Reviews in Medicine

Accident and emergency medicine – I

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Introduction

The speciality of accident and emergency medicine embraces all specialities. Over the last few years the British Association for Accident and Emergency Medicine has been making considerable efforts to improve the treatment of victims of major trauma. The inadequacies of trauma management have been highlighted in a number of important documents,^{1,2} and since major trauma represents one in every 1,000 accident and emergency department attendances³ there is a need to address this problem. Thus a major issue in accident and emergency medicine remains the optimal management of victims of trauma. This review will concentrate on some of those issues.

Trauma systems

'In general, trauma care is fragmented, disorganized and has an unacceptably bad outcome. Pre-hospital care of the accident victim is sub-optimal . . . The patient is usually taken to the nearest hospital without regard to surgical availability.' (Professor D. D. Trunkey, *British Journal of Surgery*, Travelling Fellow, 1987).

Injury is a major cause of mortality and morbidity in the UK,⁴ indeed it is the commonest cause of death in the first four decades of life. It has important economic implications, both through the cost of the immediate and long-term treatment necessary as well as the inevitable loss of productive years.

Trunkey has described the trimodal distribution of deaths following injury⁵: 50% of these deaths occur at the scene and are usually due to lacerations of the brain, brain stem, upper spinal cord, heart, aorta or other large vessels. The only effective measure here is through prevention.

The second peak occurs within the first four hours after injury. Death is usually due to intracranial haemorrhage, haemopneumothorax, or a

ruptured spleen or lacerated liver, which, together with other injuries, is associated with major blood loss. This period is known as the 'golden hour' to emphasize the time following injury when resuscitation and stabilization are critical,⁶ the third peak occurs days or weeks after the primary insult and results from sepsis or multiple organ failure.^{7,8} This third peak benefits from adequate resuscitation in the immediate or early post-injury phase.

The Royal College of Surgeons Commission on the Provision of Surgical Services reported a retrospective examination of deaths from injury in England and Wales.⁹ This study showed that one third of the deaths occurring after the patient reached hospital were judged to be preventable by three or more of the four assessors. The principal reasons for preventable death were failure to diagnose or failure to treat adequately injuries causing haemorrhage or hypoxia. The results closely parallel those obtained previously in studies undertaken in the United States.^{10–12}

Initial attempts at audit in accident and emergency departments in the UK involved the analysis of deaths and a study of the lessons which could be learnt.^{13–15} Later audit projects involved the use of trauma scoring and in-depth assessment of the patient's management to highlight errors. These studies resulted in recommendations for altering staffing arrangements and improving training in the units involved.¹⁶

This style of audit has been repeated on many occasions and has raised the issue of preventable deaths.^{17–20} Some studies have paid particular attention to the preventability of death in special areas, for example, penetrating injury²¹ and childhood accidents.

According to Trunkey a trauma system consists of four patient components: (1) access to care; (2) pre-hospital care; (3) hospital care; and (4) rehabilitation; and four societal components: (1) prevention; (2) disaster care; (3) education; and (4) research. Trunkey challenged the surgeons of the UK through the Royal Colleges of Surgeons to change a system that is currently providing suboptimal care.²²

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It is felt that the effective implementation of a regional system of trauma care to ensure the rapid transportation of critically injured patients to trauma centres has the potential to reduce substantially the level of morbidity and mortality caused by injuries.^{23–27}

Trauma systems and the concept of the trauma centre have been addressed in numerous articles.^{28–41} The major challenges to be overcome by a trauma system include the education of the public with regard to the benefits of an inclusive trauma care system, financing such a major development and, as always, quality assurance.

The Royal College of Surgeons Commission⁴² on the Provision of Surgical Services has stated what it considers to be the necessary characteristics of trauma centres and district general hospitals which receive significantly injured patients. These criteria include organizational procedures, staffing levels and operating theatre requirements amongst others.

It has been suggested that care should be provided by a multidisciplinary team consisting of senior medical personnel in anaesthesia, accident and emergency medicine, general and orthopaedic surgery and intensive care. All of these specialists should be quickly available 24 hours a day. A more detailed description of the essential and desirable requirements of both the hospital and trauma personnel for a United States Trauma Centre have been described by the American College of Surgeons.⁴³

The Royal College report recommended that there should be a general hospital in each district capable of dealing with seriously injured patients. The other district general hospitals locally should have their freedom to treat such patients restricted. They also recommended that one trauma centre should be provided for approximately 2 million of the population and this would deal with the severely injured patients. A trial trauma centre has now been set up at the North Staffordshire Royal Infirmary by the Department of Health in response to the 1988 Royal College of Surgeons Report and is at present being assessed.⁴⁴

It is thought that approximately 25,000 people per annum are severely injured in England and Wales. This quota would require approximately 20 trauma centres and their locations would be determined by factors such as population density, geography and regional resources.²²

The setting up of trauma centres has been justified on the basis that it will save the lives of catastrophically injured patients. Trunkey studied two adjacent counties in the United States and showed an improved outcome in the one with a trauma centre compared to the other which had a non-centralized trauma system. These improvements were related to the early recognition and

rapid definitive surgical management of the life-threatening injuries identified.^{45,46} The conclusion has been confirmed by several studies.

The most important function of a properly organized trauma system is to ensure that patients do not succumb from treatable injuries. Failure to recognize promptly and treat adequately simple life-threatening injuries is the tragedy of trauma rather than the inability to handle the catastrophic or complicated injury.

