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Optimizing critical care of the trauma patient at the intermediate care unit: a cost-efficient approach

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ABSTRACT

Background The aim of this study was to describe the case load, safety, and cost savings of critical care of the trauma patient provided at the surgical intermediate care unit (IMCU).

Methods This cohort study included all trauma admissions between January 1, 2011 and January 7, 2015 at the general intensive care unit (ICU), stand-alone neuro(surgical) IMCU, and stand-alone (trauma) surgical IMCU. Trauma mechanism, Abbreviated Injury Scale score and Injury Severity Score (ISS), vital signs, laboratory parameters, admission duration, intubation duration, ICU transfer, and in-hospital mortality were prospectively collected. Hypothetical cost savings were calculated using the fixed cost price per IMCU (US$1500) and ICU (US$2500) admission day.

Results A total of 1320 admissions were included, 675 (51.1%) at the IMCU and 645 (48.9%) at the ICU. Patients admitted at the IMCU had a median ISS of 17 (11, 22). Their median duration of admission was 32.8 hours (18.8, 62.5). At the IMCU, one patient died due to aneurogenic shock. A subsequent ICU transfer was required in 38 (5.6%) IMCU admissions. Of these transfers, four patients died due to neurological deterioration. At the ICU, the median ISS was 22 (14, 30). Nearly all (n=620, 96.3%) ICU trauma patients required mechanical ventilation. Expected total cost savings due to the presence of the IMCU were US$1 772 785.

Discussion A substantial amount of trauma patients in need of critical care can safely be admitted at the IMCU, without the need for further mechanical ventilation. Thereby, the IMCU could fulfill an essential cost-saving role in the management of severely injured trauma patients.

Level of evidence Level IV.

INTRODUCTION

Worldwide introduction of organized trauma systems has led to improved outcomes after injury.[1 2] This has been accomplished through an ongoing emphasis on field triage and distance to (Level I) trauma centers, regionalization of trauma care, and efficiency of managing trauma patients within hospitals.[1 3–7] One of the downsides of these effective trauma systems is their costs, as expensive trauma resources (eg, intensive care unit (ICU) availability and trauma expertise) need to be readily available 24/7.[6 8] This financial burden has already led to the closure of existing trauma centers, and containing trauma-related costs has therefore become a priority of the American College of Surgeons.[1 9]

Intermediate Care Units (IMCUs), logistically positioned between the hospital ward and the ICU, carry the potential to reduce this financial burden. Through decreasing the need for costly and sparse ICU beds, fixed costs can likely be reduced due to lower nursing costs.[10] For this purpose, IMCUs are already increasingly being used in hospitals over the last decade.[11] An important function herein is as a step-down unit, facilitating in the safe downgrading of (critical) care for ICU patients.[12] An additional advantage of using IMCUs is found in hospital settings where the ICU is supervised by general intensivists. In these settings, admitting trauma patients at the (specialist supervised) surgical IMCU could have the additional benefit of specialty-specific critical trauma care delivery.[13]

The aim of this study was to describe the case-load, safety, and potential for cost savings of in-hospital trauma critical care at the mixed-surgical, stand-alone IMCU.

METHODS

Study design and settings

This observational cohort study was conducted at the University Medical Centre in Utrecht, a tertiary university referral hospital in the Netherlands which serves as a Level 1 trauma center. In this hospital, trauma patients in need of critical care are typically admitted to one out of three units: the stand-alone mixed-surgical IMCU, the stand-alone neurosurgical IMCU, or the general, mixed ICU.

The stand-alone, mixed-surgical IMCU of this hospital admits patients from all surgical disciplines, providing hemodynamic monitoring and cardiovascular and respiratory support including inotropic use and supplementary (high-flow) oxygen. It has a nurse:patient ratio of 1:1.5 and has six beds. This IMCU is supervised by trauma surgeons with additional critical care certifications. It does not provide invasive ventilation and continuous renal replacement therapy. Emphasis is on wound and fracture care.

