Human Factors in Ballistic Trauma

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22.1 Introduction

Human Factors are described as '*enhancing clinical performance through an understanding of the effects of teamwork, tasks, equipment, workspace, culture and organisation on human behaviour and abilities and application of that knowledge in clinical settings*' [1] and also as '*the cognitive, social, and personal resource skills that complement technical skills, and contribute to safe and efficient task performance*' [2]. Healthcare has taken the lead from the aviation industry where it was estimated that approximately 70% of errors investigated were attributable to failed communication, poor decision- making and ineffective leadership [3].

Human Factors are now common in a healthcare setting, having been initially highlighted by two high profile reports [4, 5] and subsequently several high profile cases which have highlighted severe failures [6, 7]. Although initially adoption of the principles has been slow, there has been a recent drive with the signing of a national concordat by many of the lead organisations in the UK including the General Medical Council [8]. Non-technical skills frameworks have been developed for anaesthesia [9], surgery [10] and perioperative practitioners [11]. The anaesthetist's non-technical skills framework (ANTS) is broken down into four separate behaviour categories: task management, team working, situational awareness and decision-making with each category having its own elements (Table 22.1). Although a framework for trauma has not yet been developed there is considerable overlap that can be transferred to the trauma team. Human factors were thought to have played an important role in the management of casualties in the recent conflict in Afghanistan [12, 13] with rehearsal in pre-deployment training [14] and refinement on operations. They have recently been described in civilian complex trauma management [15].

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Table 22.1 The anaesthetists non-technical skills framework [9]

Category	Element
Task management	Planning and preparing management
	Prioritizing
	Providing and maintaining standards
	Identifying and utilizing resources
Team working	Coordinating activities with team members working
	Exchanging information
	Using authority and assertiveness
	Assessing capabilities
	Supporting others
Situational awareness	Gathering information awareness
	Recognizing and understanding
	Anticipating
Decision making	Identifying options
	Balancing risks and selecting options
	Re-evaluating

Damage control resuscitation is now recognised as the standard of care for the severely injured patient [16, 17]. The National Institute for Health and Care Excellence (NICE) have recently suggested that healthcare professionals who deliver care to patients with trauma to have up-to-date training in the interventions they are required to give [18]. It is important that individuals are given the opportunity to practice using simulation in their work place to test the systems in place [19], and rehearse protocols and guidelines and ensure equipment competencies. The establishment of major trauma centres around the UK has allowed for the concentration of trauma experience in key hospitals and the development of the trauma team. There is evidence that more effective clinicians use first-rate non-technical skills as part of their working routine [20].

22.2 Preparing to Receive a Patient

Multi-professional team-working is defined as '*a dynamic process involving two or more health professionals with complementary backgrounds and skills, sharing common health goals and exercising concerted physical and mental effort in assessing, planning, or evaluating patient care. This is accomplished through interdependent collaboration, open communication and shared decision-making. This in turn generates value-added patient, organizational and staff outcomes.*' [21]. The activation of the trauma team is dependent on a pre-determined criteria based on anatomy, physiology and mechanism of injury (Table 22.2). Patients with ballistic injuries would automatically activate the trauma team. The personnel involved in the trauma team are listed in Table 22.3 and are a resource rich unit of individuals with specific skills and competencies required to stabilise a casualty and then make rapid decisions about further management. Salas describes a team as being '*a*

Table 22.2 Trauma team activation criteria (taken from Kings College Hospital London, Major Trauma Service: Information for Members of the Trauma Team)

1. Traumatic event and one of the following:
• Oxygen saturation <90%
• Systolic arterial pressure 90 mm Hg
• Respiratory rate <9 or >29 bpm
• GCS <14
2. Penetrating injury to
• Head
• Neck
• Chest
• Abdomen
• Pelvis
• All gunshot wounds
3. Fractures
• Open or depressed skull fractures
• Pelvic fracture
• Two or more proximal long bone fractures
• Flail chest
4. Traumatic amputation
5. Blast or crush injury
6. Major burns
• 10% total body surface area but lower threshold in child or elderly
• Combination of burns and trauma
7. Road traffic crash
• High speed crash (0.30 mph) or pedestrian vs. vehicle at 0.20 mph
• Separation of rider and bike
• Intrusion into passenger compartment
• Ejection from vehicle
• Death in the same passenger compartment
• Bull's eyed windscreen
• 20 min extrication time
8. Falls
• Height of >3 m
• Paediatrics—consider the age and height of the child in relation to the height fallen
9. HEMS transfer
10. Drowning/submersion
This will apply to patients arriving at the hospital or who have a prehospital alert

distinguishable set of two or more people who interact dynamically, interdependently, and adaptively towards a common and valued goal, who have each been assigned specific roles or functions to perform, and who have a limited life-span membership' [22] and this definition fits nicely to the trauma team who are summoned from various areas of the hospital to assess and stabilise a patient and then return to their other duties.