Whilst many people believe that the trauma centre is an ideal, first-class trauma care can be provided by concentrating resources so that experienced staff are available to deal quickly with seriously injured patients. The treatment of the multiply injured patient has proven to be well worth the effort, as it allows large numbers of such trauma victims to return to work,^{47,48} benefitting the economy in terms of quality adjusted life years (QALYs).⁴⁹

Aspects of UK trauma care are improving.^{50,51} An integrated trauma system for the UK must be developed.^{52,53}

Injury prevention

Accident and emergency physicians play a role in injury prevention. It is suggested this may be achieved in the field of research, by direct action, through education of the public and by influencing legislation.⁵⁴

The government's consultative document *The Health of the Nation*⁵⁵ identifies injuries as a 'key area' to target a strategy for health as injuries are a major cause of concern, there is wide scope for reducing them and targets may easily be set. Without doubt injuries are a neglected epidemic.⁵⁶

Injury prevention with an injuries strategy involves specifying targets and through education, engineering and design, legislation and improvements in living and working environments, achieving these targets.⁵⁷ Much work exists on injury prevention^{58–63} and the spectre of alcohol often raises its ugly head.^{64–69} Previous work with for example seat belts,^{70–73} drink driving, child car seats, car design, motorcycle helmets, smoke alarms and flame-resistant clothing has been effective, and we need to continue to meet this challenge.⁷⁴

Pre-hospital care

Death within the first hours after injury may well be prevented by high-quality care in the pre-hospital setting. The retrospective survey of 1,000 trauma deaths by Anderson⁷⁵ noted wide variation in the

proportion of trauma victims 'dead on arrival'. The authors suggested this was due to the difference in the quality of pre-hospital care offered.

The recent 'Ambulance 2000' document recommends the national acceptance of the WHSTA RCF training package and suggests the placing of a more highly trained ambulance person on each emergency response vehicle.⁷⁶ In fatal accidents it is often the lack of very basic care such as airway management that has contributed to death.^{77,78}

Trunkey⁷⁹ states that the major controversies regarding pre-hospital care include:

1. What procedures are useful in the field?
2. What is the trade-off between the time spent in the field versus benefit of the procedure?
3. Medical control of the team in the field.

Out-of-hospital advanced life support appears to be of some benefit in blunt trauma in an urban population where improved survival at 24 hours has been noted.⁸⁰ Similarly it has also been shown to be beneficial in a rural setting.⁸¹

As far as penetrating thoracic and cardiac injuries are concerned, immediate transportation without attempted stabilization in the field seems to be the optimal pre-hospital management of these patients.^{82,83}

With regard to the treatment of haemorrhage either by intravenous fluid replacement or the use of the pneumatic anti-shock garment (medical anti-shock trousers – MAST) there is still considerable controversy.

Most data concerning MAST have been obtained from uncontrolled studies. Recently, however, Mattox has conducted a controlled, randomized trial of 911 trauma victims which reveals that the MAST seem to provide the trauma victim with no significant benefit and their use in the pre-hospital setting is not warranted.

Arguments concerning the value of intravenous fluids relate to the premise that, whilst fluid replacement is widely accepted as appropriate for trauma patients,⁸⁴ computer models reveal that intravenous infusions are of little benefit except:

- (a) where there is a significant rate of blood loss;
- (b) the pre-hospital time exceeds 30 minutes;
- (c) the infusion rate is approximately equivalent to the bleeding rate.^{85,86}

These conclusions are supported in clinical practice where pre-hospital intravenous fluid administration has been found not to influence mortality rates following trauma.⁸⁷

The placement of intravenous catheters and the initiation of fluid therapy at the scene have been reported to delay transfer to hospital.^{88,89} However, intravenous cannulation *en route*, whilst the ambulance is moving, has been shown to be as successful as when attempted at the scene. Under these circumstances also there is no delay in arrival

at the hospital.⁹⁰

The use of hypertonic saline for the correction of hypovolaemia in the pre-hospital setting is currently being evaluated and this solution may provide a useful one.^{91,92}

The goals therefore of pre-hospital care of the critically injured patient should be to reduce the time from injury to definitive surgical care and yet provide resuscitation that will increase the chances of the patient arriving at the hospital alive and in a reasonable condition. Other considerations must of course be cost, a mechanism to maintain skills, and the continuous evaluation of the usefulness of the various procedures.^{93–98}

Trunkey states that it is not possible to stabilize the critically injured patient fully and that only a few techniques are truly life-saving in the pre-hospital setting. He stresses the value of prompt careful extrication, protection of the spinal cord, the application of traction splints and endotracheal intubation for the severely shocked patient or the unconscious patient with a head injury. It was also felt that many of these techniques were not universally applied to accident victims in the United Kingdom and that improved training was necessary.⁹⁹

Accident flying squads

Debate concerning accident flying squads which attend the injured, especially the entrapped, at the scene of the incident has been re-opened by the Irving Report on Preventable Deaths and the succession of major disasters in the UK.¹⁰⁰

One of the first such flying squads organized from an accident department was started in Derby by John Collins as far back as 1955. Even then the importance of properly trained and experienced staff backed up by adequate, appropriate equipment was being stressed. At that time, their role was to cater for any emergency, medical or surgical, and also to be prepared to attend a major accident or disaster.¹⁰¹

Snook¹⁰² organized, evaluated and costed an operating accident flying squad. He felt that out of 302 casualties attended, six deaths had been prevented. Other authors have subjectively assessed their accident flying squads, generally reaching favourable conclusions.¹⁰³ Claims that flying squads 'undoubtedly save lives' must always remain open to question and studies of their effectiveness require objective analysis to validate their results.¹⁰⁴

In one study analysis was initially carried out using an injury scoring system and the retrospective review of 250 patients treated showed that two lives were saved. It was felt unequivocally, however, that, on clinical grounds, measures taken at the

scene had led to the survival of six of the patients involved.¹⁰⁵

Initially, Steedman¹⁰⁶ in 1986 failed to find evidence to confirm the subjective judgement of the benefits of pre-hospital treatment in traumatic injury. Since then further work from Edinburgh^{107,108} has shown a small, but significantly reduced mortality in the severely multiply injured patient.

The necessity for mobile medical teams to develop effectively the skills necessary to work in a pre-hospital situation has been stressed by Steedman and this allows them to train for and work more effectively in major accidents or disasters.¹⁰⁷

The costs of equipping a flying squad are not inordinate and may become more cost effective if they are used day to day, for instance, for urgent transfer of severely ill patients. Also frequent use allows them to be more practised and hence more useful in a disaster.¹⁰⁸

Helicopter transportation

The Royal College of Surgeons' Report suggested that consideration be given to more sophisticated methods of transport, such as helicopters, for transfer of patients between hospitals. They recommended, however, that further independent objective evaluation be undertaken prior to their general introduction.