The stand-alone neurosurgical IMCU also provides hemodynamic monitoring and cardiovascular and respiratory support, though does not support inotropic use. Emphasis is on neurological observation. The nurse:patient ratio is also 1:1.5 with six beds, and supervision is provided by the neurologists.

The general ICU is led by intensivists of various non-surgical backgrounds and consists of 36 beds and a nurse:patient ratio of 1:1. The nurse:patient ratio at the hospital ward was 1:5. All admissions after sustained trauma admitted at one of

Table 1 Baseline of trauma admissions at the intermediate and intensive care units

	Total, n=1320	IMCU, n=675		ICU, n=645	
	n (%)	n (%)	Missing, n (%)	n (%)	Missing, n (%)
General characteristics					
Age (SD)	52.3 (21.0)	54.2 (20.5)	0 (0.0%)	50.3 (21.3)	0 (0.0%)
Sex, male (%)	910 (68.9%)	462 (68.4%)	0 (0.0%)	448 (69.5%)	0 (0.0%)
Trauma mechanism (%)					
Traffic—HET	500 (37.9%)	251 (37.2%)	0 (0.0%)	249 (38.6%)	0 (0.0%)
Traffic—LET	130 (9.8%)	57 (8.4%)		73 (11.3%)	
Fall—HET	136 (10.3%)	76 (11.3%)		60 (9.3%)	
Fall—LET	373 (28.3%)	207 (30.7%)		166 (25.7%)	
Penetrating—firearms	21 (1.6%)	7 (1.0%)		14 (2.2%)	
Penetrating—other	59 (4.5%)	36 (5.3%)		23 (3.6%)	
Drowning	5 (0.4%)	0 (0.0%)		5 (0.8%)	
Burn/inhalation trauma	31 (2.3%)	14 (2.1%)		17 (2.6%)	
Other	65 (4.9%)	27 (4.0%)		38 (5.9%)	
Global injury severity					
ISS (IQR)	19 (13–26)	17 (11–22)	0 (0.0%)	22 (14–30)	0 (0.0%)
Maximum AIS score (%)					
≤3	551 (41.7%)	332 (49.2%)	0 (0.0%)	219 (34.0%)	0 (0.0%)
4	543 (41.1%)	288 (42.7%)		255 (39.5%)	
5–6	226 (17.1%)	55 (8.1%)		171 (26.5%)	
Head injury severity					
First ED GCS score					
14–15	666 (54.6%)	528 (78.2%)	53 (7.9%)	138 (21.4%)	47 (7.3%)
9–12	152 (12.5%)	75 (11.1%)		77 (11.9%)	
≤8	402 (33.0%)	19 (2.8%)		383 (59.4%)	
Maximum head AIS score					
≤2	626 (47.4%)	366 (54.2%)	0 (0.0%)	260 (40.3%)	0 (0.0%)
3	160 (12.1%)	84 (12.4%)		76 (11.8%)	
4–6	534 (40.5%)	225 (33.3%)		309 (47.9%)	
Thoracoabdominal injury severity					
Maximum thorax AIS score					
≤2	843 (63.9%)	439 (65.0%)	0 (0.0%)	404 (62.6%)	0 (0.0%)
3	260 (19.7%)	135 (20.0%)		125 (19.4%)	
4–6	217 (16.4%)	101 (15.0%)		116 (18.0%)	
Maximum abdominal AIS score					
≤2	1222 (92.6%)	634 (93.9%)	0 (0.0%)	588 (91.2%)	0 (0.0%)
3	60 (4.5%)	28 (4.1%)		32 (5.0%)	
4–5	38 (2.9%)	13 (1.9%)		25 (3.9%)	
Extremity injury severity					
Maximum extremity AIS score					
≤2	1108 (83.9%)	570 (84.4%)	0 (0.0%)	538 (83.4%)	0 (0.0%)
3	195 (14.8%)	97 (14.4%)		98 (15.2%)	
4–5	17 (1.3%)	8 (1.2%)		9 (1.4%)	
Vital signs at presentation (SD) (IQR)					
Systolic blood pressure	135 (28.5)	137 (24.6)	29 (4.3%)	133 (32.1)	31 (4.8%)
Respiratory rate	19 (5.9)	19 (5.3)	123 (18.2%)	18 (6.6)	156 (24.2%)
Saturation	1.00 (0.97–1.00)	1.00 (0.97–1.00)	42 (6.2%)	1.00 (0.97–1.00)	57 (8.8%)
Laboratory parameters at presentation (SD) (IQR)					
Hemoglobin	8.5 (1.2)	8.6 (1.0)	38 (5.6%)	8.3 (1.4)	46 (7.1%)
Lactate	2.2 (1.5–3.3)	2 (1.4–2.8)	208 (30.8%)	2.6 (1.7–3.9)	135 (20.9%)
pH	7.4 (7.3–7.4)	7.4 (7.4–7.4)	174 (25.8%)	7.3 (7.3–7.4)	64 (9.9%)
pCO_2	44 (10.5)	41 (7.5)	174 (25.8%)	47 (11.8)	64 (9.9%)