Table 22.3 Typical UK National Health Service Trauma Team in a Major Trauma Centre

• Trauma team leader (Emergency Medicine Consultant)
• Primary survey doctor (Emergency Medicine Registrar)
• Anaesthetist 1 (Registrar/Consultant)
• Anaesthetic nurse or practitioner
• Scribe (trauma nurse coordinator)
• ED nurse 1 (circulator)
• ED nurse 2 (rapid infuser)
• ED nurse 3 (rapid infuser)
• Runner (Health Care Assistant)
• Orthopaedic surgeon (Registrar/Consultant)
• General surgeon (Registrar/Consultant)
• Radiographer

The trauma team leader (TTL) is usually a consultant in emergency medicine and is responsible for leading the trauma team. The definition of a leader is '*a person whose ideas and actions influence the thought and the behaviour of others*' [2]. In this role they must influence, inspire and direct the actions of the team in order to attain a desired objective, namely to rapidly assess and stabilise a patient and make a decision regarding their next location of treatment. This also requires management as situations are analysed, goals set, activities co-ordinated and the team directed. The TTL at times will have a job similar to that of the conductor of an orchestra [23] with multiple teams all working on a severely injured patient and numerous others supporting the resuscitation this has also been described as '*driving the ship*' but essentially means that their role is 'hands off' maintaining a complete overview of what could potentially be a rapidly changing situation.

Once assembled, the TTL will deliver a brief to the team. This will confirm information from the pre-hospital team, the mechanism of injury any physiological signs available and the time of arrival. At this point the TTL will also confirm their mental model, this is essentially what they expect to happen or what the likely clinical sequence will be, based on their own previous experience. One example of this might be in the case of a traumatic cardiac arrest where the administration of adrenaline and commencing chest compressions are no longer recommended [24] and it is important to recognize the need for oxygenation, correction of hypovolaemia and management of cardiac tamponade and tension pneumothorax [25]. This also might require an emergency thoracotomy of which the trauma team must be prepared for. This brief not only prepares the team but encourages good followership. The team is introduced by name and role and competencies confirmed. Contingency planning is also discussed, for example dealing with a difficult airway and discussing which member of the team will perform a surgical airway. Once the team has assembled then they must remain in the trauma bay until the trauma team leader dismisses them.

In essence it is the job of the TTL to maintain the situation awareness of the team defined as '*the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future*' [26], and this accurately describes how the TTL should be thinking

throughout the assessment in the trauma bay. Depending on the severity of the injuries a 'code red call' might be triggered. Code Red activation criteria include a systolic arterial pressure <90 mm Hg (at any time), patients who are non-responders to fluid boluses and suspected or confirmed haemorrhage [15]. The protocol enables blood products to be available prior to the patient arriving and additional consultants to be summoned. This can be activated by the pre-hospital clinician [27]. Major trauma centres will have a massive transfusion protocol [28]. Blood delivered in the form of a 'shock pack' must be supplied in a box with a timer on it so that products that are not required can be returned under the direction of the TTL to be used for another patient.

Additional jobs in the preparation period include checking equipment, preparing drugs and communicating with other agencies in the hospital such as radiology (for CT), laboratory and communication with the operating theatre. It is particularly important during this time that the operating theatre to be used is identified, additional staffs are summoned and specialist equipment prepared.

22.3 Patient Arrival

The European Trauma Course teaches team-working and leadership and uses a 5-s check performed by the team leader on the arrival of the casualty, prior to the team starting work [29, 30]. This confirms that the patient is alive, has a patent airway and does not have visible catastrophic haemorrhage. This process allows the team leader and team members an overview of the patient, which is vital to maintaining situational awareness and forming a mental model. Once this check is performed, the pre-hospital clinician will be invited to deliver their handover. This is performed in silence with all team members listening and one example, the AT-MIST handover is described in Table 22.4.

22.4 Patient Assessment

Once the handover has been delivered the primary survey is immediately commenced. This is conducted in a <c> ABC [31] fashion but using a horizontal approach [32] so that in reality many aspects of the primary survey are all performed at the same time and has been likened to a 'Formula One pit-stop' [15]. This can only be achieved if coordinated by the TTL who is waiting for information to be

Table 22.4 AT-MIST handover

A	Age
T	Time of injury
M	Mechanism of injury
I	Injuries sustained
S	Signs and symptoms
T	Treatment given

Table 22.5 Initial management tasks performed by the trauma team in ballistic trauma management

• Primary survey <c> ABC
• Checking of tourniquets and pelvic binder positioning if applied
• Administration oxygen (15 L via non-rebreather mask)
• Cervical spine mobilisation
• Additional IV access inserted and then blood samples taken for
– Full blood count
– Thromboelastometry (e.g. RoTEM®)
– Venous blood gas
– Group and save
• Focused assessment with sonography for trauma scan (FAST)
• Chest and pelvis X-rays
• Commencement of haemostatic resuscitation if appropriate via a rapid infuser (Belmont)
• Rapid sequence induction may be required.
• Consideration of drugs
– Antibiotics
– Tranexamic acid (15 mg/kg)
– Tetanus
– Analgesia as required
– Consider calcium chloride

communicated to them from the team. Table 22.5 details some of the initial tasks that must be performed in the first few minutes in the emergency department. This is the gathering information stage of the TTL's situational awareness [2]. The other stages are interpreting the information and then anticipating and planning for the future. Patients seriously injured by ballistics may rapidly change their physiology and so situational awareness is very important.

