Advanced Respiratory Support
Mechanical Ventilation (excluding CPAP and non invasive ventilation.
Possibility of a sudden deterioration in respiratory function requiring immediate endotracheal intubation.
Basic Respiratory Support
Need for FIO_2 >0.5
Patients recently extubated after prolonged intubation.
Possibility of progressive deterioration.
Patients who are intubated to protect the airway but do not require ventilatory support.
Need for mask CPAP or non-invasive ventilation.
Circulatory Support
Need for vasoactive drugs.
Support for circulatory instability due to hypovolaemia unresponsive to modest volume replacement.
Patients resuscitated after cardiac arrest.
Neurological Monitoring and Support
Central Nervous System depression obtunding the protective airway reflexes.
Invasive neurological monitoring.
Renal Support
Need for acute renal replacement therapy.

Box 1. Indications for ITU admission include patients requiring or suffering from:

Age and physiological reserve
Diagnosis and prognosis
Co-morbidities
Availability of treatment
Response to treatment to date
Quality of life pre and post treatment
Severity of illness
Patient's wishes/religious beliefs if known

Box 2. Other factors affecting suitability for ITU admission.

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SCORING SYSTEMS AND THEIR POSSIBLE USE IN A MILITARY ICU SETTING

T Nutbeam[1], M O'Meara[2], J Henning[3]

[1]Emergency Medicine Specialist Trainee, City Hospital, Birmingham. [2]Anaesthetic Specialist Trainee, Nottingham. [3]Consultant in Intensive Care, Royal Army Medical Corps.

Abstract

Scoring systems for both trauma and intensive care patients have been widely used since the 1960's. This article will introduce several scoring systems currently in use and discuss their potential use for military ICU patients.

Introduction

There are few areas of medicine that do not routinely collect data from patients and attempt to collate them into easily usable numbers to guide clinical practice. Perhaps the best known of these is the Glasgow Coma Scale (GCS), but many more of increasing complexity have been developed. All scoring systems attempt to objectively compare groups of patients, in order that meaningful comparisons can be made. This allows the clinician to:

Corresponding Author: Dr T Nutbeam, Trainee in Emergency Medicine, City Hospital Birmingham.
Email: timnutbeam@hotmail.com

- grade severity of injury and illness
- assess quality of treatment
- compare different treatment modalities
- compare mortality
- compare systems of care

The search to find a universal scoring system which is prospective, pragmatic, reliable and reproducible for all groups of patients is the alchemy of modern epidemiology. To date their use in prospectively predicting survival (or futility) of ***individual*** patients is contentious, despite many attempts at validation. No one system serves all patients at all points in time. Instead, different scoring systems have been developed to serve individual groups of patients at different times. They may, however, have a role in determining resource allocation, which could be useful to military medical planning. In addition, attempts have been made to apply scoring systems at multiple stages of patient care in order to simplify the decision making process, e.g.: initial triage, dispatch of pre-hospital teams, Emergency Department prioritisation, assessing the risk of surgical interventions, assessing the efficacy of ICU based treatments etc.

The scoring systems used in conventional ICU do not necessary fully embrace the nature of the military ICU patient. The military see higher proportions of trauma than civilian ICU; furthermore, a greater proportion of that trauma will be ballistic or blast. To that end, trauma scoring methodology has direct relevance to the military trauma patient, irrespective of, but affecting all stages of military care, including ICU. Thus, this review will focus on both trauma scoring methodology – and how this can be applied to the ICU care of the military patient – as well as conventional ICU scoring systems.

Trauma Scoring Systems

Trauma scores can be categorised into: Anatomical Scoring Systems, Physiological Scoring Systems or those which use data from both.

Anatomical Scoring Systems

Abbreviated Injury Scale (AIS)

The AIS is a six point injury severity scale introduced by the Association for the Advancement of Automotive Medicine in 1971 [1]. It has been updated by consensus methodology since it's inception and is often described with the year of update, e.g., AIS-71, AIS-90.