The evacuation of casualties by helicopter¹⁰⁹ has been used extensively in both West Germany,¹¹⁰ the United States¹¹¹ and in parts of the UK for many years.^{112,113} More recently, dedicated helicopter emergency medical services (HEMS) have been established in Cornwall¹¹⁴ and London.¹¹⁵

The role of helicopters includes the primary evacuation and secondary transfer of seriously ill medical¹¹⁶ and surgical patients including those with burns.^{117–118} Of prime importance has been the safety record of HEMS' helicopters which have accident rates substantially higher than those of commercial helicopters.¹¹⁹ The accident rate of 1 per 5,000 flying hours is twice the general aviation rate and 100 times the rate experienced by scheduled airlines.

Important factors identified as being related to the accident rate were the number of flights made by the programme (the busier programmes having a low accident rate). It was also found that programmes which had the ability to fly under instrument flight rules had no mishaps whatsoever.¹²⁰ In addition, the not inconsiderable costs of a helicopter system needs careful consideration before one is instituted.^{121,122}

Any doctor escorting a critically ill patient by air needs to be aware of the differences between the

airborne and terrestrial environments. Factors such as the effects of altitude and acceleration/deceleration forces need to be considered.¹²³ Model curriculae in air medical transport are now available for the emergency physician resident¹²⁴ and articles reviewing the role of emergency medical air transport services which provide advice concerning staff training, evaluation and safety criteria are appearing.^{125,126}

Inter-hospital transfer of the critically ill patient by helicopter as a secondary transport mode was reviewed by Ridley *et al.*¹²⁷ They advocated the need for an adequate secondary transport service and reviewed the requirements for transporting the critically ill. This has been adopted and assessed by, in particular, Dr Audrey Bristow at St Bartholomews Hospital, who has designed a dedicated hospital transfer scheme which deals with these problems.^{128,129} The Barts team have recently published the results of the inter-hospital transfer of the first 50 patients of the Careflight Project.¹³⁰ Pre- and post-transfer sickness scores were measured and it was found that there was no deterioration during transfer. They suggested that a helicopter transfer system using suitable equipment and appropriate staff was a practical and safe method of inter-hospital transfer and was probably preferable to land transfers for distances in excess of 25 miles. However, helicopter transport as a secondary transfer mode often has delays.¹³¹

Whilst the helicopter has a role in the transport of the critically ill/injured patient it should always be only one component of a thoroughly integrated system for the care of a trauma victims. It should be used with effective triage guidelines, ensuring that the right patients receive the right treatment at the right time in order to save life.¹³²

The use of appropriate scoring systems will allow objective audit to compare air/ambulance programmes as there is no doubt that a number of patients transported by air are not necessarily critically ill.¹³³ Some studies have looked at a simpler system just using on-scene field triage in order to make a decision with regard to helicopter transport.¹³⁴

Studies have consistently demonstrated a significant decrease in mortality for patients transported to a trauma centre by helicopter.¹³⁵ The helicopter service has improved survival more markedly in patients with low trauma scores. Increased survival may relate to a shorter interval between injury and the institution of pre-hospital resuscitative treatment, than to more rapid arrival at the trauma centre. The helicopter transport team are experienced in many life-saving techniques and are well equipped.^{136–141}

Studies by Baxter and Moody^{141,142} found that the presence of an in-flight physician reduced mortality by 52% when compared with paramedic-

staffed land-based systems. There was a 35% reduction in predicted mortality for patients treated by a nurse/physician team compared with that of the flight/nurse/paramedic helicopter.

Further, Baxter and Moody found that physicians' psychomotor skills and judgement were the two factors most instrumental in lowering mortality; aggressive life-saving procedures were performed more frequently by the physicians particularly when considering head-injured patients.¹⁴² In addition, Champion¹⁴³ found that physician input had significant implications for the control of triage of patients to trauma centres. Fisher found that 'a physician in attendance was deemed medically desirable for one half of the flights.'¹⁴⁴

Other studies came up with opposing views, for instance, Hamman *et al.* felt that there were no differences between a physician-led team and that composed of an experienced nurse and paramedic operating with well-established protocols.¹⁴⁵ Rhee *et al.* conversely showed the need for the flight physician and felt that they made an essential contribution in 22% of cases.¹⁴⁶ The most important factor influencing patient management appears to be the physician's judgement and this factor is most pronounced in the care of the paediatric patient.¹⁴⁷

Schiller found that there appeared to be no survival advantage for the helicopter transported group of patients in an urban area which had a sophisticated pre-hospital care system.¹⁴⁸ However, the mortality reduction produced by the use of helicopters in rural areas has been proven.¹⁴⁹ It appears that aeromedical transport systems using fix-wing or helicopter transport can extend the clinical benefit of the regionalized trauma service up to 800 miles without increasing trauma-related mortality.¹⁵⁰

Owing to the prohibitive cost of airborne transportation, many authorities continue to question the effectiveness of this mode and there have been many calls for definitive objective assessment.¹⁵¹⁻¹⁵³ We eagerly await the result of the Royal London Hospital Helicopter Emergency Medical Service which the Department of Health has commissioned.

