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**Title:** Human Factors in Preventing Complications in Anaesthesia

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**Summary**

Human Factors in anaesthesia were first highlighted by the publication of the Anaesthetists Non-Technical Skills Framework (ANTS) and since then they have gradually become adopted into routine clinical practice. This review article examines recent literature around human factors in anaesthesia and highlights recent national reports and guidelines with a focus on team working, communication, situation awareness and human error. We highlight the importance of human factors in modern anaesthetic practice using the example of complex trauma.

**Introduction**

There is wide spread recognition that human factors are key to safe delivery of healthcare in the UK. Human factors are defined 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) or more simply, *‘the science of improving human performance and well-being by examining all the effectors of human performance’*(2).

There has been research into how human factors for anaesthetists (3), surgeons (4) and scrub practitioners (5) are translated into clinical practice. Safe and efficient task performance require both technical and non-technical skills (6). Deficiencies in non-technical skills at the individual level increase the chance of errors and adverse events (7). There is also evidence that teamwork glitches, communication failures, cultural and hierarchal barriers contribute to safety failures (8-10). Sir Liam Donaldson, a previous Chief Medical Officer stated that *‘to err is human, to cover up is unforgivable, and to fail to learn is inexcusable.’* (11). It is hoped that the recent concordat

(12) signed by sixteen organizations including the General Medical Council, NHS England and the Care Quality Commission will lead to further embedding of human factors into everyday practice.

This review article examines the literature around human factors in anaesthesia and highlights recent national reports and guidelines, with particular focus on how their adoption can promote safer delivery of care.

**Methods**

We searched Medline and CINAHL for papers reporting on human factors and non-technical skills in anaesthesia. We limited the search to articles published from the year 2000 onwards to represent contemporary practice. The search included full text reports of articles from peer-reviewed journals published in English with no restriction to study methodology. In addition, we manually searched anaesthesia specific journals by typing ‘human factors’ into the search box for *Anaesthesia, Anesthesiology, Anesthesia & Analgesia, The British Journal of Anaesthesia,* the *Canadian Journal of Anaesthesia* and *European Journal of Anesthesiology* accepting articles (not abstracts presented at conferences) from >2000. In addition, reference lists of the articles reviewed were scrutinized for additional relevant articles and book chapters.

**Article selection**

Titles and abstracts of the references obtained were reviewed by two independent reviewers (SJM and CJ). Inclusion criteria: papers referring to human factors, non-technical skills, team resource or crew resource management, papers published on or after 2000. Exclusion criteria: animal studies, papers not referring to human factors, non-technical skills, team resource management or crew resource management in theatres, anaesthesia, trauma or critical care. Articles were removed if both reviewers agreed independently to exclude. In the event of agreement to include or a discordant opinion, articles were reviewed in full by one of five independent reviewers (SJM, CJ, JFC, CL and PG). Our full protocol and search strategy are registered with and published by PROSPERO (<http://www.crd.york.ac.uk/PROSPERO>), ID: CRD42017060872

**Literature search results**

The results of the literature search are described in Figure 1.

**[Figure 1 Here]**

**Figure 1:** Systematic review literature search flow

**Paper Review Results**

Work performed by the University of Aberdeen on Anaesthetists Non-Technical Skills (ANTS) (3) provides a practical framework for clinical practice (Table 1). Initial analysis reported that the ANTS system had a satisfactory level of validity, reliability and usability in an experimental setting(3). The increasing importance of human factors is recognized by the recommendations of several recent national reports and guidelines. In this review, we highlighted some of the individual components of human factors described in the literature and examine their importance further in clinical practice by considering Complex Trauma management in the Emergency Department and in the Operating Theatre as this is our sub-speciality interest.