Continued

Table 1 Continued

	Total, n=1320	IMCU, n=675		ICU, n=645	
	n (%)	n (%)	Missing, n (%)	n (%)	Missing, n (%)
pO_2	178 (99–292)	149 (91–238)	174 (25.8%)	205 (106–349)	64 (9.9%)
HCO_3	23.9 (3.6)	24.4 (3.1)	174 (25.8%)	23.4 (4.0)	64 (9.9%)
BE	−1.0 (−4.0 to 1.0)	0.0 (−2.6 to 2.0)	174 (25.8%)	−2.0 (−5.0 to 1.0)	49 (7.6%)
Saturation	1.00 (1.00–1.00)	1.00 (1.00–1.00)	202 (29.9%)	1.00 (1.00–1.00)	83 (12.9%)

This baseline table shows the overall characteristics of trauma admissions which received critical care during the study period, stratified per location of delivered critical care (intermediate or intensive care unit).
AIS, Abbreviated Injury Scale; BE, base excess; ED, emergency department; GCS, Glasgow Coma Scale; ICU, intensive care unit; IMCU, intermediate care unit; ISS, Injury Severity Score; HET, high energy trauma; LET, low energy trauma; BCA, bootstrapped confidence interval; ICP, Intracranial pressure.

the IMCUs or ICU between January 1, 2011 and January 7, 2015 were included in the study. According to the Institutional Review Board, the study was not subject to the Medical Research Involving Human Subjects Act and therefore the necessity of informed consent was waived (protocol no. 17-326/C).

Study variables

Data were collected from the Dutch National Trauma Database for the area Central Netherlands. The following variables were collected: age, sex, trauma mechanism (from the International Classification of Diseases, 10th revision),[14] Abbreviated Injury Scale (AIS)[15] score and Injury Severity Score (ISS),[16] vital signs (Glasgow Coma Scale (GCS) score, systolic blood pressure, respiratory rate, and saturation), and laboratory parameters (hemoglobin level, lactate, arterial blood gas parameters: pH, pCO_2, pO_2, bicarbonate (HCO_3), base excess, and saturation).

Trauma mechanism data were further classified in the following groups: high-impact (collision of a car driver, cyclist, or pedestrian with a car or motorcycle) or low-impact (collision of a car driver, cyclist, or pedestrian with either a cyclist or pedestrian) traffic injuries, falling from high (≥2 m) or low height, penetrating injuries due to firearms or other causes, drowning, or inhalation trauma. The AIS score per region (head, thorax, abdomen, extremities) was categorized in low (AIS ≤2), middle (AIS 3), and high (≥4) severity. Neurotrauma was defined as head injury with an AIS score ≥3. Brain injury according to the GCS score was categorized in minor (≥13), moderate (9–12), and severe (≤8). This dichotomization is in line with a previous report.[13]

Study outcomes

The following outcome parameters were collected at the IMCU: admission duration, transfer location, indication for ICU transfer (if applicable), and in-hospital mortality. At the ICU, the outcome parameters were the admission duration, intubation duration, reason for ICU admission (if not intubated), post-ICU transfer location, and in-hospital mortality.

