This is due to the fact that the patient population (as apparent from our baseline characteristics) and the composition of the medical team as well as treatment strategies did not change over the study period. Therefore, the decision making itself did not differ and patients were treated similarly in both periods. For example, nighttime and weekend surgeries were performed in the OH period as well in order meet our standards of care. Even though decision making remained similar, our results clearly show that the time to interventions that require decision-making was significantly shorter after introduction of IH attending trauma surgeons.

Based on the triage characteristics in our cohort as well as existing literature, a relatively high percentage of severely injured and polytrauma patients is under triaged [22]. It was shown previously that under triaging and not activating a full trauma

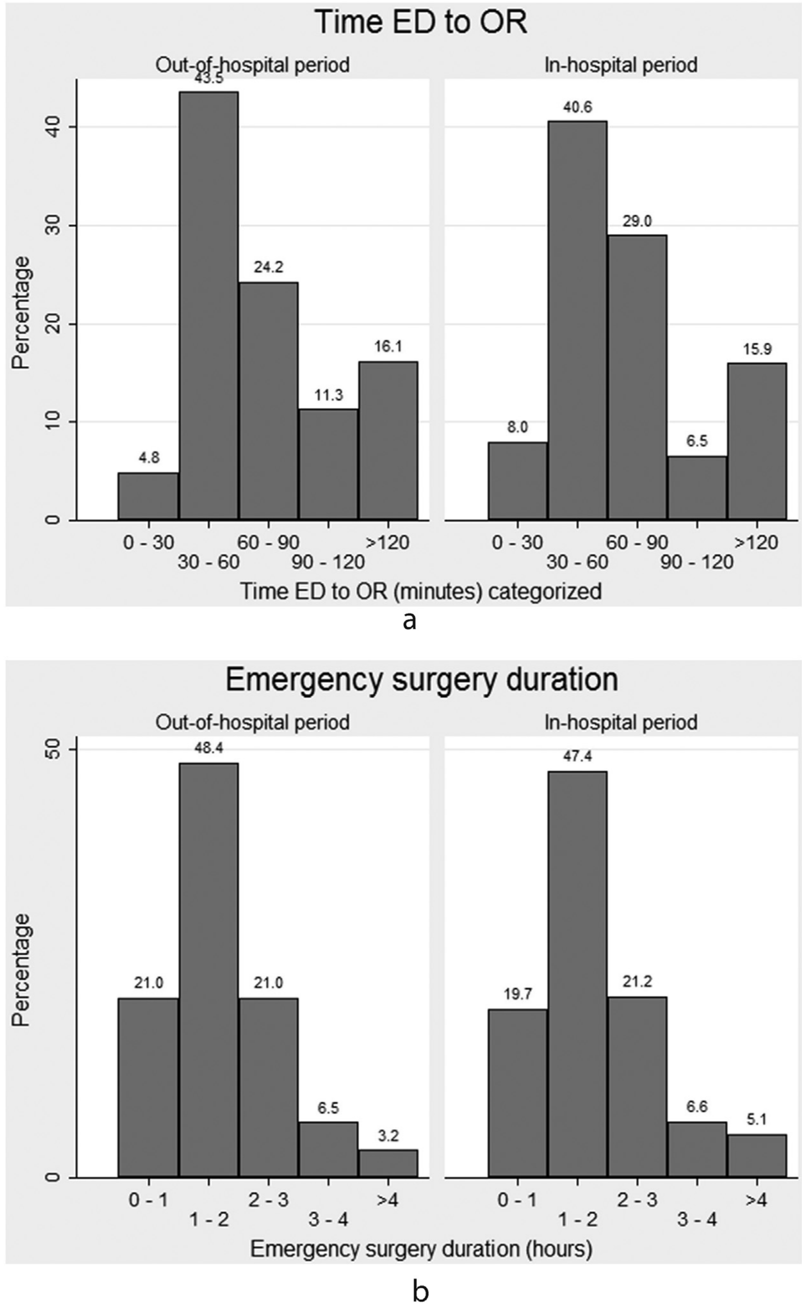

Fig. 4. a) Time to OR for patients with ISS > 24 (directly from ED) (n = 200). b) OR duration for emergency surgeries (directly from ED) (n = 199).

team increase the odds of mortality [22,23]. When taking this into account, presence of an IH experienced surgeon for all trauma team activations is even more important as one cannot completely rely on triage characteristics. In addition, injuries in patients who appear to be more severely injured than expected may be diagnosed and treated sooner with their presence.

