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Pre-hospital triage according to METTS-T provides more effective trauma care
Simple and medically safe methods shows retrospective study

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Most Swedish emergency hospitals have introduced "trauma alarms" during the past 15 years. This means that ambulance personnel using certain pre-determined criteria can activate a "trauma team" that is ready and waiting at the emergency room when the injured patient arrives. The system was introduced based on an American model and the alarm criteria at most hospitals are generally directly copied from the ATLS (Advanced Trauma Life Support) manual. The criteria are from three different categories:

• impact on certain physiological parameters (respiratory rate, blood pressure and impaired consciousness)
• certain specific anatomical injuries
• injury mechanisms

The composition of the trauma team may vary depending on the hospital's size but they usually include one or more surgeons, anesthetists, anesthetic nurse, possibly an orthopedic surgeon and a varying number of staff from the emergency department.

Activation of the trauma team thus results in a number of key individuals are not able to participate in the hospital's other activities for a varying period of time. This affect is often further reinforced by the operating theater and the DT in the radiology department standing ready in case the trauma patient requires such resources.

The problem in activating trauma teams is that in the case of over-triage (patients with alarm levels that are too high) resources are taken from other activities unnecessarily, while under-triage (patients receiving alarm levels that are too low) can lead to increased medical risks. Therefore, all triage systems aim to reduce over-triage and minimize under-triage.

Tiering of trauma alarms
Most countries have introduced different models for tiering of trauma patient care [1] .The tiering of trauma alarms has been designed so that only limited staff resources rather than the entire trauma team initially meet the trauma patients who only have injury mechanism criteria and who lack impact on physiological vital signs, or specific anatomical injuries. The injury mechanism means that the patient is exposed to various types of force and sometimes has injuries with a potential risk of serious pre-hospital unidentified injuries or complications.
Activating the entire trauma team for mere mechanical criteria has been questioned [2], whereas patients with impact on physiological vital signs have often been shown to have medical requirements involving the entire trauma team [1].
Tiering using two levels, where Level 1 means the activation of the entire trauma team and Level 2 means limited resource activation has been shown to be effective and medically safe with a sensitivity of 65 % and specificity of 87 % and only 8 % under-triage [3].
Tiering has, in addition to good medical safety, also shown to save resources [4, 5].
Studies have also shown that patients who meet the triage criteria established by the American College of Surgeons Committee on Trauma (ACSCOT) have higher mortality, higher ISS points (Injury Severity Score) and longer duration of stays on intensive care units [6]

Two alarm levels at the Sahlgrenska University Hospital

At the emergency and accident unit at the Sahlgrenska University Hospital in Gothenburg the entire trauma team was previously activated following each trauma alert. This meant that strategic parts of the hospital's work were fragmented and was subjected to disturbances during part of the day despite there not being an obvious medical need.

Most trauma care resources were centralized to a central point at the Sahlgrenska University Hospital, This led to a sharp increase in the number of trauma patients at the emergency and accident unit (Figure 1). In 2006 therefore, trauma alarms were sorted into Level 1 where the entire trauma team was alerted, and Level 2 where the existing organization in the ER handled the lower level alarms as an integral part of the emergency care.

The aim of the present study was to validate this method of METTS-T (Medical Emergency Triage and Treatment System Trauma) tiering and test the hypothesis of whether or not the protocol for the activation of the trauma team even at the pre-hospital stage is capable of tiering trauma alarms in a medically safe way and predict the outcome in the level of care, length of stay, mortality and need for intensive care while the proportion of patients with pre-hospital too low alarm levels should be <5%.

MATERIAL

The Sahlgrenska University Hospital in Gothenburg is a regional hospital for the Västra Götaland region and parts of northern Halland and covers a population of approximately 2.3 million people. Locally, the Sahlgrenska University Hospital/Sahlgrenska has the task of being the final instance for trauma care for a growing population that currently comprises 750,000 individuals.

The Emergency and Accident unit is essentially an adult emergency department with currently 48,000 visits per year. Within the Sahlgrenska University Hospital, the emergency and accidents unit is the recipient unit for the majority of all trauma care in Gothenburg, but it is also a regional reception unit for trauma patients in the entire Västra Götaland region.