It was originally designed to stratify injuries of those involved in motor vehicle collisions. It is an anatomically based, consensus derived, global, severity scoring system classifying each injury in each body region on a six point ordinal (non linear) scale (1= minor, 6 = unsurvivable injury). Each injury generates a six digit code based on body region involved, system involved, and exact location; this code generates a one digit AIS severity code. The AIS is the relative risk of "threat to life" in an average person who sustains the coded injury as his or her only injury.

Further revisions added loss of consciousness to the score, increasing accuracy. It is important to note that the AIS does not take into account: preliminary diagnosis, complications (e.g. infection) consequences or outcomes.

AIS in isolation offers only a 'relative risk' of threat to life. The retrospective nature of the data collection means; it cannot be used to predict mortality, complications, or as an aid to direct treatment. Importantly it does not reflect the combined effect of multiple injuries. As such it has limited use in the military setting, it does however form the basis of several other scoring systems.

Injury Severity Score (ISS)

ISS was introduced in 1974 by Baker [2]. It was initially developed on a dataset of North American patients who sustained injuries in road traffic collisions. The original authors recognised the folly of AIS in it's failure to numerically evaluate multiple injuries and developed an aggregate score of the three most severely injured areas (using AIS).

The body is divided into six regions: Head, Face, Chest, Abdomen and Pelvic contents, Extremities (including Pelvis) and External (skin). The AIS score is calculated for each region, the three regions with the highest score are taken and squared. These figures are added together to produce the ISS score. The score ranges from 1 to a maximal score of 75, if the AIS is 6 (unsurvivable injury) for any body region the maximal score of 75 is automatically applied. The ISS has been shown to predict survival, ICU admission and length of hospital stay [3].

The ISS is widely used throughout the world and is the most frequently encountered 'trauma' scoring system found in medical literature. It is widely considered as the "Gold Standard for trauma scoring". It is a good predictor of mortality and was the first scoring system to accurately enumerate multiple trauma, facilitating comparison between patient groups within the trauma literature. It has been criticised as it does not account for multiple serious injuries in one body region [4]. The ISS suffers from the flaws of anatomical scoring systems; it cannot account for interventions, complications and cannot be used for triage purposes.

New Injury Severity Score (NISS)

In response to some of the criticisms of ISS, the NISS was introduced in 1997 [5]. The NISS is calculated from the top three AIS scores regardless of region. These numbers are squared and added together (similar to ISS). The NISS will always be greater than or equal to the ISS and in the range 1-75 but allows for multiple serious injuries in one body system. Similar to ISS, an AIS score of 6(unsurvivable injury) for any body region invokes the maximal score of 75. The NISS has been shown to be a better predictor than ISS of mortality and morbidity in most trauma types, however, this may reflect the case mix on the database from which it was derrived [6].

Physiological Scoring Systems

The Trauma Score (TS), Revised Trauma Score (RTS) and Triage Revised Trauma Score (TRTS)

The Trauma score was introduced in 1981 by Champion *et al* [7]. It used five physiological parameters (respiratory rate, respiratory expansion, systolic blood pressure, capillary return and Glasgow coma score (GCS)) to calculate a score of 1-16. These parameters were chosen from the clinical experience of the authors and some were difficult to measure (e.g. respiratory expansion) Furthermore it was noted that only 3 of the parameters had any predictive value, so in 1989 the TS was superseded by the Revised Trauma Score [8].

The RTS uses three physiological variables (GCS, systolic blood pressure and respiratory rate), the actual values are used to determine a "score" (Table 1). The higher the degree of physiological derangement the higher the score (0-4). This score is multiplied by a weighting parameter and combined to give a total score of 0-7.8408. The total RTS is rounded to the nearest whole number: a data table (Table 2) is used to determine the probability of survival. Unweighted RTS values may be used to calculate priorities in mass casualty incidents (Table 3) as the TRTS.

Coded Value	GCS	SBP (mm Hg)	RR (breaths/min)
0	3	0	0
1	4-5	<50	<5
2	6-8	50-75	5-9
3	9-12	76-90	>30
4	13-15	<90	10-30

Table 1. Calculation of the Revised Trauma Score (RTS). The RTS = 0.9368 GCS + 0.7326 SBP + 0.2908 RR.