[Table 1 Here]

**Table 1**. The Anaesthetics Non-Technical Skills Framework(3)

|  |  |
| --- | --- |
| **Categories** | **Elements** |
| Task Management | * Planning and preparing
* Prioritizing
* Providing and maintaining standards
* Identifying and utilizing resources
 |
| Team working | * Co-ordinating activities with team members
* Exchanging information
* Using authority and assertiveness
* Assessing capabilities
* Supporting others
 |
| Situation Awareness | * Gathering Information
* Recognizing and understanding
* Anticipating
 |
| Decision making | * Identifying options
* Balancing risks and selecting options
* Re-evaluating
 |

**National Reports and Guidelines**

We highlight two recent reports and two national guidelines that demonstrate the importance of Human Factors in Anaesthesia:

1. **Fourth National Audit Project (NAP 4)**(13)

This was the first prospective study of all major airway events occurring throughout the UK and resulted in a review of any complications resulting from airway management that led to: death, brain damage, the need for an emergency surgical airway, unanticipated ICU admission, or prolongation of ICU stay. After final review, 184 reports met the inclusion criteria and subsequent in-depth analysis identified human factors to influence every case. Latent threats (poor communication, poor training and teamwork, deficiencies in equipment, and inadequate systems and processes) predisposed to loss of situational awareness and subsequent poor decision-making(14). We have divided human factors errors into individual and team non-technical skills and system and design management (Table 2).

[Table 2 Here]

**Table 2.** Human Factors recognised by NAP 4 taken directly from the published report *(Section 2 Chapter 24, Pg 196-201)* (15)

|  |  |
| --- | --- |
| **Individual and team non-technical skills**   | * Casual attitude to risk/overconfidence
* Peer tolerance of poor standards
* Lack of clarity in team structures
* Incomplete or inadequate briefing and handovers/poor or non-existent debriefing
* Poor or dysfunctional communication – especially between specialties
* Failure to follow advice from a senior colleague
* Inadequate checking procedures
* Failure to request previous patient records
* Failure to take and document a comprehensive history
* Failure to undertake appropriate preoperative investigations
* Wrong interpretation of clinical findings/test results
* Failure to use available equipment (e.g. capnography)
* Attempts to use unfamiliar equipment in an emergency situation
* Failure to cope with stressful environment/interruptive workplace
* Failure to formulate back-up plans and discuss with the team members
* Fixation errors, resulting in a failure to recognise and abort a plan which is not working, and move to another potential solution
* Frequent/last-minute changes of plan
 |
| **System design and management**  | * Equipment shortages
* Inadequate maintenance of equipment
* Incompatible goals (e.g. conflict between financial and clinical need)
* Reluctance to undertake a formal analysis of adverse events/learn from errors
* Loss of documentation (e.g. previous patient records not available)
* Inadequate systems of communication
* Highly mobile working arrangements leading to difficulties in communication
* Inexperienced personnel working unsupervised
* No scheduled training sessions for updating staff in the use of new techniques/equipment
* Incomplete training/inadequate knowledge or experience
* Heavy personal workloads/lack of time to undertake thorough assessments
* Organisational and professional cultures which induce or tolerate unsafe practices
* No requirement at organisational level to undertake formalised checking procedures
 |

1. **Fifth National Audit Project (NAP 5)**(16)

The 5th National Audit Project (NAP5) on accidental awareness during general anaesthesia (AAGA) reported that two-thirds of awareness occurred during induction and emergence. Contributing factors included the use of thiopentone, rapid sequence induction of anaesthesia, obese patients, difficult airway management, neuromuscular blockade and transfers to theatre(16). Of those cases of AAGA reported, 73% were deemed to be avoidable with miscommunication found to be the main contributory factor in greater than 80% cases of AAGA associated with sedation. Human Factors recognised by NAP 5 are described in Table 3.

[Table 3 Here]

**Table 3.** Human Factors recognised by NAP 5 are described in Table 2.

|  |  |
| --- | --- |
| Induction of anaesthesia | * Drugs errors (mislabelling, syringe swaps, failure to mix drugs, under-dosing due to lack of knowledge)
* Distraction (by colleagues or by unexpected difficulty)
* Timing (rushing, busy lists with multiple changes)
* Fatigue
* Seniority (unsupervised juniors, lack of knowledge)
 |
| Maintenance of anaesthesia | * Under-dosing (due to CV instability, risk to foetus, inattention/judgement errors)
 |
| Emergence from anaesthesia | * Switching off anaesthetic agents to early due to poor communication or lack of knowledge
* Failure to monitor neuromuscular blockade
* Rushing and mistiming
 |