The costs per admission day (costs 2016) for the hospital ward, IMCU, and ICU were calculated by dividing the total annual costs of the unit by the annual number of admission days. These costs include all the overhead and operating costs (thereby excluding patient costs, such as radiography or laboratory costs). Due to business purposes and negotiations with insurance companies, exact costs per admission day were not given. Instead, the ratio of IMCU and ICU costs relative each other was used (ratio 3:5). The reimbursed fee per ICU day in the Netherlands in 2018 was used to obtain the approximate (hypothetical) costs of US$1500 per IMCU and US$2500 per ICU day.

Statistical analyses

Normally and non-normally distributed continuous variables were described with the mean and SD or the median and IQR, respectively. Categorical variables were described as numbers and proportions. As the aim of the study was descriptive rather than confirmative, no tests for statistical significance were performed. Total costs for all IMCU and ICU admissions were obtained by multiplying the admission days with the respective costs per admission day. All descriptive analyses were performed using R software for statistical computing (V.3.3.2.).[17]

RESULTS

An overview of the baseline characteristics of trauma admissions at the IMCU and ICU is provided in tables 1 and 2. A total of 1320 admissions were included, 675 (51.1%) at the IMCUs and 645 (48.9%) at the ICUs. Of the IMCU admissions, 324 (24.5%) patients were admitted at the neuro(surgical) IMCU and 351 (26.6%) at the mixed-surgical IMCU.

Trauma admissions at both IMCUs

Table 2 shows the baseline characteristics of the trauma admissions at both IMCUs. The transfers to the ICU (n=38, 5.6%) were admitted for a median of 28.1 hours (IQR 16.3–51.0) at the IMCU before subsequent ICU transfer. Indication for ICU transfer were mainly neurological deterioration or respiratory complications. Of these patients, four died during their hospital stay due to neurological herniation (n=3) or cervical myelopathy (n=1). During IMCU admission, one patient died from a neurogenic shock due to cervical spinal injury without treatment options and palliative care without ICU transfer was agreed on.

Trauma admissions at the neuro(surgical) or mixed-surgical IMCU

Table 3 shows the differences between the admission characteristics of admissions at the neuro(surgical) and mixed-surgical IMCU. The rate of subsequent ICU transfer was 6.2% (n=20) at the neuro(surgical) and 5.1% (n=18) at the mixed-surgical IMCU.

The indications for transfer from the IMCU to the ICU per type of IMCU are provided in table 4.

Trauma admissions at the ICU

Table 3 shows the characteristics of the trauma admissions at the ICU. Of the 24 (3.7%) admissions that were not intubated, one received care which could not have been provided at the IMCU (non-invasive ventilation) whereas the others did not receive any ICU-specific care in this setting. These non-intubated admissions at the ICU were on average admitted for 18.3 hours (IQR

Table 2 Differences between trauma admissions at the neuro(surgical) and mixed-surgical intermediate care unit