RTS (nearest whole number)	Probability of Survival (%)
0	3
1	7
2	17
3	36
4	61
5	81
6	92
7	97
8	99

Table 2. The Probability of Survival using RTS.

TRTS	Priority	Category
0	T0	Dead
1-9	T1	Urgent
10-11	T2	Immediate
12	T3	Delayed

Table 3. Use of unweighted RTS scores in triage as the Triage Revised Trauma Score (TRTS).

Unlike the anatomical scoring systems, the RTS accounts for the high mortality from severe isolated head injuries. TRTS represent an easily calculated triage tool which is widely used in mass casualty incidents in both the civilian and military setting and has been validated as a field triage tool. The weighted values calculated for the RTS are derived from logistic regression of large USA trauma registries. As such, they may be more applicable to this group of patients. There is a significant proportion of penetrating trauma in these databases, making the weightings more applicable to a military setting.

The RTS does not allow for those with a pharmacological reduction in GCS. It makes no allowance for intubated and ventilated patients. With an increase in early critical care involvement (particularly in the military environment) this may limit its use. It does however remain an easily reproducible score with some clinical relevance that can be easily calculated on the ground.

Combined Anatomical and Physiological Scoring Systems

Trauma Score Injury Severity Score (TRISS)

Introduced in 1987 the TRISS method was designed and is still used today to compare trauma outcomes from different centres and systems [9]. It combines data from ISS, RTS and the patient's age along with a coefficient to allow for penetrating and blunt injury. The calculation (Box 1) uses coefficients derived from multiple regression analysis of the Major Trauma Outcome Study (MTOS) database. The logistic regression allows calculation of probability of survival.

It is subject to the criticisms of its component systems (ISS and RTS) and makes no allowance for pre existing medical conditions – though this may be of less importance in the military population. Some concerns have been raised about it's discriminatory power [10].

$$Ps = \frac{1}{1+e^{-b}}$$

Box 1. Calculation of TRISS where Ps is the probability of survival and b = is a standard weighted coefficient comprised of the sum of the separate coefficients for Revised Trauma Score, Injury Severity Score and age according to blunt or penetrating mechanism of injury.

A Severity Characterisation of Trauma (ASCOT)

ASCOT was introduced in 1990 and intended as a refinement to TRISS [11]. It uses a similar type coefficient calculation to TRISS and combines RTS with the Anatomic Profile (AP) score (in place of ISS).

AP is a scoring system which groups AIS score of ≥3 into three anatomical regions (Box 2). The AP score is the square root of the sum of the squares of all the AIS scores in a region: the total component values for the four regions give the AP score. Using logistic regression the AP score can be used to calculate a probability of survival.

Despite evidence that ASCOT outperforms TRISS[12] (especially for penetrating trauma), the complexities of calculating the score have prevented its widespread use. It has similar uses to TRISS in comparison of trauma centres and systems.

A = Head and Spinal Cord
B = Thorax and Anterior Neck
C= All other serious injuries
(D = All other non-serious injuries)

Box 2. Anatomic profile (AP) scoring system: AIS scores of ≥3.

Intensive Care Scoring Systems

Whilst the above systems have shown their utility in the military and some are routinely collected and published by other departments, such as the Major Trauma Audit for Clinical Effectiveness (MACE Audit) from the Academic Department of Military Emergency Medicine, they do focus on a specific patient group and give little indication of ICU workload. They do not give meaningful data on medical admissions e.g. heat injuries, nor give an idea on length of stay so are not useful for manpower predictions. Presented below are some Intensive Care systems.

Acute Physiology And Chronic Health Evaluation (APACHE)

The APACHE score has been through several changes since its first introduction by Knaus *et al* in 1981 [13]. The most commonly used system worldwide is APACHE II [14]. It consists of two component parts: a chronic health evaluation and an Acute Physiology Score (12 variables – Box 3). The total score ranges from 0-71 and gives an indication of mortality. APACHE III and APACHE IV [15,16] scores have been revised in recent years but, despite their reported advantages, they have not been widely adopted or validated, because the algorithm for data interpretation is subject to commercial protection.