1. **Difficult Airway Society (DAS) Guidelines for Unanticipated Difficult Airway 2015 Guidelines**(17)

These revised guidelines included a whole section on Human Factors and incorporated recommendations made by the NAP4 report. The guidelines highlight the importance of clinician awareness that poor communication, poor training and teamwork, deficiencies in equipment, and inadequate systems and processes predispose to loss of situation awareness and subsequent poor decision-making. In stressful situations such as can’t intubate, can’t oxygenation (CICO), anaesthetists can become overloaded and the DAS Guidelines provide explicit instructions for the team to ‘stop and think’. A ‘declaration of the emergency’ ensures that all members of the team start this critical situation on the ‘same page’ and can follow the same mental model (i.e. follow the DAS Guidelines)

It is also important that teams rehearse together and consider using simulation to develop non-technical skills, such as leadership, team co-ordination, communication, and shared understanding of roles (17). A team brief prior to the start of each anaesthetic, particularly between anaesthetist and operator department practitioner (ODP) is also considered to be good practice and encourages thinking about specific challenges and checking availability of appropriate equipment.

1. **Difficult Airway Society Guidelines for the management of tracheal extubation** (18)

These guidelines recognized that human factors compound problems related to extubation. Problems arise when there is inadequate equipment, inadequate skilled assistance, suboptimal patient positioning, limited access to airway (e.g. due to dressings / gastric tubes / rigid fixators), interruption of oxygen supply during patient transfer, communication difficulties (e.g. language, mental capacity) and the removal of oxygen by agitated or uncooperative patient.

**Human Factor Components**

1. **Teamwork**

The term ‘teamwork’ describes a number of behavioral processes and emergent states (19) and is defined as *‘a 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’*(20). Although the team consists of individuals, it is important to work towards maximizing the mental and physical problem-solving capabilities of the group, such that the sum is greater than its parts (21). In complex teams, teamwork is more than just subordinates doing what their leader tells them to do and relies on good followership (followership is *‘the active engagement of followers in helping the group achieve its goals’*(22))*.* Good teamwork is associated with improved productivity, innovation and job satisfaction (23). Teams who demonstrate similar mental models move quicker through the phases common to most crises. This is important, particularly in complex trauma(24).

1. **Communication**

It is estimated that communication failures account for 43% of errors in the operating theatre in the USA(25). Communication failures can be categorized as: the provision of insufficient information, poor timing of the communication (eg too late), unresolved issues at the end of the communication or the absence of key personnel (26). In time critical situations, it is important that there is a team leader who can impartcritical information without the potential for misinterpretation or misunderstanding, irrespective of the situation or the composition of the team.

Effective communication relies on clarity (*‘keeping it clear’)*, brevity (*‘keeping it brief)’*, empathy, (*‘how will it feel to receive this?’)* with provision for a feedback loop. Directed communication and closed loop communication is particularly important when rapid response is critical and involves specification of who the order or communication is directed toward, usually by using a hand signal or saying the person’s name (27). It is vital that an atmosphere of open information exchange is achieved by empowering all team members to speak out. Barriers to challenging include poor communication skills (28,29) and poor intra-operative communication between seniors and juniors (30) and should be taught as part of the anaesthetic curriculum (31).

A shared mental model promotes an accurate understanding of the facts, defends against error and allows the cognitive resources of the entire team to be fully leveraged for decision-making and error detection (32). This model can be facilitated by a team brief to involve: the introduction of all team members by name and role, briefing as to what is expected to happen and allocation of tasks (e.g. World Health Organisation (WHO) Safety Checklist

(33). To maintain effective communication during a critical emergency it is vital that increased noise does not cause distraction. A ‘sterile cockpit’ has been described in the airline industry during key moments in emergency care(34). This is achieved by the noise level being kept to an absolute minimum and is reliant on good ‘crowd control’ so that excessive noise levels are kept low.

It is important to adopt a culture of good communication. There is evidence that nurses and trainee doctors (35) do not feel sufficiently empowered during interactions with senior doctors. Factors responsible for this included hierarchy, gender, differing patient care responsibilities, differing perceptions of requisite communication standards, and differences in the training methods (35) .