By having a dedicated TTL who is completely 'hands-off' and maintaining situational awareness, members of the trauma team are now permitted to focus on their immediate tasks. If there were not a team member 'driving the ship' then there is the potential to lose situational awareness, and potentially develop fixation errors (i.e. focusing on a single problem to the detriment of the casualty as a whole) [33]. In stressful situations individuals can very quickly fill their 'bandwidth' (the available mental capacity) and become overloaded and this too can lead to errors. Should a rapid sequence induction be required, this would ideally occur in silence similar to a 'cock pit moment' such as the 'take off' or landing of a plane [34], with all team members focused.

Following the end of the primary survey, a decision will need to be made on the next stage of the patient pathway. In order to facilitate decision making and communication a 'Trauma WHO' has been suggested [35]. The World Health Organisation (WHO) introduced a surgical safety checklist with three components; a pre-surgical check, a time out prior to starting surgery and a 'sign out' and this has

already been reported to have reduced hospital mortality [36]. In time critical situations such as complex trauma this checklist was thought to not be appropriate and could even hinder the timeliness of interventions [35]. The four components of the 'Trauma WHO' are

- The Command Huddle
- Snap Brief
- Regular Sit-Reps (Situation Updates)
- Sign out (handover)

22.4.1 Command Huddle

At the end of the primary survey the Command Huddle should occur. This will allow an initial treatment plan to be determined (or the futility of continuing with treatment discussed). Options for onward management will include an immediate transfer to the operating theatre for damage control surgery, transfer to radiology for a CT scan or interventional radiology (this may or may not be in the emergency department), to critical care or to the trauma ward. Key people involved in the decision making process will be

- Trauma Team Leader—Who provides overall leadership and situational awareness, including an understanding of the resources available
- Lead Surgeons (There will be a trauma (general) surgery and orthopaedic surgeon) who will provide expert assessment of the injuries found, surgical options available, and priorities for surgical treatment
- Lead Anaesthetist—Who provides expert assessment of physiological stability, response to transfusion, and priorities for airway management

The key decisions that must be considered by the Command Huddle are

- Is treatment futile? This is a hard decision to make but a catastrophic injury may necessitate stopping treatment.
- Can the patient be treated at the current hospital or do they require a transfer for specialist services and if a transfer is required then what are the relative risks of this?
- What is the most appropriate next stage of treatment? Is it to transfer to CT Scan or transfer directly to the operating theatre or is interventional radiology more appropriate?
- Will the patient tolerate a delay in surgery to have a CT scan?
- If transfer to the operating theatre is recommended, then which body cavity is to be opened first?
- Does the patient require a Rapid Sequence Induction of Anaesthesia? If so, should this be performed in the emergency department or in the operating

theatre? How great is the risk of airway obstruction or respiratory failure before reaching the operating theatre?
- If the patient requires a transfer (either intra or inter-hospital) then can they tolerate this without anaesthesia?

22.4.2 Snap Brief

Once positioned on the operating table and prior to the start of surgery a snap brief is conducted. The key points of information that must be communicated include [35]:

- The main injuries found on clinical examination and reported radiology
- The current physiological status and degree of stability of the patient
- The transfusion status including the volume of blood and blood products administered, estimated on going requirements and the coagulation status (using near point testing e.g. RoTEM©
- The surgical plans and expected timescale of the operation.

The surgical plan may consist of several options and these should be written out on a white board in theatre with the trigger points to move to the plan.

22.4.3 Sit Reps

Once surgery is underway a series of SIT REPS (situation reports) [35] should take place. These provide the opportunity to bring the whole team '*back on the page*' and to maintain situational awareness and should be conducted when there is a new piece of information or every 30 min. Recently the mnemonic for the sit-rep has been changed to STACK [*Personnel communication Lt Col Harry Pugh*] (Table 22.6).

22.4.4 Sign Out

At the end of the surgery there is a formal 'sign out' with a handover to the critical care team who will then assume responsibility for the patient. This might also be an appropriate time for a debrief (although this could potentially be delayed for 24 h if necessary).

Table 22.6 Sit-rep mnemonic

S	Systolic blood pressure
T	Temperature
A	Acidosis
C	Coagulation
K	Kit (including blood products used)

22.5 Summary

Human Factors are now a common place in healthcare and their importance in complex trauma has been described in both military [13] and civilian practice [15]. The trauma team, once activated is a resource rich unit that facilitates a rapid assessment of a casualty and robust decision making concerning their treatment. The 'Trauma WHO' [35] provides a structure to allow communication with the team in complex trauma.

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