As expected, it was not possible to show any effects of the IH attendings on mortality in this study. Our patient population consists almost solely of blunt trauma patients (where patients with penetrating injuries are suspected to benefit most from early presence of an experienced surgeon), the mortality rate is relatively low and the majority of trauma deaths in our institution is due to brain injuries [24]. Furthermore, the mandatory OH on-call response time was twenty minutes and with a senior surgical resident in house, resuscitation processes were already at a high standard for most patients. Unfortunately, we were not able to assess preventable deaths, functional recovery and quality of life, as that was beyond the scope of this study. As debated previously, in our pursuit to optimize trauma care, we aim to improve all individual elements in the chain of care in our hospital and thus focused on the process-related outcomes of the in-house schedule.

The volume of a trauma center might have impact on the efficiency analysis of IH attendings, as in-house staff is supposedly most beneficial for patients with poor baseline status (thus, a relatively small part of the total number of patients) [25]. Therefore, the findings of our study are not generalizable to every institution delivering care to trauma patients. For low-volume trauma centers not dealing with severely injured patients frequently, having an IH attending may be less favorable due to the number of surgeons needed on the schedule, with increased costs and only little effects on outcomes and process-related factors expected. However, for larger volume hospitals treating multiple injured patients, an IH schedule is feasible and likely beneficial. The presence of IH attendings resulted in improved utilization of resources and reduced ED transit time, thereby increasing the availability of the resuscitation bays and nurses at the ED.

Our study has several strengths. First, as we excluded all patients presenting six months prior or after the transition to the IH schedule, we reduced possible effects of anticipation on and first implementation of the new call schedule on our outcomes. Second, our retrospective before-and-after study was based on prospectively gathered data continuously monitored by trained data managers and a trauma surgeon. Third, we present a large series with a large time span providing a complete overview of processes potentially influenced by trauma surgeons. This study also has its limitations. To our knowledge, there were no major transitions during our study period except for the attendance policy and 24/7 availability of ICU beds in the second half of the IH period. The availability of this latter resource will have influenced the shorter time to ICU admission in the in-house period. Therefore, this finding should not be attributed to continuous presence of IH attending surgeons alone. However, the availability of an ICU bed will not have affected the time to emergency surgery. As the time to this intervention also decreased in the second period, we do believe that part of the faster ICU admission also reflects the change in personnel structure (for example due to attending-to-attending communication with the ICU staff). The historical control design poses its limitations. We were not able to account for the precise difference in surgeon response time, as we did not have data on the arrival time of the out of hospital calls (mandatory response time was twenty minutes) and nor were we able to retrieve the number of cases in the OH period where an attending surgeon was present at the bedside on arrival. As trauma surgeons will have been present at presentation of severely injured patients during the out-of-hospital period as well, especially during daytime but also ‘off hours’, the results of the present study may even underestimate the true effects of continuous presence of experienced surgeons. During the IH period, AIS coding has been updated, which is known to reduce ISS scores [26]. This may have caused presence of more severely injured patients in the IH group, potentially causing another underestimation of the effects of IH trauma surgeons.

Conclusions

In conclusion, introduction of a 24/7 in-house attending trauma surgeon in a large volume Level 1 Trauma Center led to improved process-related outcomes, especially for the most severely injured patients. There is a clear benefit of the continuous presence of physicians with sufficient experience in trauma care in hospitals treating a large number of severely injured patients.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.injury.2018.08.006.

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