1. **Situation Awareness**

Situation awareness (SA) is the continuous monitoring of the task, detection of events and changes in the environment. Almost all aspects of the anaesthetists' intraoperative tasks rely heavily on their vigilance and situation awareness skills. (36). SA is defined by three questions *‘Where have we come from?’, ‘Where are we now?’* and *‘Where are we going?’* (37). Practically, factors such as clinical signs and physiology on the monitors, the rest of the operating theatre team, and other technology are vital to inform SA(38). The importance of a shared SA is key to effective teamwork and in the military this is improved by regular updates by the team leader in the form of situational updates (‘sit-reps’)(24). The three levels of situation awareness and an error taxonomy are described in Table 4)

[Table 4 Here]

**Table 4.** Levels of Situation Awareness and Error Taxonomy adapted as described by Endsley(37)

|  |  |
| --- | --- |
| Level 1 SA: failure to correctly perceive the situation *‘Where have we come from?’* | * The data is not available
* The data is difficult to detect or perceive
* There is a failure to scan or observe data due to
	+ omission
	+ attentional narrowing or distraction
	+ high taskload of individual
* There is misperception of the data
* Individual memory failure
 |
| Level 2 SA: Failure to comprehend situation *‘Where are we now?’* | * There is a lack of or a poor mental model
* There is use of the incorrect mental model
* There is over-reliance on default values in the mental model
* Individual memory failure
 |
| Level 3 SA: Failure to project situation into the future *‘Where are we going?’* | * There is a lack of or a poor mental model
 |
| General  | * There is a failure to maintain multiple goals
* Habitual schema
 |

1. **Human Error**

It is reported that there was is an average of 1 error in every 133 anaesthetics and 130 errors for every 1000 patient ICU days(39). Anaesthetic drug errors are commonly caused by slips and lapses, fixation errors (failure to revise a situation assessment as new evidence emerges (40)), mistakes, knowledge-based errors and deliberate violations(41). Recommendations to avoid drug errors include:

* Careful inspection of labels before a drug is drawn up or injected
* Optimise label legibility and contents on syringes according to agreed standards.
* Formal organization of drug drawers and workspace
* Second checker for labels before a drug is drawn up or administered
* Thorough reporting and reviews of intravenous drug administration errors
* Manage drug inventory to focus on minimizing the risk of drug error
* Avoid similar packaging and presentation of drugs where possible

Accidents occur due to the interrelationship between real time ‘unsafe acts’ by front-line operators and latent conditions (42). This is thought to be due to holes appearing in the multiple levels of the system and when these holes line up, as in multiple slices of Swiss cheese, an accident can occur. ‘The Parmesan cheese model’(43) may be a better representation of the clinician’s responsibility in routine patient care and the importance of minimizing any deficiencies in our routine practice. In this analogy, small shavings from the cheese occur every time our practice contributes to sub-standard practice *‘with each shave—no matter how small—we remove from the whole’* and decrease the chance of optimal patient outcome (43).

Observable team errors may be classified into five basic types; i) task execution: an unintentional physical act that deviates from the intended course of action, ii) procedural: an unintentional failure to follow mandated procedures, iii) communication: a failure to transmit information, failure to understand information, or failure to share a mental model, iv) decision: a choice of action unbounded by procedures that unnecessarily increase hazard and v) intentional noncompliance, violations of formal procedures or regulations(44)**.** Latent errors in the operating theatre are further classified as follows(45):

* Equipment, design, and maintenance (availability, functioning, standardization design, and maintenance of machines)
* Staffing (adequate staffing, skills)
* Communication (work-directed communication, openness, interrelation, atmosphere)
* Training (training for machines, procedures, team training)
* Teamwork and team training (team performance)
* Procedures (presence of protocols, adherence to protocols)
* Situational awareness (awareness of present situation, own tasks, and future developments)
* Incompatible goals (balance between goals and safety)
* Planning and organization (process of care)
* Housekeeping (hygiene)

**Importance of Human Factors in Clinical Practice**

The authors work in a busy Major Trauma Centre in the North West of England. We have taken the results of the literature review and applied this to our clinical practice. Much of these findings generalised into other areas of clinical anaesthesia.