Training in accident and emergency medicine

Accident and emergency (A & E) medicine, which is an expanding speciality, is attracting increasing interest from undergraduates and junior medical staff who recognize that experience in the discipline is likely to be useful to them in their future careers. This was acknowledged by postgraduates in a survey¹⁵⁴ which revealed that accident and emergency medicine was one of the five most important specialities in which to gain experience. In view of such evidence, the establishment of an

organization of Teachers of Emergency Medicine has been suggested. This would run along the lines of the Society of Teachers of Emergency Medicine which is already in existence in the United States.^{155,156}

The recommended teaching standards for undergraduates in accident and emergency departments should include instruction in first aid and basic life support. As well as this, formal lectures on emergency medicine and a period of attachment to the floor of the department where practical experience could be gained. A log book of this theoretical and practical experience should be maintained. Unfortunately, there are still medical schools in the United Kingdom where an accident and emergency attachment is not mandatory.¹⁵⁷

By the time of graduation, all medical students should be able to, amongst other things, provide immediate life-sustaining treatment, create a problem list, discuss a differential diagnosis, present a treatment plan and carry out essential clinical skills.¹⁵⁸⁻¹⁶⁰ Unfortunately, this is not always the case and senior house officers starting a job in A & E medicine are often found to be poorly trained in many aspects of the work.¹⁶¹

A teaching programme for senior house officers has been formulated by the BAEM Executive Committee. This includes an induction course of perhaps 1-2 days, weekly teaching and audit sessions as well as situational teaching.¹⁶²

Emergency medicine training in the USA and Australasia is based on curricula and study guidelines produced by the National Colleges of Emergency Medicine and affiliated organizations.¹⁶³⁻¹⁶⁷ Consideration should be given to the introduction of such a scheme in the UK.

Some of the deficiencies resulting from the lack of administrative and managerial training have been highlighted.¹⁶⁸⁻¹⁷⁰ Gradually a 'core curriculum' is emerging which emphasizes advanced trauma and cardiac life support, practical clinical skills, secondments to the emergency services and poisons centres as well as formal management training.¹⁷¹

In the USA the emergency medicine resident's experience is now tracked by computer. This allows the course organizer to monitor the extent of the trainees clinical experience¹⁷² and provide a record of the various practical procedures performed.¹⁷³

Theoretical knowledge and case simulations can be supplemented as necessary using computer-assisted instruction.¹⁷⁴

Advanced trauma life support (ATLS)

The initial and continuing education and training of those involved in the management of trauma is ideally organized on a national basis in order to

ensure uniformly high standards. Appropriate to this need is the advanced trauma life support (ATLS) course run under the auspices of the Royal College of Surgeons of England in London. ATLS training and certification is valuable for all members of the multidisciplinary team involved in handling trauma patients, namely the general and orthopaedic surgeons, neurosurgeons, anaesthetists, and accident and emergency clinicians. Completion of this course means that the trauma team will have received training, as well as guidance as to what roles they can most appropriately play in the immediate resuscitation of the injured and which facet of the procedure they are best trained to undertake. Ideally, a specialist training programme would include attachments to a trauma centre.¹⁷⁵

The ATLS course was originally established some years ago by the American College of Surgeons in order to train doctors in the assessment and prioritized management of the multiply injured patient in the first hour or so following the injury. It is based on well-established treatment methods and approaches trauma care in a systemized manner.^{176–178}

The objectives of the course are to ensure that upon completion the physician will be able to:

1. demonstrate the concepts and principles of primary and secondary patient assessment;
2. establish management priorities in a trauma patient;
3. initiate the primary and secondary management necessary, within the first hour of emergency care, to deal with acute life-threatening emergencies;
4. demonstrate, in a simulated scenario (moulage), the following clinical and surgical skills necessary for the initial assessment and management of a patient with multiple injuries:
 - a. primary and secondary assessment of a moulage victim with multiple injuries;
 - b. orotracheal and nasotracheal intubation on adult and infant manikins;
 - c. cricothyroidotomy;
 - d. initiation of central venous catheterization and central venous pressure monitoring;
 - e. administration of intravenous fluids in conjunction with different types of shock;
 - f. venous cutdown;
 - g. application, inflation, deflation and removal of a pneumatic anti-shock garment;
 - h. needle thoracentesis and chest tube insertion;
 - i. pericardiocentesis;
 - j. peritoneal lavage;
 - k. X-ray interpretation of cervical spine injuries;
 - l. cervical spine and long spine immobilization and stabilization prior to patient transfer;

- m. application of extremity splints.

The initial assessment and management must be rapid yet thorough. The physician must prioritize the patient's treatment and this must be considered in the overall management of the patient.

Evaluation and care are divided into four phases:

1. Primary survey – assessment of ABCs:
 - a. airway and cervical spine control;
 - b. breathing;
 - c. circulation with haemorrhage control;
 - d. disability: brief neurological evaluation;
 - e. exposure: completely undress the patient.
2. Resuscitation:
 - a. shock management – oxygen therapy, intravenous lines and fluid resuscitation;
 - b. the management of life-threatening problems identified in the primary survey is continued;
 - c. electrocardiographic monitoring.
3. Secondary survey – Total evaluation of the patient:
 - a. head and skull;
 - b. maxillofacial injuries;
 - c. neck;
 - d. chest;
 - e. abdomen;
 - f. perineum/rectum;
 - g. extremities – fractures;
 - h. complete neurological examination;
 - i. appropriate X-rays, blood tests and special studies;
 - j. 'tubes and fingers' in every orifice.
4. Definitive care;
5. Transfer.

After identifying the patient's injuries, managing life-threatening problems, and obtaining special studies, definitive care begins. This phase includes comprehensive management, fracture stabilization, and any necessary operative intervention.

If the patient's injuries exceed the hospital's immediate treatment capabilities, the process of transferring the patient is initiated as soon as the need is identified. Delay in transfer may significantly increase the patient's risk of mortality. The patient should be optimally stabilized prior to transfer.

Transfer protocols should exist between referring centres and include details regarding the responsibilities of the referring and receiving physicians. A documentation transfer record, guidelines regarding the basic investigation, and management procedures to be performed prior to transfer and recommendations regarding management during transport should be made.

ATLS training is offered on two levels:

1. provider;
2. instructor.

The provider course focuses primarily on the first hour of trauma management, when rapid assessment and resuscitation can be carried out. The course consists of standardized lectures and practical skill stations.¹⁷⁹ Assessment is based on multiple-choice questionnaires, continuous assessment and 'moulage'¹⁸⁰ where human models with simulated injuries are utilized to test the candidate under stress. Upon satisfactory completion of the course the participant acquires certification in ATLS.