	Neuro IMCU, n=324		Surgical IMCU, n=351	
	n (%)	Missing, n (%)	n (%)	Missing, n (%)
General characteristics				
Age (SD)	58.3 (20.3)	0 (0.0%)	50.3 (20.0)	0 (0.0%)
Sex, male (%)	212 (65.4%)	0 (0.0%)	250 (71.2%)	0 (0.0%)
Trauma mechanism				
Traffic—HET	82 (25.3%)	0 (0.0%)	169 (48.1%)	0 (0.0%)
Traffic—LET	43 (13.3%)		14 (4.0%)	
Fall—HET	25 (7.7%)		51 (14.5%)	
Fall—LET	153 (47.2%)		54 (15.4%)	
Penetrating—firearms	1 (0.3%)		6 (1.7%)	
Penetrating—other	8 (2.5%)		28 (8.0%)	
Burn/inhalation trauma	0 (0.0%)		14 (4.0%)	
Other	12 (3.7%)		15 (4.3%)	
Global injury severity				
ISS (SD)	18.1 (8.4)	0 (0.0%)	16.6 (9.2)	0 (0.0%)
Maximum AIS score				
≤3	107 (33.0%)	0 (0.0%)	225 (64.1%)	0 (0.0%)
4	178 (54.9%)		110 (31.3%)	
5–6	39 (12.0%)		16 (4.6%)	
Head injury severity				
First ED GCS score				
14–15	223 (68.8%)	25 (7.7%)	305 (86.9%)	28 (8.0%)
9–12	62 (19.1%)		13 (3.7%)	
≤8	14 (4.3%)		5 (1.4%)	
Maximum head AIS score				
≤2	72 (22.2%)	0 (0.0%)	294 (83.8%)	0 (0.0%)
3	50 (15.4%)		34 (9.7%)	
4–6	202 (62.3%)		23 (6.6%)	
Thoracoabdominal injury severity				
Maximum thorax AIS score				
≤2	273 (84.3%)	0 (0.0%)	166 (47.3%)	0 (0.0%)
3	32 (9.9%)		103 (29.3%)	
4–6	19 (5.9%)		82 (23.4%)	
Maximum abdominal AIS score				
≤2	322 (99.4%)	0 (0.0%)	312 (88.9%)	0 (0.0%)
3	2 (0.6%)		26 (7.4%)	
4–5	0 (0.0%)		13 (3.7%)	
Extremity injury severity				
Maximum extremity AIS score				
≤2	307 (94.8%)	0 (0.0%)	263 (74.9%)	0 (0.0%)
3	17 (5.2%)		80 (22.8%)	
4–5	0 (0.0%)		8 (2.3%)	
Vital signs at presentation (SD)[IQR]				
Systolic blood pressure	139 (23.9)	20 (6.2%)	136 (25.2)	9 (2.6%)
Respiratory rate	19 (5.3)	66 (20.4%)	19 (5.2)	57 (16.2%)
Saturation	1.00 [0.97 to 1.00]	30 (9.3%)	1.00 [0.98 to 1.00]	12 [3.4%]
Laboratory parameters at presentation (SD)[IQR]				
Hemoglobin	8.6 [8.5 to 8.7]	22 (6.8%)	8.7 [8.6 to 8.8]	16 (4.6%)
Lactate	2.0 [1.5 to 2.9]	128 (39.5%)	1.9 [1.4 to 2.8]	80 (22.8%)
pH	7.4 [7.4 to 7.4]	116 (35.8%)	7.4 [7.3 to 7.4]	58 (16.5%)
pCO_2	40 (7.8)	116 (35.8%)	42 (7.0)	58 (16.5%)
pO_2	154 [96 to 238]	116 (35.8%)	148 [88 to 243]	58 (16.5%)

Continued

Table 2 Continued

	Neuro IMCU, n=324		Surgical IMCU, n=351	
	n (%)	Missing, n (%)	n (%)	Missing, n (%)
HCO_3	24.2 (3.0)	116 (35.8%)	24.6 (3.1)	58 (16.5%)
BE	0.0 [–3.0 to 2.0]	116 (35.8%)	0.0 [–2.0 to 2.0]	58 (16.5%)
Saturation	1.00 [1.00 to 1.00]	129 (39.8%)	1.00 [1 to 1.00]	73 (20.8%)

The numbers presented here are the descriptive statistics of intermediate care unit admissions after sustained trauma, stratified per intermediate care unit: the neuro(surgical) and mixed-surgical.
AIS, Abbreviated Injury Scale; BE, base excess; ED, emergency department; GCS, Glasgow Coma Scale; IMCU, intermediate care unit; ISS, Injury Severity Score.

11.5–23.7). They were transferred to the IMCU (n=10), the hospital ward (n=8), or discharged home (n=6).

The ICU admissions without head injury were admitted for a median of 26.7 hours (14.6–111.8), of which 68.8% were admitted ≤72 hours. These patients were intubated for a median of 15 (5.0–71.3) hours, of which 75.0% ≤72 hours. The ICU admissions after sustained severe head injury were admitted for a median of 65.3 hours (20.7–175.2), of which 52.5% were admitted ≤72 hours. These patients were intubated for a median of 42.0 (10.0–143.0) hours, of which 58.7% ≤72 hours.