1. **Emergency Department**

Anaesthetists are frequently called to support critically unwell, time critical patients in the emergency department (ED). At the time of the call, patients may physically be in the department or en route. This can result in overwhelming or inadequate clinical information respectively. Both circumstances provide an immediate cognitive load and increased risk for cognitive errors. These patients frequently require high risk anaesthetic interventions to promote safety but there is minimal time to consider factors that may prevent poor critical decision making (Table 4).

[Table 4Here]

**Table 4: Emergency Department contributory factors to poor critical decision making, delayed diagnosis and missed injury. To be considered prior to delivery of high risk anaesthetic interventions.**

|  |  |
| --- | --- |
| **Patient Factors** | Evolving pathophysiology (medical and surgical)Altered level of consciousness – inability to take a historyHaemodynamic and respiratory compromiseMinimal clinical assessment completed so farDistracting injuriesMultiple injuriesChild versus adultUrgency of clinical problem |
| **Provider Factors** | Lack of knowledge, inexperienceFailure to adapt (low to high mental workload)Lack of skilled assistanceComplacencyFatigueEmotive casePractical difficulties and frustrationFailure to reassessConfirmation biasPoor team dynamics* Ineffective communication
* Hierarchical gradients(46)
* Loss of situational awareness
* Poor followership
 |
| **Environmental factors** | Unfamiliar clinical environmentIncreased auditory and physical distractions* Raised noise levels – crowd control
* Multiple equipment alarms(47)
* Increased staff observation & movement

Ergonomic design – visibility of patient monitorEquipment familiarity and maintenanceRemote from specialist anaesthetic equipmentRemote from immediate senior anaesthetic supportDelayed access to specialist surgical support and imagingStandardised operational procedures and cognitive aids |

There are increased distractions, mental workload and cognitive pressures in ED that further increase risk of team errors. These particularly include deviation from standardised operating procedures, not using cognitive aids (checklists), violations of formal procedures or regulations and intentional noncompliance (44). Lack of familiarity and poor ergonomic design of ED resuscitation bays can have a significant negative impact on situational awareness. Fatigue, frequently encountered on call, can further exacerbate this situation. Fatigue has been reported to degrade or cause variability in performance by reducing attention–vigilance, slowing cognitive throughput, impairing memory and decision-making, prolonging reaction time and disrupting communications. When managing high-acuity patients in ED, it takes only a moment of reduced performance during a critical task to have a negative outcome(48).

The reception and resuscitation of a critically unwell patient in ED can be divided into three stages:

1. **The initial handover**

Prehospital teams should give a pre-alert notification for admission of all critically unwell patients to the ED. This allows time to assemble appropriate skilled resources and can trigger several defined protocols for preparation of key interventions, additional logistical, specialist support (for example; activation of trauma versus medical cardiac arrest teams, major haemorrhage protocol, paediatric and obstetric teams, and ensuring an emergency theatre is on stand-by to receive). On arrival, the handover is delivered in a standardised manner. Although there is variability amongst services, many use the AT-MIST acronym (Table 5). Early and robust decisions are required from the team leader, often in conjunction with the anaesthetic team and other specialties present. A formalized handover process ensures that the team are prepared and switched on to receive crucial information in complete silence, ready to assimilate information into orders of priority. However, this process may fall short when handovers are inadequate and the mental model is no longer ‘shared’; this is referred to this as ‘the Bermuda Triangle of health care’(49).

[Table 5 Here]

**Table 5: Elements of the AT-MIST pre-alert and handover (Trauma & Medical)**

|  |  |
| --- | --- |
| **TRAUMA** | **MEDICAL** |
| **A**ge (include name for handover) | **A**ge (include name for handover) |
| **T**ime of incident | **T**ime of onset |
| **M**echanism of injury | **M**edical complaint / history |
| **I**njuries top to toe | **I**nvestigations (brief examination findings) |
| Vital **S**igns (first set and significant changes) | Vital **S**igns (first set and significant changes) |
| **T**reatment | **T**reatment |
| Additional pre-alert information:Estimated time of arrivalMode of transportSpecialist resources standing by | Additional pre-alert information:Estimated time of arrivalMode of transportSpecialist resources standing by |

1. **Primary systematic assessment**

The role of the designated team leader is to allocate roles (according to clinical competencies) and facilitate a primary systematic assessment and other subsequent tasks in a ‘horizontal fashion’(50). Systematic reassessments are vital for the management of complex critically unwell patients. This process permits: shared understanding (especially important in evolving pathophysiology), formulation of clear mental models and supports subsequent critical decisions. Failure to perform reassessment promotes cognitive bias and may impact on critical decisions e.g. CT imaging *versus* immediate surgical intervention, or critical care support *versus* futility and palliation.