Both courses ensure training for those handling trauma, but having completed the provider sessions some successful candidates will then continue on to the instructor course which includes sessions on teaching techniques and arranging skill stations in order to be able to teach ATLS in the future. Training should be repeated at 4 year intervals in order to maintain the competency and ensure that the doctor keeps up with modern developments.

As well as the scheme described above, a separate nursing module has been developed as well as a course in paediatric advanced life support (PALS).^{181,182}

The first instructor course outside North America was held in November 1988 under the auspices of the Royal College of Surgeons of England. Currently there are 46 provider courses with 133 certified instructors. To date over 1,000 candidates have successfully completed the provider course.¹⁸³

Courses in advanced trauma life support provide an opportunity to improve the basic standards of care. Expansion of the programme is to be welcomed but presently the demand for places far outstrips the supply, and the introduction of abridged courses, based upon ATLS principles, will allow more widespread training of junior staff.¹⁸⁴

Trauma team

The care of a trauma victim is improved if it is undertaken by a multidisciplinary team consisting of trained doctors and nurses. The medical component requires senior doctors in anaesthetics, general and orthopaedic surgery, emergency medicine and intensive care who are immediately available 24 hours of the day.¹⁸⁵ This is much to be preferred to the situation where a young, inexperienced doctor receives a trauma victim and quickly runs into difficulties due to his inadequate training.¹⁸⁶

In the UK this trauma team concept was initially attempted at the Birmingham Accident Hospital.¹⁸⁷ More recently the Department of Health has set up an experimental trauma centre at Stoke-on-Trent which will be evaluated over a 3 year period.¹⁸⁸ A

team response to cases of major trauma may be equally appropriate and more achievable in many hospitals rather than the construction of new dedicated trauma reception units.

Spencer¹⁸⁹ set up a trauma team at Lewisham Hospital and reported on its organization and work. He questioned why the concept had not been adopted in the UK. This message was later¹⁹⁰ repeated and others have since introduced such teams.¹⁹¹

Rutherford¹⁹² expounds on the organizational requirements and states that the most efficient and cost-effective system would be to appoint a sufficient number of accident and emergency consultants to allow them to carry out the initial resuscitation whilst mobilizing the trauma team. The trauma team is mobilized by using the revised trauma score as a triage tool which enables doctors in the accident and emergency department to identify seriously injured patients rapidly. Then a senior accident and emergency specialist supervises the resuscitation, with the trauma team, with a resulting marked improvement in standards of care.¹⁹³ Similar studies utilizing alternative triage criteria have also validated this trauma team model.¹⁹⁴

The objectives and responsibilities of members of the trauma team are elaborated on in the 'ABC of major trauma'¹⁹⁵ (see Tables I and II). The individual roles of the various specialists are now being recognized and developed.¹⁹⁶

The organization of the trauma team influences the effectiveness of patient resuscitation¹⁹⁷ and the most efficient method appears to be that known as 'horizontal organization.' This involves each member of the team carrying out their individual tasks simultaneously as opposed to sequentially, that is, 'vertical organization'.^{198,199}

To work efficiently the team members need to have their tasks precisely and individually allocated by the team leader. The tasks must be equally distributed in order to avoid inadvertently overloading a particular member.¹⁹⁸

The introduction of 'horizontal organization' into a particular trauma unit allows significant reductions in the time taken to institute particular procedures. It is vital that the team has an essential understanding of the principles of and a thorough grounding in advanced trauma life support.²⁰⁰

Hopefully, the question proposed by Spencer as to why our hospitals do not make more use of the trauma team will rapidly become obsolete.

Trauma scoring

Reliable, properly validated methods of measuring the severity of injuries have to be available to quantify the extent of the damage, aid triage,

Table I Objectives of the trauma team

Identify and correct life-threatening injuries.
Resuscitate the patient and stabilize the vital signs.
Determine the extent of other injuries.
Prepare the patient for definitive care, which may mean transporting him or her to another centre.

Table II Responsibility of members of the trauma team

Team leader: primary survey; secondary survey; co-ordinate team effort; overall responsibility for patient while in accident and emergency department.
Anaesthetist: airway control; ventilation; central venous cannulation; fluid balance.
Other doctor: all other procedures; chest drain; catheterization; splintage of fractures; removal of clothes, etc.
Nurses (ideally two): measure vital signs; record data; removal of clothes; help doctors; attach monitor.
Radiographers: take specific radiographs of cervical spine, chest, and pelvis in all patients as soon as possible, co-ordinating with team and taking other radiographs as clinically necessary.

predict outcome, and allow audit of care for quality assurance and research. Numerous scoring methods exist based on anatomical and/or physiological parameters and several review articles of trauma scoring methods exist.^{201–206}

Glasgow coma scale (see Table III)

The Glasgow coma scale (GCS)^{207–209} is now a widely accepted measure of assessing the severity of brain damage after head injury. The GCS is a simpler method of predicting the outcome in patients with head injury than other severity scores.²¹⁰

It correlates well with the Glasgow outcome scale,²¹¹ is useful as a quality assurance filter²¹² and forms part of the trauma score and the revised trauma score. The GCS has been widely accepted as a reliable scale²¹³ yet inexperienced or untrained users still make errors when using it.²¹⁴ Its use in children is also valuable.²¹⁵

Trauma score ²¹⁶ (see Tables V and VI)

The trauma score (TS) is based on five parameters: Glasgow coma scale; respiratory rate; respiratory expansion; systolic blood pressure; and capillary refill. The variables are assigned weighted points which are summed to give the TS. This has a range from 1 (worse) to 16 (normal). The TS is used as a

Table III Glasgow coma scale

	Score
Eyes open:	
Spontaneously	4
To speech	3
To pain	2
Never	1
Best motor response:	
Obeys commands	6
Localizes pain	5
Flexion withdrawal	4
Decerebrate flexion	3
Decerebrate extension	2
No response	1
Best verbal response:	
Orientated	5
Confused	4
Inappropriate words	3
Incomprehensible sounds	2
Silent	1