In the current retrospective study, all patients who arrived at the emergency and accident unit via trauma alarms during the period January 1st, 2007 to June 30th, 2007 were included. During this period a total of 23,381 patients were admitted to the unit of which some 520 were trauma patients. Data was collected using “Kvittra” which is the quality register we use for trauma care [7]. Supplementary data was retrieved from the electronic patient medical records and the trauma journal.

METHODS

Previously, our protocol for emergency care and triage, METTS-A (Medical Emergency Triage and Treatment System Adult), has been evaluated and published [8]. METTS-A was implemented in January 2005, and a protocol called METTS-T was developed at the same time for trauma care. The difference between METTS protocols and other triage methods is that METTS contains both a triage method and a module for logistics and care processes as well as a decision making support for both healthcare staff and physicians. The METTS-T protocol was implemented in the trauma care chain on January 1st, 2006 and has so far been used for >2200 trauma alarms.

Activation of trauma alarms occurs in the form of the responsible alarm nurse ringing the ambulance or helicopter and asking a set of structured questions according to the METTS-T protocol. The trauma alarm level is based on the METTS-T protocol algorithm found in the trauma journal and which contains criteria for the vital signs designated ABCD, anatomical injuries to the patient and injury mechanisms. The vital signs comprise:

A free airways
B respiratory rate (using capnograph) and oxygen saturation (using pulse oximeter)
C heart rate (using cardioscope) and blood pressure (automatic noninvasive blood pressure measurement)
D level of consciousness according to RLS (Reaction Level Scale) (subjective assessment)

The outcome of the pre-hospital data provides the alarm nurse with decision making support about which of the two alarm levels, red (level 1) or orange (level 2), should be activated. In METTS-T the vital signs and anatomical injuries are the primary injury mechanisms. If the patient only has injury mechanisms and lacks the other criteria, the alarm level is always orange. Upon arrival at the emergency and accident unit, a new evaluation of the trauma alert level is performed. The trauma leader can then either upgrade, downgrade or cancel the alarm completely based on the METTS-T criteria.

All METTS documentation, manuals, algorithms, and emergency/trauma medical records are available on the emergency and accident unit's website:
http://www.sahlgrenska.se/vgrtemplates/Page____64675.aspx.

Statistics

Standard statistical methods were used to calculate average levels and standard deviations. Variance analysis was used for testing hypotheses regarding differences in average levels between the groups. Sensitivity and specificity were calculated and defined as 1-sensitivity and 1-specificity and overtriage as 1-specificity. SPSS 15.0 was used for statistical processing.

RESULTS

Basal data. The highest trauma alert level, red, accounted for 42 % of all trauma alerts which means that the complete activation of the trauma team had decreased by 58 % after tiering was introduced Women represented 30% of all trauma patients. In the red priority level, 28 % were women and in the orange priority level they represented 31 % which shows that distribution between the groups in relation to total numbers between men and women was relatively similar in this material. Age did not differ significantly regarding gender within or between the trauma alarm levels (Table I).

Physiological vital signs. In the red trauma alarm level group breathing rates were significantly higher, despite the fact that low respiratory rate (<8/minute) is included as a criteria for red trauma alarm level. Patients with severe respiratory failure, a respiratory rate <8 /minute, also had low Glasgow Coma Scale scores (GCS) and belonged to the red alarm level.
As expected, systolic blood pressure and GCS scores were significantly lower in the red trauma alarm level than in the group that was prioritized to the orange trauma alarm level. In the orange trauma alarm level group there were no patients with systolic blood pressures of <90mmHg or GCS scores of <8 (GCS scale 3-15), while in the group with red trauma alarm level there were 17 patients with systolic blood pressures of <90 mm Hg. The Injury Severity Scores (ISS) were significantly higher in the group with red trauma alarm level, and the number of patients with ISS scores >15 (ISS scale 0-75) was significantly higher in the red than the orange trauma alarm group (Table II)
The distribution of GCS scores between trauma alarm levels shows a large spread against low scores in the red trauma alarm level. The injury outcome, calculated as an ISS score after arrival at the hospital, showed a clear difference with more patients with ISS scores of >15 in the red trauma alarm group than in the orange group (Figure 2 and 3).