1. **Communication for critical decisions**

Best practice management of critically unwell patients in the ED requires a multi-disciplinary team approach with excellent communication. The key to delivering damage control resuscitation and surgery has been shown to be effective communication(51). Although this requirement is self-evident, the principles to achieving this can be forgotten or sub-optimal in stressful situations. In response to this, the Trauma WHO checklist has been proposed to improve and streamline communication during the damage control resuscitation(24). This checklist has been tested and modified in a military field hospital in Afghanistan(52) with the main elements described in Table 6. The key features of the Command Huddle (described below) could be applied within NHS practice for all ED medical and surgical resuscitations. Following initial assessment and resuscitation the team leader should have formulated their own mental model and plan. Prior to presenting it to the team, the team leader should share and exchange critical information with key members (anaesthetist, surgeon, medical physician, intensivist, theatre lead *etc*.). Once agreed on a shared mental model, the team leader presents their plan and explores opinions from key members. The objective of the command huddle is to formulate a plan of action with clear order of priorities.

**[Table 6 Here]**

**Table 6.** The Trauma WHO

|  |  |
| --- | --- |
| Command Huddle | Following the primary and secondary survey a senior team use the information gleaned from the handover from the pre-hospital team, the physical examination, imaging and blood test to arrive at a decision on the next step in patient care. This is often transfer to the CT Scanner, but may involve direct transfer to the operating theatre or critical care. |
| Snap Brief | Prior to commencing surgery there is a reconfirmation of vital information to ensure the right patient is in theatre followed by a recap of the mechanism of injury, the injuries sustained, any additional radiology results and then the surgical and anaesthetic plans |
| Sit-Reps | Every 10-30 minutes there will be an update or ‘sit-rep’. Usually when additional information is known. The STACK acronym described above is used here. |
| Debrief | At a convenient moment when the case has finished their will be a debrief for all team members. |

1. **Emergency department RSI**

During the command huddle, the anaesthetist needs to justify why an ED rapid sequence induction of anaesthesia is required and complete their own risk *versus* benefit analysis (Table 7). The less situationally aware anaesthetist may immediately agree to delivering an RSI, especially for a patient with a ‘solid’ indication(s). This is fraught with danger unless there is clear understanding of the patient’s pathology, consideration of specific anaesthetic cautions, and contingency planning to manage unanticipated difficulty with tracheal intubation. As outlined in NAP4, the incidence of a serious airway complications causing death or brain damage is significantly greater in the ED, with at least one in 50,000 anaesthetics requiring a surgical airway(13). The 2015 Difficult Airway Society guidelines suggest waking a patient up when both tracheal intubation and supraglottic airway device insertion have failed(17), however, this will not be possible for patients receiving an RSI for indications 1-3 (see below) and requires careful discussion and planning.

**[Table 7 Here]**

**Table 7: Indications for Emergency Department Anaesthesia; a risk versus benefit analysis of “hard” (1-3) and “soft” (4-6) indications.**