Table IV Revised trauma score

	Coded value	× weight	= score
Respiratory rate (breath/min)			
10–29	4		
> 29	3		
6–9	2		
1–5	1	0.2908	
0	0		
Systolic blood pressure (mmHg)			
> 89	4		
76–89	3		
50–75	2		
1–49	1	0.7326	
0	0		
Glasgow coma scale			
13–15	4		
9–12	3		
6–8	2		
4–5	1	0.9368	
3	0		
Total = revised trauma score			

triage tool and accurately predicts the outcome from severe injuries. Patients with a TS of less than or equal to 12 are recommended for transfer to a trauma centre as this level carries an average mortality of 10%.^{217,218} A TS of 3 or less is valuable in identifying patients for whom prolonged resuscitation is futile.²¹⁹ Finally, the TS has also proven to be a reliable, simple means of assessing the quality of care by comparing the patients outcome with that of their expected survival.²²⁰

Table V Scoring of the trauma score

	Trauma score
Respiration/min	
≥ 36	2
25–35	3
10–24	4
1–9	1
none	0
Respiratory expansion	
Normal	1
Shallow	0
Retractive	0
Systolic blood pressure (mmHg)	
≥ 90	4
70–89	3
50–69	2
0–49	1
No pulse	0
Capillary return	
Normal	2
Delayed	1
None	0
Glasgow coma scale	
14–15	5
11–13	4
8–10	3
5–7	2
3–4	1

Revised trauma score (see Table IV)

The revised trauma score includes GCS, systolic blood pressure and respiratory rate but excludes capillary refill and respiratory expansion. Two versions of the revised trauma score have been developed, one for triage (T-RTS) and the other for use in outcome evaluation (RTS).

The revised trauma score has been shown to be a valuable tool in the accident and emergency department for the rapid identification of severely injured patients on arrival. The RTS is a weighted sum of coded variable values and yields a more accurate outcome prediction for patients with serious head injuries than the TS.²²¹ A list of the scoring systems used in field triage are listed in Table VII.

Other improvements of field triage scoring systems include the application of field photography,²³¹ physician input in the triage process²³² and the judgement of the emergency medical technician.²³³ The primary goal of triage is to identify the majority of patients with life-threatening injuries whilst retaining an acceptable level of over-triage. This has been achieved by combining physiological criteria with non-time-dependent triage criteria²³⁴ such as anatomic injury,^{235,236} mechanism of injury criteria,²³⁷ vehicle

Table VI Trauma score and probability of survival

Trauma score	Probability of survival (%)
16	99
15	98
14	95
13	91
12	83
11	71
10	55
9	37
8	22
7	12
6	7
5	4
4	2
3	1
2	0
1	0

Table VII Scoring system used in field triage

Glasgow coma scale ²⁰⁷
Trauma scoring ²¹⁶
Revised trauma scoring ²²¹
Paediatric trauma score ²²²
Crams scale ^{223,224}
Simbol rating system ²²⁵
Trauma index ²²⁶
Revised trauma index ²²⁷
Illness–injury severity index ²²⁸
Triage index ²²⁹
Trauma triage rule ²³⁰

damage,²³⁸ the presence of pre-existing disease^{239–241} and age of the patient.^{242,243} An example of a triage decision scheme from the American College of Surgeons is shown in Figure 1.²⁴⁴

Hospital scoring of injury severity

The second group of techniques used for assessment of injury severity is that based on the categorization of specific anatomical injuries. This information is available from the clinical findings, investigative procedures, operative findings and in fatal cases the post-mortem examination.^{245,246}

Abbreviated injury scale

The abbreviated injury scale (AIS) was developed and published in 1971 and still undergoes regular revision.^{247,248} Every injury is assigned a code based on its anatomical site, nature and severity. Injuries are grouped by body region (Tables VIII and IX). The AIS enables ranking of injury severity and correlates with patient outcome, but a major

Figure 1 A triage decision scheme from the American College of Surgeons.²⁴⁴

disadvantage is that because it codes individual injuries, it cannot be adjusted for multiple injuries.²⁴⁹

Injury severity score

The AIS can be used to derive the injury severity score (ISS). The ISS provides a valid numerical

measure of the overall severity of injury in patients with multiple injuries and correlates with mortality, morbidity and other measures such as length of hospital stay. The ISS has been validated for use with blunt and penetrating injuries in adults and also for use in children over the age of 12 years.^{250,251}

The ISS may not be completely correlated with

Table VIII Sample page from AIS dictionary

Injury description	Code
Whole area	
Decapitation	40101.6
Skin (includes all external skin and subcutaneous injury) [see EXTERNAL]	
Penetrating injury	
NFS	40102.2
no organ involvement	40103.2
complex with tissue loss/organ involvement	40104.3
Nerves	
Brachial plexus [see SPINE]	
Cervical spinal cord or nerve root [see SPINE]	
vague or phrenic injury	40201.2
Vessels	
Carotid (common, internal, external) artery	
NFS	40301.3
intimal tear no description	40302.3
with neurological deficit nor head related laceration	
NFS	40304.3
minor (superficial) ^m	40305.3
with neurological deficit not head related	40306.4
major ⁿ (transection, rupture)	40307.4
with neurological deficit not head related	40308.5
with segmental loss	40309.5
with thrombosis secondary to trauma	40310.3
with neurological deficit not head related	40311.4

^mMinor (superficial) = subtotal transection without major bleeding; ⁿmajor (rupture, transection) = major bleeding (approx. 100cc blood loss).

Table IX Abbreviated injury scale

AIS code	Description
1	Minor
2	Moderate
3	Serious (non-life-threatening)
4	Severe (life-threatening – survival probable)
5	Critical (survival uncertain)
6	Unsurvivable (with current treatment)

the resource requirements of injured patients and should not be used as the sole means by which to define major trauma.²⁵²

Every injury is given an AIS code and classified into one of the six body regions (Table X). The ISS is calculated by summation of the squares of the highest AIS codes in each of the three most severely injured body regions. The maximum ISS is 75 [(5 × 5) + (5 × 5) + (5 × 5)]. Any injury coded AIS = 6 automatically converts the ISS to 75.