The APACHE scores are widely used to trigger certain medications or interventions (e.g. the use of activated protein C). They have also been validated extensively in diverse patient groups as predictors of mortality. However it is probably of limited use in military ICU patients. The original population used to derive the score consisted of only 8% trauma patients and this group had only a 9% mortality, so concern has been raised about its ability to accurately predict outcome in this population. Also APACHE scores are calculated after 24hrs on ICU, so the quality of initial resuscitation is not accounted for – the normalising of physiological parameters by high quality resuscitation will lead to further decrease in the accuracy of the score.

Glasgow Coma Scale
Age
Mean arterial pressure (mmHg)
PaO^2 (FIO^2 <0.5)
[K^+] (mmol/L)
WBC x 1,000/cm^3
Heart rate (beats/min)
Respiratory rate (breaths/min)
pH (arterial)
[creatinine] (mg/dL)
Core temperature (C°)
[Na^+] (mmol/L)
Hematocrit (%)

Box 3. APACHE II – Variables to Calculate Acute Physiology Score.

Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (POSSUM)

Introduced in 1991 [17] POSSUM is designed as a simple method of approximating risk adjusted surgical quality, allowing comparison between different surgeons and institutions. In most situations it is a good predictor of 30 day mortality and morbidity. It is a two part scoring assessment: a pre-operative physiological score (12 variables) combined with an operative severity score (6 variables). Several modifications have been suggested for specific surgical interventions and patient groups, (CR-POSSUM, R-POSSUM, O-POSSUM) however none of these are specifically for the multiple injured trauma patient or military patient. It is however widely used in surgical units throughout the world and is used as a basis for surgical audit, comparison of outcomes and evaluating new techniques. The data required for the calculation of POSSUM can be found in Box 4.

Physiological Pre-operative data
Age
Cardiac signs
Respiratory signs
Systolic blood pressure
Pulse
Coma score
Serum urea
Serum sodium
Serum potassium
Haemoglobin
White cell count
ECG
Operative Severity Data:
Operative magnitude
Number of operations within 30 days
Blood loss
Peritoneal contamination
Presence of malignancy
Timing of operation

Box 4. The data required to calculate POSSUM.

POSSUM in isolation may not deliver the necessary sensitivity for use in the military trauma population. It does not account for preoperative injuries, the nature of the operation performed (e.g. damage control surgery), availability and nature of pre and post operative support. It may be possible to produce a modified POSSUM for use in military trauma populations.

Simplified Acute Physiology Score (SAPS)

SAPS was initially developed in 1993 [18]. Since then it has found wide acceptance in ICU, because of its ease of use. It has been validated on a large population of American and European Intensive care unit patients. The data set can be seen in Box 5. It's ability to predict mortality does however vary according to the country in which it is used, and therefore, presumably the military subset of patients would need careful evaluation. On top of this, like APACHE, it incorporates values relating to chronic health which contribute up to 50% of the reliability of the score [19], which may not have relevance to the essentially fit military population. It is however easy to compute and may give some valuable information.

Type of admission	Chronic Disease	
GCS		
Age		
Systolic BP	Heart rate	Temperature
Oxygenation	Urine output	
White Cell Count	Urea	
Potassium	Sodium Bicarb	Bilirubin

Box 5. Parameters for SAPS-II.

Sequential Organ Failure Assessment (SOFA)

Originally called the Sepsis-related Organ Failure Assessment score, SOFA was introduced in 1994 [20]. It is the most widely used of the Organ failure scoring systems and has many similarities to its rivals: Multiple Organ Dysfunction Score (MODS) and Logistic Organs Dysfunction Systems (LODS).

The SOFA score is a composite of scores from six organ systems: respiratory, cardiovascular, hepatic, coagulation, renal, and neurological. The degree of dysfunction is graded from 0 to 4, with the total maximum SOFA score calculated by adding the worst scores for each of the organ systems during the patients ICU stay. The six organ systems are assessed using a total of twelve objective variables (Table 4).

The SOFA score had been shown to be reliable across many patient groups [21,22] including trauma patients [23] though much of the work done has been focused around sepsis related organ failure. It is useful in that it takes into account a series of complications (organ failures) which may occur in a critically ill patient rather than those which occur at a set time (e.g. at point of wounding) or in a set time period e.g. APACHE.