Cost savings of the use of the IMCU

Total estimated expenditure was US$2 659 177 at the IMCU and US$7 464 417 at the ICU, with a total cost of US$10 123 594. If all trauma patients who were admitted to either one of the IMCUs would have been admitted to the ICU (eg, in the hypothetical scenario that our hospital would not have had IMCU care), this would lead to a total expenditure of US$11 896 378. The IMCU has thus potentially led to cost savings of US$1 772 785 in the total period, that is, US$393 952 per year.

Table 3 Trauma admissions at the intermediate and intensive care unit

	IMCU	ICU
Total admission, n	n=675	n=645
Admission characteristics		
Admission duration, median (IQR)	32.8 [18.8–62.5]	46.7 [16.8–155.5]
Admissions <72 h, n (%)	544 (80.6)	380 (59.2%)*
Transfer characteristics		
Hospital ward, n (%)	592 (87.7)	225 (34.9%)
Intermediate care unit, n (%)	–	324 (50.4%)
Intensive care unit, n (%)	38 (5.6)	–
Home, n (%)	44 (6.5)	–
Death at the hospital unit, n (%)	1 (0.1)	95 (14.8%)
Indication ICU admission		
Mechanical ventilation, n (%)	–	620 (96.3%)
No mechanical ventilation, n (%)	–	24 (3.7%)
Risk of intubation due to head injury	–	5 (0.8%)
Risk of intubation due to airway obstruction	–	3 (0.5%)
Risk of pulmonary deterioration	–	3 (0.5%)
Hemodynamic monitoring for bleeding or cardiac contusion	–	7 (1.1%)
Exchange bed (IMCU full)*	–	6 (0.9%)
Indication ICU transfer		
Postoperative after neurosurgical decompression, n (%)	9 (1.3)	–
Postoperative after rib fixation, n (%)	4 (0.6)	–
Postoperative after other operations†, n (%)	7 (1.0)	–
Intubation due to respiratory deterioration, n (%)	7 (1.0)	–
Intubation due to sepsis, n (%)	2 (0.3)	–
Intubation for other reasons‡, n (%)	6 (0.9)	–
Respiratory support with non-invasive ventilation, n (%)	2 (0.3)	–
Multiple vasopressive medication, n (%)	1 (0.1)	–
In-hospital mortality, n (%)	23 (3.4)	134 (20.8%)

The numbers presented are the indications, admission and transfer characteristics of intermediate care unit and intensive care unit admissions after sustained trauma.
*The exchange patients were admitted for other non-surgical disciplines due to full occupancy of their IMCU.
†Cholecystectomy due to perforated gallbladder, stabilization of the spine, thoracotomy, pelvic fixation, femoral nail placement.
‡Atrial flutter, Guillain-Barré syndrome, combined respiratory and neurological deterioration, sedation to reduce the ICP, epileptic insult.
ICU, intensive care unit; IMCU, intermediate care unit.

Table 4 Indications transfer from intermediate to intensive care unit (ICU) per intermediate care unit (neurosurgical and mixed-surgical)

Indication ICU transfer, n (%)	Total (n=38)	Neuro (n=20)	Surgical (n=18)
Postoperative	20 (52.6)	10	10
Intubation due to respiratory deterioration	7 (1.04)	5	2
Intubation due to sepsis	2 (0.30)	1	1
Intubation for other reasons*	6 (0.89)	2	4
Respiratory support with non-invasive ventilation	2 (0.30)	1	1
Multiple vasopressive medication	1 (0.15)	1	0

*Atrial flutter, Guillain-Barré syndrome, combined respiratory and neurological deterioration, sedation to reduce the ICP, epileptic insult.

DISCUSSION

In the current study, half of the trauma patients in need of critical care were safely admitted at dedicated IMCUs. We also found that most ICU trauma admissions without severe neurotrauma are intubated only for a short time period (≤72 hours). Further, the IMCU reduced the overall costs of critical trauma care.