The ISS correlates closely with mortality and is the ‘gold standard’ for anatomical coding of injury severity. An ISS of 16 or more signifies major

trauma with an average predicted mortality of more than 10%.

The effect of age on the outcome of injury has been incorporated into the ISS by Bull²⁵³ using probit analysis to derive LD50 values for different age groups.

Refinements of the ISS include the organ injury scaling for the spleen, liver and kidney²⁵⁴ and characterizing the anatomic profile which improves the predictive power of survival probability when compared with the ISS.^{255,256}

Early identification of high-risk patients using the ‘estimated’ injury severity score²⁵⁷ used prospectively in the resuscitation room has proven useful.

Table XI lists some trauma scores for injury severity and outcome prediction.

Paediatric trauma scores

Previously the use of the save-a-child mnemonic²⁶⁶ in the accident department provided systemic organization of the important clinical observations that might serve as a marker of serious disease. More recently, however, specific trauma scores have been developed for the paediatric trauma victim (Table XII).

Table X Body regions used in ISS

1. Head and neck
2. Face
3. Chest
4. Abdominal/pelvic contents
5. Extremities/pelvic girdle
6. External, i.e. skin and burns

Table XI Trauma scores for injury severity and outcome prediction

Comprehensive injury scale ²⁵⁸
Penetrating blunt code ²⁵⁹
Revised estimated survival probability ²⁶⁰
AIS
ISS
Estimated ISS ²⁵⁷
Organ injury scoring
CHOP index ²⁶¹
Anatomic index ²⁶²
The hospital trauma index ²⁶³
The probability of death score ²⁶⁴
Outcome predictive score ²⁶⁵

Table XII Paediatric trauma scores

MISS	Modified injury severity score
PTS	Paediatric trauma score
CTT	Children’s trauma tool

Modified injury severity scale (MISS)²⁶⁷

MISS is a modification of AIS which incorporates the GCS. A MISS score of 25 or more represents a significant injury with related mortality and morbidity.

Paediatric trauma score (PTS)

The PTS is recommended for triage by the American College of Surgeons.^{268,269} Six parameters are scored to produce a sum ranging from + 12 to – 6 which is inversely related to the ISS and mortality²⁷⁰ and correlates with the adult equivalents, namely the trauma score²⁷¹ and the revised trauma score^{272,273} (Table XIII).

The PTS is independent of the age of the child²⁷⁴ and may be useful in predicting what hospital resources might be needed.²⁷⁵ Other trauma scoring systems for paediatric patients include the children’s trauma tool.²⁷⁶

TRISS methodology (trauma score injury severity score)²⁷⁷

The patient’s survival and functional outcome are important determinants of trauma care evaluation. Survival probabilities computed from a large database such as the major trauma outcome study (MTOS) are essential for assessment of the appropriateness of patient survival or death.

The TRISS method estimates the probability of patient survival based on the regression equation (Table XIV) and takes into account:

- 1. patient age;
- 2. the severity of anatomical injury as measured by the ISS;
- 3. the physiological status of the patient on admission based on the revised trauma score; and

- 4. the type of injury (blunt or penetrating). (See Table XV for example of a case study).

A three-tier method of assessing injury, severity and mortality outcome has been developed to aid audit by identifying patients with unexpected outcomes.^{278,279}

Preliminary method²⁷⁸ (see Figure 2)

Unexpected deaths or survivors can be identified by plotting the RTS and ISS for patients on a PRE-chart – see figure 2. The Ps50 isobar represents the 50% probability of survival of the baseline normal population, whilst the patients are represented by a symbol depicting outcome: L for live, D for dead. Unexpected survivors with a Ps less than 50% (L symbols above the isobar) and

Table XIV TRISS methodology

Probability of survival of individual patient	
$(P_s) = \frac{1}{1 + e^b}$	
where e = natural logarithm and $b = b_0 + b_1$ (RTS) + b_2 (ISS) + b_3 (A)	
b_{0-3} = Weighted coefficients based on major trauma outcome study (United States) data.	
These differ for blunt and penetrating injuries.	
RTS = revised trauma score	
ISS = injury severity score	
A = age (score 0 if < 54, score 1 if ≥ 55)	
Injury severity match ('M' statistic)	
Compares the range of injury severity in the sample population with that of the main database (range 0.00–1.00). Z statistic is invalid if $M < 0.88$.	
Population outcome comparison	
('Z' statistic)	
Measures difference between actual and predicted number of deaths or survivors (range – 1.96 to + 1.96).	

Table XIII Paediatric triage and injury scoring

Pts	+ 2	+ 1	– 1
Weight	>44 lbs (>20 kg)	22–44 lbs (10–20 kg)	<22 lbs (<10 kg)
Airway	Normal	Oral or nasal airway	Intubated, tracheostomy invasive
Blood pressure	>90 mmHg	50–90 mmHg	<50 mmHg
Level of consciousness	Completely awake	Obtunded or any LOC	Comatose
Open wound	None	Minor	Major or penetrating
Fractures	None	Minor	Open or multiple fractures
Totals			

Table XV Case study

A 65 year old pedestrian is knocked down, sustaining head, abdominal and leg injuries. On arrival in the accident and emergency department he has a Glasgow coma score of 9, respiratory rate of 35 beats/min, and systolic blood pressure of 80 mmHg. Computed tomography shows a small subdural haematoma with swelling of the left parietal lobe. There is a major laceration of the liver but no other intra-abdominal injury. Radiographs of the lower limbs show displaced fractures through both upper tibias.

Revised trauma score

Glasgow coma score = 9; coded value 3 × weighting 0.9368 = 2.8104.
Respiratory rate = 35; coded value 3 × weighting 0.2908 = 0.8724.
Blood pressure = 80; coded value 3 × weighting 0.7326 = 2.1978.