Duration of care and level of care. In the red priority level group the duration of the hospital stay was significantly greater in total at the hospital, in intensive care and regarding the number of days on a ventilator. In the orange trauma alarm level group only 2 patients were nursed using a respirator. One patient had a neurological disease with known, pre-existing respiratory failure and was ventilated in relation to moderate head trauma. The second patient with orange trauma alarm level and respiratory care developed pneumothorax secondary to a rib fracture and was ventilated for less than 24 hours (Table III).

Specificity and sensitivity in METTS-T. The METTS T specificity is 85 % with an overtriage of 15 %. In the red trauma alarm group, 32 patients were downgraded regarding priority to orange level after secondary triage according to METTS T in the emergency room, and only one case had the trauma alarm cancelled. The sensitivity was >99 % with the under-triage of <1 %. Only 1 % in the orange trauma alarm group was upgraded to a higher priority level than that initially awarded using pre-hospital data. The trauma alarm was cancelled in 141 cases in the orange trauma alarm group. These cases are not classified as over-triage since the orange level is the lowest trauma alert level (Table IV).

Status after 30 days. In the red group there were more patients who remained at the emergency hospital or in rehabilitation after 30 days compared with the orange group. None of the patients that were prioritized to the orange group died during their hospital stay, calculated from the date that the alarm was initiated using pre-hospital triage. The mortality rate in the red group was 10.1 % and in the whole trauma material it was 4.2 % (Table V). In a multiple logistic regression analysis there was a significant connection (P <0.001) between death and GCS points and between death and ISS scores.

DISCUSSION

The current study shows that METTS-T, a protocol based on vital signs in combination with anatomical injuries and injury mechanisms, resulted in significantly improved resource management of the collective trauma skills and expertise and capacity at the hospital. In addition, a high level of medical safety was achieved using the tiering.

This has been confirmed by mortality in orange trauma alarm group being zero and the fact that only two patients required intensive care and respiratory care for a short period of time, while the group with red trauma alarm level, as expected, had a very different outcome regarding both duration of stay, intensive care requirements and respiratory care and mortality.

Affected vital signs should according to the protocol algorithm appear as a red trauma alarm level. The study shows that even at the pre-hospital stage there was very high adherence to the alarm criteria in METTS-T despite limited training efforts.

Our study also showed that patients who were prioritized to red trauma alarm level at the pre-hospital stage also had higher ISS scores in addition to the effect on the vital signs confirming that METTS-T acts as a pre-hospital triage tool within our entire trauma panorama.

The study also clearly showed that the METTS-T method works both in hospital settings and during pre-hospital activities, which is an important observation regarding triage and its associated problems regarding different and inadequately evaluated methods [9]. Another important methodological strength of the current study is that all patients who arrived via trauma alarms during the study period could be monitored regarding patient data and outcomes.

Previous studies have shown that when the injury mechanisms are used during the activation of trauma alarms the specificity is low [1], which may mean that at the pre-hospital stage it may be difficult to determine the current medical care requirements when only using injury mechanisms. The reason for this low specificity in these studies may be that one does not, as in the case of the Sahlgrenska University Hospital, use a protocol where all variables are integrated in the level decision or the decision about which trauma alarm level should be triggered is not a direct interaction between the emergency department and pre-hospital care. In METTS-T, vital signs and anatomical injuries override injury mechanisms which contributes to a lower proportion of patients resulting in high trauma alarm levels which is a common problem with most trauma triage methods [10, 11].

At the emergency and accident unit the decision regarding trauma alarm activation and alarm levels is made by the charge nurse based on the pre-hospital report, where the trauma journal automatically produces the correct alarm level. During the development of METTS-T the aim was to reduce over-triage and minimize under-triage. In the current study, this method produced a very high level of specificity and sensitivity, providing built-in high medical safety. Both the over-triage and under-triage goals were achieved using METTS-T.

A study carried out by Santaniello et al found a significant mortality or need for intensive care in patients who were triaged to a lower trauma alarm level based solely on injury mechanical criteria. These patients did not differ sufficiently from the trauma patients that were triaged based on vital signs and anatomic injury criteria [10]. The study discovered however significant deficiencies in the form of a 34 % decrease in the material included as well as methodological problems with group division, which was based on ISS outcomes retrospectively and not on the primary trauma alarm level. The study concluded that injury mechanisms cannot be used for pre-hospital triage.