In total, 51.1% of trauma critical care was provided at the IMCU. These admissions were major trauma patients (median ISS 17 (11–22)) of whom none died from preventable causes (ie, no deaths with respiratory or heamodynamic causes) after subsequent ICU transfer, indicating that this is a safe application of IMCUs. Combined with lower fixed costs at the IMCU this means that implementing the IMCU can substantially decrease the costs of overall provided care for trauma patients.[11] This effect was indeed observed and could be explained by the graded requirements of supportive critical care: although most major trauma patients may require critical care, not all are in need of ICU admission. However, as the IMCU typically lacks maximum supportive capacities (eg, in our situation mechanical ventilation, intracranial pressure monitoring, and continuous renal replacement therapy), adequate triage and identification of the deteriorating patients are herein essential.

The majority of patients admitted at the ICU (96.3%) received mechanical ventilation (eg, in major head injury), thus they were in need of specialized critical care therapy, which was not possible at the IMCU. However, many of these patients required only a short period of mechanical ventilation, as the intubation duration was ≤72 hours in the majority of admissions (65.2% in all and 75.0% in admissions without a head injury). This indicates that possibly, with the addition of the ability to ventilate trauma patients for a short time period, the majority of trauma patients in need of critical care could successfully be resuscitated in a dedicated unit. This supports the potential of a specialized trauma resuscitation unit, as described previously.[13] Additional benefits could then be the direct involvement of both the trauma surgeon and the (trauma) anaesthesiologist and in-hospital centralization of specialized trauma critical care.[13 18]

To demonstrate the cost-efficiency of the IMCU, ideally a comparative study design is used to assess the effect of implementation (or dissemination) of the IMCU. Such designs include a cluster-randomized trial, stepped-wedged cluster randomized trial or an advanced before–after design. However, as there is a lack of evidence in this research field, we believe such studies should first be preceded by exploratory descriptive analyses such as presented here. Also, comparison of IMCU and ICU admissions with a propensity score analysis was not feasible due to the high rate of intubation at the ICU. From this, it follows that the populations are too different to warrant a matched analysis.

This study has several important practical implications. First, it supports the opening or maintaining of the IMCU to more precisely match hospitals' resources to patients in an economically efficient way. For example, a patient with a moderate head injury and a low (though not zero) risk of deterioration might not receive safe monitoring at the hospital ward, but does not require all the ICU resources. Second, it supports the possible implementation of specialized trauma care units in which trauma patients can shortly be mechanically ventilated.

Strengths of this study are that it is the first to show that critical trauma care can safely be provided at IMCUs. Also, it uses a large dataset obtained through a standardized data collection protocol over a 4.5-year period. Additionally, this study is not limited to only the IMCU but also analyses the ICU, which provides a more comprehensive description of all relevant provided critical trauma care.

This study has several limitations. First of all, the generalizability of the results is subject to the organization of the trauma system as well as the in-hospital organization of trauma care delivery. Second, this study uses the ISS as a proxy for the requirement of critical care, assuming that patients with a high ISS at the IMCU also require critical care. Third, the validity of the cost savings calculation depends on two important assumptions. The first assumption is that all patients at the IMCU would—in the absence of the IMCU—have been admitted at the ICU. This seems reasonable to assume, as an earlier report at the same IMCU has shown that >75% of patients at the IMCU received ICU care. This percentage is likely even higher in trauma patients, who frequently require a short period of monitoring. However, it is important to realize that if—in absence of the IMCU—*all* IMCU patients would have been admitted at the hospital ward, the IMCU would actually cost US$1 772 785. The second assumption is that the average IMCU and ICU costs are representative for this trauma population, whom in reality may require (more or) less financial resources at the ICU than the average ICU patient. However, one should realize that >80% of ICU (and IMCU) costs are fixed, and thus the variable costs are less important.[19]

CONCLUSIONS

A substantial amount of trauma patients in need of critical care can safely be admitted at the stand-alone specialist-driven IMCU, without the need for further mechanical ventilation. Thereby, the IMCU could fulfill an essential cost-saving role in the management of severely injured trauma patients.

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Patient consent Not required.

Ethics approval According to the Institutional Review Board, the study was not subject to the Medical Research Involving Human Subjects Act and therefore the necessity of informed consent was waived (protocol no. 17-326/C).

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