$RTS = 5.8806$

Injury severity score

	Abbreviated injury score
Subdural haematoma (small)	4
[Parietal lobe swelling]	[3]
Liver laceration (major)	4
Upper tibial fracture (displaced)	3

$ISS = 4^2 + 4^2 + 3^2 = 41$

Probability of survival

Coefficients from major trauma outcome study database for blunt injury:

$b_0 = -1.2470$
 $b_1 = -0.9544$
 $b_2 = -0.0768$
 $b_3 = -1.9052$

$b = -1.2470 + (0.9544)(5.8806) + (-0.0768)(41) + (-1.9052)(1)$

$P_s = \frac{1}{1 + e^{(0.6886)}} = 0.3343$

Probability of survival = 33%

Figure 2 A revised TRISS per-chart.

unexpected deaths with a P_s greater than 50% (D symbols below the isobar) are identified for further study.

Definitive method²⁷⁸

This compares outcome and the patient mix regarding severity of injury in different hospitals with the MTOS ‘norm’ data.

The Z statistic²⁸⁰ is a measure which can be used to test whether the observed number of survivors in a specific trauma population is significantly different from what would be expected based on the major trauma outcome study norms. Values greater than + 1.96 or less than - 1.96 indicate a significant difference ($P < 0.05$) from predicted, with greater or fewer survivors, respectively.

The W statistic provides perspective on the clinical relevance of the Z score. A positive W value is the number of survivors more than expected from the norm predictions per 100 patients analysed. The M statistic evaluates the match of injury severity between the study group and the MTOS baseline group. Values range from 0 to 1 and the closer to 1 the better the match of injury severity.

TRISS analysis is also valid for evaluation of paediatric trauma care²⁸¹ but still has limitations:²⁸²

1. no account is taken for multiple injuries to a single body part;

PRIMARY SURVEY ON ARRIVAL

AIRWAY

Clear ☐

Compromised ☐

CERVICAL SPINE

Suspect injury ☐

BREATHING

Respiratory rate/minute

> 29

10 - 29

6 - 9

1 - 5

Bag and mask

Intubated

TS

(3)

(4)

(2)

(1)

(0)

(0)

CIRCULATION

Systolic BP

> 89

76 - 89

50 - 75

1 - 49

No carotid pulse

TS

(4)

(3)

(2)

(1)

(0)

Oxygen via mask %

Oropharyngeal airway

Nasopharyngeal airway

Endotracheal tube

Other (specify)

Gag reflex

N/G tube

Rigid collar

In line traction

Flail segment

Compound/open chest injury

Tension pneumothorax

Pneumothorax

Haemothorax

Intercostal drain site

Cardiac tamponade

External haemorrhage, site:

Internal haemorrhage

Thorax

Abdomen

Pelvis

Central

Peripheral

Intravenous access:

External cardiac massage

Blood gases

Time

pH

pO₂

pCO₂

BE

O₂ Sat

Urine

Protein

Blood

Sugar

Ketones

BM stick

mmols

HB

WBC

Plat

Sickle

NA

K

U

CR

BS

Alcohol

Toxicology

Crossmatch

No of units

Peritoneal lavage

MACRO

MICRO

Result

Pink

Red

Clear

RBC

WBC

Amylase

Performed by

(Signature)

DISABILITY

Alert

Responds to verbal commands

Responds to pain

Unresponsive

EXPOSURE

Completely undress patient. Ensure genitalia and back are examined.

SECONDARY SURVEY: SOFT TISSUE INJURY

Mark injuries on diagram clearly. Abrasion, contusion, burn (incl. depth), stab etc

Laceration use

Indicates pulse present

X RAYS

C/Spine:

CXR:

Pelvis:

SXR:

Other X-rays:

CT scan/US result:

Summary of injuries:

ALCOHOL/DRUG INTOXICATION SUSPECTED

Disposal of patient

ITU

Theatre

Ward

CT scan

Transfer

Mortuary

Figure 3 Example of part of a documentation sheet.

2. the TRISS method is unable to predict the survival rate of patients suffering low falls; and

3. TRISS has difficulty with the subcategory of penetrating trauma where the patient's functional status is of greater importance for the outcome than the anatomical severity.²⁸³

Trauma audit using TRISS has been undertaken prospectively in the UK to show that specialized

units can improve outcome²⁸⁴ and TRISS methodology is now commonplace.²⁸⁵⁻²⁹⁰

The goals of a trauma quality assurance programme²⁹¹⁻²⁹³ are to monitor the process and outcome of patient care, to assure the appropriate and timely provision of such care, and to provide the structure and organization to promote this care.

The major trauma outcome study (UK) (MTOS-

UK) methodology²⁸⁷ provides a foundation for this. The Department of Health is funding the major trauma outcome study which is a prospective analysis of major trauma care in the UK and data upon which it is based include the injury severity score, the revised trauma score and the patient's age. These produce a TRISS score which is a probability of survival. MTOS thus allows audit of the trauma care in the participating centre and then comparison with the national and international databases.

Currently 36 hospitals in the UK participate. Collection of data requires trauma patients to meet one or more of the following criteria: hospital stay of more than 3 days, admission to the intensive care unit, death, or transfers to another hospital for continuing care.

The data collection relies on the retrieval of information from records hence the value of documentation sheets²⁹⁴⁻²⁹⁶ for use in cases of major

trauma as often data collected in these cases are inadequate (Figure 3). Hopefully this situation will be improved by data collection using computer assisted coding with a microcomputer.^{297,298}

The ultimate aim is to produce a trauma registry. This is a database to provide information for analysis and evaluation of the quality of patient care, but which ideally should include epidemiological and demographic characteristics of trauma patients and review issues such as resource utilization, injury control and education.

The trauma registry relies on uniformity of data and presently the lack of standardization regarding core definitions, data content and coding conventions are impeding the process of pooling or computing data. In the United States recommendations regarding standardizing data collected have been made.²⁹⁹

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