Our study, however, shows the opposite. Using the right protocol and used in the correct manner within a stable organization, the trauma alarm level is correct and medically safe.

The most important protocol property used for trauma alarms is that the team is only activated when it is absolutely necessary and that those patients who have a lower alarm level are actually in need of a lower medical level of activity. Previous studies have shown great potential for saving time and costs by using tiering [4, 5]. In most of the triage systems for activation of trauma teams, criteria are used to minimize under-triage which often results in considerable over-triage, which in turn results in large and unnecessary costs [12]. Tiering of trauma alarms at the Sahlgrenska University Hospital, according to METTS-T, has resulted in >800 hours/year being saved for each constituent function in the complete trauma alarm team

In our material, the proportion of over-triage was low and the proportion of under-triage was almost non-existent, which is a prerequisite for pre-hospital tiering and selective activation of the trauma team.

Possible competing and conflicts of interest: None stipulated

“… **>**800 hours/year have been saved for every constituent function in the total trauma alarm team.”

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Number of trauma alarms/year

Figure 1. Number of trauma alarms/year at the emergency and accident unit at the Sahlgrenska University Hospital in Gothenburg

SUMMARY

Overtriage and undertriage are both major problems during tiering of trauma alarms.
Tiering of trauma alarms can be performed safely using simple methods both at the pre-hospital stage and at the hospital.
METTS-T has high sensitivity and specificity.
Tiering according to METTS-T results in a resource-optimized trauma care chain with maintained safety.

TABLE I. Basal data in the two trauma alarm levels: red = trauma level 1, orange = trauma level 2.

Trauma level	Men, n=365	Age, years, men	Women, Age, years, n=155 women	Total, n=520
Red trauma level	158 40 ± 17		60 43 ± 22	218
Orange trauma level	207	39 ± 16	95 40 ± 18	302

TABLE II. Physiological vital signs and injury index in the two trauma alarm levels: red = highest trauma level, orange = lowest trauma level.

Vital signs and injury index	Trauma level Red, n=218	Trauma level Orange, n=302	P value
Breathing rate/min	20 ± 7	18 ± 5	0.01
Number of patients with breathing rate <8/min	7 (3.2 %)	0	
Systolic blood pressures, mm Hg	134 ± 36	144 ± 24	<0.001
Number of patients with systolic blood pressure<90 mm Hg	17 (7.8 %)	0	
Glasgow coma scale (GCS)	12.5 ± 4.0	14.9 ± 0,3	<0.001
Number of patients with GCS points <8	43 (19.7 %)	0	
Injury severity score (ISS)	15.2 ± 15.7	4.1 ± 4.7	<0.001
Number of patients with ISS points >15	80 (37.0 %)	11 (3.6 %)	

Number of patients

Red: highest trauma level
Orange: lowest trauma level

Figure 2. Allocation of GCS points in the two trauma alarm levels.

Number of patients

Red: highest trauma level
Orange: lowest trauma level

Figure 3. Allocation of ISS points <15 respective >15 in the first two trauma alarm levels

TABLE III. Total care duration at hospital, care duration within intensive care and ventilator care in the two trauma alarm levels: red = trauma level 1, orange = trauma level 2.

Care duration	Trauma level Red, n=218	Trauma level Orange, n=302	P value
Care duration, days	12.6 ± 28.3	2.4 ± 8.8	<0.001
Care duration IVA, days	2.7 ± 8.1	0.1 ± 0.4	<0.001
Number patients on ventilator	55 (25.0 %)	2 (0.6 %)	<0.001
Number of ventilator days	413	5	

TABLE IV. Final hospital alarm level (secondary) in the two primary trauma alarm levels: red = trauma level 1, orange = trauma level 2.

Final alarm level	Trauma level Red, n=218	Trauma level Orange, n=302
Secondary level, red	185	1
Secondary level, orange	32	160
Cancelled alarm, yellow	1	141

TABLE V. Follow-ups at 30 days after arriving at hospital. Red = trauma level 1, orange = trauma level 2.

Follow-ups	Trauma level Red, n=218	Trauma level Orange, n=302
Discharged to home	160	296
Emergency care hospital	24	2
Other hospital	4	3
Rehabilitation	8	1
Dead	22	0