The SOFA score provides an easily calculated score which indicates how the status of a patient evolves over time, and also some indication of workload.

Mortality Prediction Model (MPM)

This score was first developed in 1985, revised in 1987 [24] and a second version (the version still most commonly used) released in 1993 [25]. MPMII is derived from multiple regression analysis based on data from thousands of patients. The MPM model applies weighting scores to 15 variables at time of admission related to: physiology, acute and chronic disease, reason for admission, age and interventions performed. MPM_0 is calculated at time of admission, MPM_{24}, MPM_{48} and MPM_{72} at 24, 48 and 72hours respectively.

Intensive Care National Audit and Research Centre (ICNARC)

This UK based, non-profit organisation was established in 1994 to develop and undertake comparative audit and evaluate research in intensive care. They undertake data collection from throughout the UK and Ireland. This data is used to calculate various mortality prediction scores (e.g. APACHE II) and compare outcome from matched patients/patient groups between participating intensive

Organ system	Score				
	0	1	2	3	4
Respiratory: PaO_2/FiO_2	>400	≤400	≤300	≤200	≤100
Renal: creatinine (mol/l)	≤110	110-170	171-299	300–440; urine output ≤500 ml/day	>440; urine output <200 ml/day
Hepatic: bilirubin (mol/l)	≤20	20-32	33-101	102-204	>204
Cardiovascular: hypotension	No hypotension	MAP <70 mmHg	10-30	Dopamine >5[a] or epinephrine ≤0.1[a] or norepinephrine ≤0.1[a]	Dopamine >15[a] or epinephrine >0.1[a] or norepinephrine >0.1[a]
Hematologic: platelet count	>150	≤150	≤100	≤50	≤20
Neurologic: Glasgow Coma Scale score	15	13-14	10-12	6-9	<6

Table 4. The Sequential Organ Failure Assessment (SOFA) score indices.
[a]Adrenergic agents administered for at least one hour (doses given are in μg/kg per minute). FiO_2, fractional inspired oxygen; MAP, mean arterial pressure; PaO_2, arterial oxygen tension; SOFA, Sequential Organ Failure Assessment.

care units. There is a standard data collection and diagnosis coding form which is used to accumulate data from the first 24hours of the patients care. Whilst the information produced is useful especially as it allows direct comparisons with similar units, the data collection is time consuming and the information held in the public domain, with attendant security implications.

Discussion

This paper has outlined the history, use and validation of various scoring systems which could be of use to a military ICU population of patients. No one score fits perfectly for all patients and at the present time, there is no score specifically validated for military patients *per se*. The scoring systems in general use have their own limitations. There is debate as to the appropriateness of rationing care based on scores generated, however in the Field Environment where there is the potential to be rapidly overwhelmed any information regarding prognosis could be useful. There is little dissent in using disease-specific scoring systems to guide treatment (e.g., CURB or Glasgow scoring for pneumonia or pancreatitis), but there is unease in using scoring systems to withhold treatment. Furthermore, many of the systems take single point-in-time measurements, which prevent them from factoring in pre-ICU treatment. Most scoring systems focus on easily measurable tangible outcomes, such as mortality of length of stay, these may not be the most relevant. From a patient's point of view, quality of life indices may be more appropriate. From a military planning perspective, return to duty may be a more meaningful index of a system of care. Clearly, such indices are difficult to incorporate into an acute setting.

In particular, their discriminatory power is enhanced by the inclusion of chronic disease parameters or organ dysfunction, which could not / should not be treated in a military setting. An appropriately functioning military occupational health service should screen out chronic medical conditions which many scoring systems are biased towards. On the other hand, military medical services may take on an increasing workload of indigenous population workload in areas of the world with failing healthcare systems. To this end, more conventional ICU scoring systems may be appropriate to such groups of patients (in comparing them with UK equivalents) when determining ICU outcome data. To our knowledge, little information currently exists on quality outcome data for such patients. If it were evaluated on whatever scale, there is a high chance that it would out-perform many of it's NHS counterparts.