|  |  |  |
| --- | --- | --- |
| **Indication** | **Consider?** | **Actions, specialist equipment & additional personnel** |
| 1. Actual or impending airway compromise
 | Ensure mechanism fully understood (blunt, penetrating, burn injuries, anaphylaxis, foreign body, malignancy, infectious etc) | Video laryngoscopyFibre-optic bronchoscopeDifficult Airway TrolleyENT Surgeon Present |
| 1. Ventilatory failure
 | Risk stratify patients at high risk of apneoic desaturation {Weingart & Levitan, 2012}. | Optimise patient position, consider adding PEEP, provide apneoic oxygenation +/- positive pressure ventilation pre intubation. |
| 1. Unconsciousness
 | Could this be secondary to an unsecured intracranial aneurysm. | Caution with RSI drugs used – avoid hypertensive response to laryngoscopy. |
| 1. Unmanageable and agitated after head injury
 | Consider delayed sequence induction (DSI) to improve oxygenation and IV access before completing RSI {Weingart et al, 2015} | Use small boluses of Ketamine to achieve sedation, preserve airway reflexes and maintain spontaneous breathing. |
| 1. Anticipated clinical course
 | This rarely applies in a hospital setting. Analyze clinical progression and risk of performing RSI later in theatre. | Continue to improve physiology and reassess. |
| 1. Humanitarian need
 | Dependent on patient cooperation.  | Consider multimodal analgesia and sedation for anxiolysis versus delayed sequence induction (DSI) to get control. |
| **Additional notes:** **“Code Red”** **patients:** ensure there is large bore IV access, major haemorrhage protocol activated and consider starting blood pre RSI using a rapid transfuser.**Blunt trauma:** at the level of the larynx or below can be difficult to diagnose. The hallmark of airway management for such patients is the maintenance of spontaneous ventilation, intubation under direct vision to avoid the creation of a false passage, and avoidance of both intermittent positive pressure ventilation and cricoid pressure (the latter for laryngotracheal trauma only) during a rapid sequence induction of anaesthesia {Mercer et al, 2016}.**Severe metabolic acidosis:** often seen in patients with septic shock or metabolic crises (e.g. diabetic ketoacidosis). Consider ventilating these patients through the apneoic phase, a mixed respiratory and metabolic acidosis during this time can plummet pH and precipitate cardiac arrest. |

Improving safety requires engagement. Emerging evidence on safer practices offer substantial gains in safety, but only if effectively implemented(44). Developing methods for a systematic approach to the safety of ED RSI is supported by results of other high-reliability organisations(45). Without this, the effectiveness of human factors training and awareness would necessarily be limited. Safety culture specifically for use of ED RSI checklists has increased since the implementation of the World Health Organisation (WHO) Surgical Safety Checklist(53) and following recommendations from NAP4(13) to use cognitive aids for emergency anaesthesia. A systematic approach to safety around RSI in the ED is described in Table 8.

[Table 8 Here]

**Table 8:** A Systematic approach to the safety of ED RSI

|  |
| --- |
| 1. “Stop & Think”
2. Consider indication for emergency anaesthesia (Risk stratification for apneic hypoxia)
3. Consider RSI drug regime as per a standardised approach
4. Use of Emergency Department RSI Checklist
5. Strict Clinical Governance
 |

It is not uncommon to perform complex procedures in ED (for example an emergency resuscitative thoracotomy) or prolonged resuscitation prior to critical care admission or performing a tertiary transfer to a specialist hospital. When this occurs there is often a transfer of leadership to the anaesthetist.

1. **Operating Theatre**

The operating theatre is recognized as a high-risk, accident-prone environment where the consequences of failure can be catastrophic(53) and failures in non-technical skills, particularly communication(25) and teamwork have contributed to adverse events(55). To elucidate these we have focused on four specific areas: handover, hierarchy, checklists and equipment. Again, we have used complex trauma as an example as this is often a complex situation that is highly stressful involving a multi-disciplinary team and often individuals are placed out of their own usual zone of comfort.

1. *Handover*

The use of checklists and protocols have been described and improve the routine handover of patients (56). Moving forward, electronic handovers have been tested and found to be useful (57). Failed communication upon transfer of care may lead to adverse events(57)**.** In the example of complex trauma there should be a formal handover from the trauma team leader to the lead anaesthetist in the operating theatre. This process ensures that the whole trauma team are aware of who the team leader is at all times(58).