In conclusion, there is no unique scoring system developed for the military ICU patient load. Trauma scoring should form part of the evaluation of ICU care, despite much of the data being generated in pre-hospital or ED phases of care, however the information from these systems is limited. This will ensure that service personnel continue to be treated in an appropriately governanced ICU system. For other patient populations, a dilemma remains as to which system to use. There can be little doubt however that a system of data collection needs to be developed, where patient indices can be held centrally and all of the above systems used to see if any fits well. Clearly we can not go on any longer without having this sort of information readily available. In the fullness of time it may then become possible to analyse the database and develop a military-specific scoring system.

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FOCUS ON SEPSIS AND INTENSIVE CARE

A McD Johnston

Department of Military Medicine, Institute of Research & Development, West Wing, Birmingham Research Park, Vincent Drive, Edgbaston.

Abstract

The Surviving Sepsis Campaign (SSC) Guidelines collate the evidence for managing sepsis. Most of the interventions suggested by the SSC guidelines are very relevant to military critical care, including rapid microbiologic investigation, early antibiotic administration and many aspects of early goal directed therapy. Other interventions may be more difficult to provide in remote theatres of operation where resources may be limited. This article discusses the application of the SSC guidelines to deployed military hospitals, with suggestions as to which interventions are feasible, and which may not be indicated.

Introduction

In this article I discuss the military relevance of the Surviving Sepsis Campaign (SSC) Guidelines for management of sepsis. These are considered to be the current gold-standard guidelines for managing sepsis. I will attempt to highlight those parts of the guidelines particularly relevant to practice in a deployed military setting. I will also discuss other aspects of management of particular interest to the military setting.

Definition

Sepsis is defined using a consensus definition published in 1992 by the American College of Chest Physicians and the Society of Critical Care Medicine [1].

The definition requires the presence of at least two of a possible four features of the systemic inflammatory response syndrome (SIRS) in the presence of infection (Table 1).

Sepsis - two or more of the features of Systemic Inflammatory Response Syndrome in the presence of infection	
Temperature dysregulation	T > 38°C or < 36°C
Immune dysregulation	WBC < 4 or > 12x10^9 (or > 10% band forms)
Tachycardia	HR > 90
Tachypnoea	RR > 20 or mechanical ventilation
Severe sepsis	**Septic shock**
Sepsis and organ dysfunction or hypoperfusion	Sepsis with hypotension that doesn't respond to adequate fluid resuscitation or requires vasopressors

Table 1.

Corresponding Author: Major A McD Johnston MRCPI DMCC RAMC, Department of Military Medicine, Institute of Research & Development, West Wing, Birmingham Research Park, Vincent Drive, Edgbaston B15 2SQ
Email: amcdj@doctors.org.uk

Many military critical care patients with significant trauma will have features of SIRS. This may make the detection of subsequent infection more difficult than in patients presenting with internal medical conditions such as pneumonia. Sepsis should be foremost in the military specialist's mind when faced with a patient who unexpectedly deteriorates at a point in their hospital stay when they should be improving.

Sepsis in deployed military populations

Retrospective studies of "preventable" deaths from both the Vietnam conflict and US Special forces deaths in the recent past [2,3] suggest a significant minority of around 4-6% of patients die from sepsis. The incidence of sepsis in other historical conflicts is not well defined [4], however there is some data from the more recent conflicts in Iraq and Afghanistan. In patients treated at a US military hospital in Iraq around 5% of patients sustained colorectal trauma, with a 16% incidence of sepsis [5]. Data from the USS Comfort cohort of patients suggests severe infection is more likely in patients with abdominal injury, soft tissue trauma or a high Injury Severity Score[6]. At the time of writing no sepsis deaths have occurred in UK personnel injured in recent conflicts [7].

The Surviving Sepsis Campaign - adapting the guidelines to a deployed military setting

The Surviving Sepsis Campaign guidelines are international evidence based guidelines for managing sepsis [8]. They were revised in 2008, and are the basis for managing septic patients in many civilian hospitals around the world. The campaign management recommendations include a six-hour care bundle and a twenty-four hour care bundle.

A care bundle is a collection of interventions that are individually effective, and therefore should be effective when combined. Bundling these together may simplify compliance. Audit of bundle compliance is done on an all or nothing basis, where the whole bundle must be completed to count as bundle completion.