1. *Hierarchy*

In emergency situations, it is important that the team are empowered to challenge their seniors. ‘Speaking-up’ or the ability to effectively challenge erroneous decisions is essential to preventing harm and that despite significant multifactorial barriers, systematic training in effective ‘speaking up’ could improve the confidence and ability of juniors to challenge erroneous decisions(31). Perceived barriers to challenging include assumed hierarchy, fear of embarrassment of self or others, concern over being misjudged, fear of being wrong, fear of retribution, jeopardizing an ongoing relationship, natural avoidance of conflict, and concern for reputation

(59). In the airline industry the acronym ‘CUS’ is used: ‘I’m concerned’, ‘I’m uncomfortable,’ and ‘this is unsafe or I’m scared’ to challenge in a crisis situation.(60)

Further steps that we think are important in further flattening the medical hierarchy include(61):

* Encouraging staff to address each another by their first name
* Trying to create an inclusive atmosphere
* Consultants specifically inviting juniors to ask questions and vocalise uncertainties
* Agreeing at departmental and national professional level to a ‘two-challenge rule’ triggering the involvement of a second consultant, without threat of professional sanction
* Regular consultant assessment by juniors
1. *Checklists*

The primary purpose of checklists is to avoid unintentional harm by accounting for mental fallibility(62). There are cultural hurdles to implementing checklists(63) and acceptance of these cognitive aids requires a certain amount of humility in a profession known for independence and authority(62). ‘Smart Checklists’ are designed not to threaten provider autonomy but to mentally off load the many repetitive tasks in health care that must be completed in a largely predictable sequence(64). Displaying cognitive aids during emergencies reduces omissions, time to perform tasks and improves team skills, communication and performance in most instances(65).

As described above, The World Health Organization (WHO) surgical safety checklist was introduced in 2009 (53) with the primary aim of eliminating ‘never events’[[1]](#footnote-1) and has recently been reported to reduce hospital mortality(66). This process involves a team brief and then a series of questions to review key aspects of the operation, any patient specific factors and any unusual steps in the process.

It has been suggested that during an emergency there is potential unwillingness or inability to revert to more systematic thinking

(67). Under stress there is an increase in cortisol and other stress hormones which can lead to cognition and behaviour changes. This may account for deficiencies in recalling information, missed treatment steps or mistakes in sequential procedures (68). The use of cognitive aids during simulation scenarios has demonstrated improvements in the management of anaesthetic emergencies such as malignant hyperpyrexia(69) and local anaesthetic toxicity(70). An anaesthetist’s decision to follow or deviate from guidelines are influenced by the beliefs held about the consequence of their actions, the direct or indirect influence of others and the presence of factors that encourage or facilitate particular courses of action(71).

Accepting a cognitive aid like a checklist requires a certain amount of humility. Use is now seen as a sign of strength, failing to use them a sign of weakness and perhaps taking on unwarranted risk. To avoid complacency completion of an RSI checklist is a two-person task, following a ‘challenge’ and ‘response’ process. Visual and tactile checks are completed prior to the responder confirming a positive or negative response. A ‘pre-induction of anaesthesia checklist’ has been shown to significantly improve information exchange, knowledge of critical information and perception of safety in anaesthetic teams(72).

1. *Equipment*

The design of equipment is crucial in the field of Human Factors. One very topical equipment issue currently is the universal ‘Luer connector’ and its role in intrathecal administration of drugs. In the UK, in 2001, Wayne Jowett, a teenager who was in remission from leukaemia died following the intrathecal administration of vincristine (73). The luer lock connection had enabled the vincristine syringe to be attached to the spinal needle and removed the final safeguard for the patient(73). Similar tragedies have been reported with chlorhexidine cleaning solution administered epidurally(74). Although this problem was recognized over 40 years ago there is still no satisfactory solution. NHS trusts and independent healthcare institutions in England and Wales were supposed to have taken action to use spinal needles with non-Luer connectors by 1 April 2011 but unfortunately this still has not been achieved.

**Conclusion**

Human Factors are now firmly embedded into clinical anaesthetic practice having been highlighted by several recent national reports and guidelines. We have reviewed the current literature and described the human factor components teamwork, communication and situation awareness, we have also commented on human error. The importance of human factors in clinical practice has been highlighted using the example of complex trauma in the emergency department and the operating theatre.

**Conflict of Interest**

The authors have no conflicts of interest to declare and there was no funding granted to undertake the writing of this article

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1. Never Events are serious, largely preventable patient safety incidents that should not occur if the available preventative measures have been implemented. (http://www.nrls.npsa.nhs.uk/neverevents/) [↑](#footnote-ref-1)