Review Article

Human factors in preventing complications in anaesthesia: a systematic review

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Summary
Human factors in anaesthesia were first highlighted by the publication of the Anaesthetists Non-Technical Skills Framework, and since then an awareness of their importance has gradually resulted in changes in routine clinical practice. This review 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.

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Introduction
There is widespread recognition that human factors are key to the 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 requires 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, and 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 signed by 16 organisations including the General Medical Council, NHS England and the

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Care Quality Commission will lead to further embedding of human factors into everyday practice [12].

This review article examines the literature around human factors in anaesthesia, and highlights recent national reports and guidelines, with a 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 and Analgesia, The British Journal of Anaesthesia,* the *Canadian Journal of Anesthesia* and *European Journal of Anesthesiology,* accepting articles (not abstracts presented at conferences) from after 2000. In addition, reference lists of the manuscripts reviewed were scrutinised for additional relevant articles and book chapters.

The titles and abstracts of the references obtained were reviewed by two independent reviewers (SM and CJ). Inclusion criteria were: papers referring to human factors; non-technical skills; team resource or crew resource management; and papers published on or after 2000. Exclusion criteria were: animal studies; and 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 out of five independent reviewers (SM, CJ, JC, CL and PG). Our full protocol and search strategy are registered with and published by PROSPERO (http://www.crd.york.ac.uk/PROSPERO).

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

Anaesthetists Non-Technical Skills

Work performed by the University of Aberdeen on Anaesthetists Non-Technical Skills (ANTS) [3]

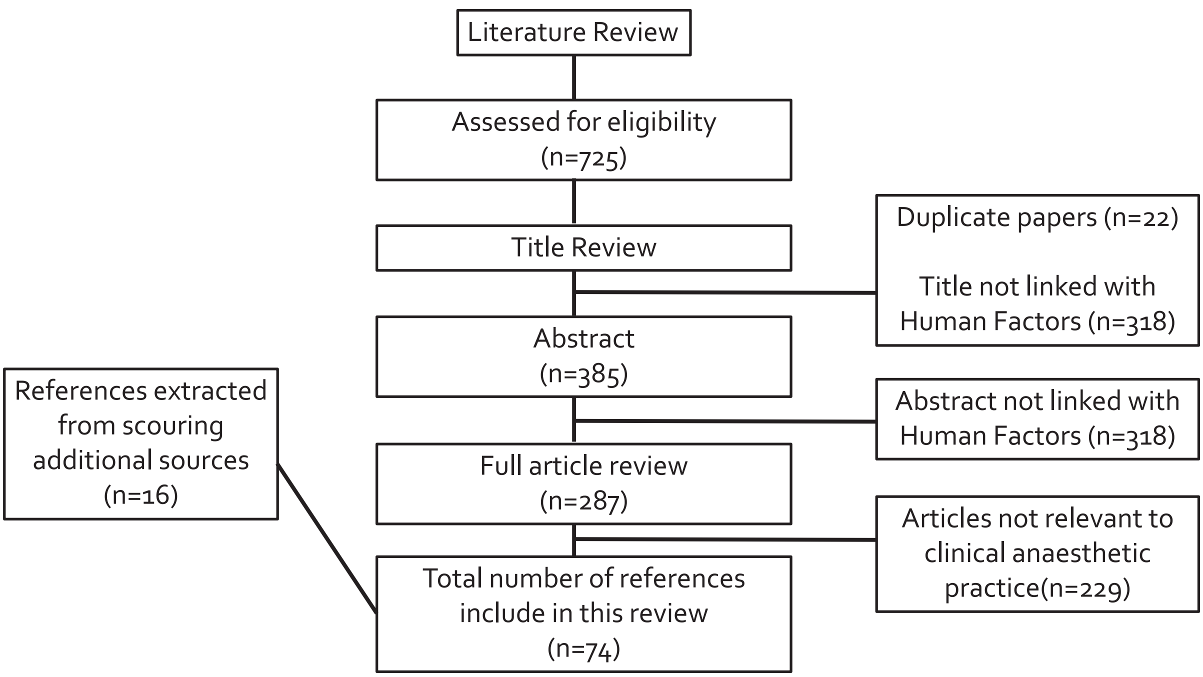

Figure 1 Systematic review literature search flow.

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Table 1 The Anaesthetists Non-Technical Skills Framework [3].

Categories	Elements
Task management	• Planning and preparing • Prioritising • Providing and maintaining standards • Identifying and utilising resources
Team working	• Coordinating activities with team members • Exchanging information • Using authority and assertiveness • Assessing capabilities • Supporting others
Situation awareness	• Gathering Information • Recognising and understanding • Anticipating
Decision making	• Identifying options • Balancing risks and selecting options • Re-evaluating

provides a practical framework for clinical practice (Table 1). Initial analysis showed that the ANTS system had a satisfactory level of validity, reliability and usability in an experimental setting [3]. The increasing importance of human factors has been recognised in the recommendations of several recent national reports and guidelines. In this review, we highlight some of the individual components of human factors described in the literature, and examine their importance in clinical practice by considering complex trauma management in the emergency department (ED) and in the operating theatre, as this is our subspeciality interest.

National reports and guidelines

We highlight two recent reports and two national guidelines that demonstrate the importance of human factors in anaesthesia. They share common themes that will be explored in more depth below.

The 4th National Audit Project (NAP4) [13] 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 either 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 as having been a relevant influence in every case. Latent

Table 2 Human factors recognised by NAP4 taken directly from the published report [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 pre-operative 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 work-loads/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

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Table 3 Human factors recognised by NAP5.

Induction of anaesthesia	• Drugs errors (mislabelling, syringe swaps, failure to mix drugs, underdosing 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	• Underdosing (due to cardiovascular instability, risk to fetus, inattention/judgement errors)
Emergence from anaesthesia	• Switching off anaesthetic agents too early due to poor communication or lack of knowledge • Failure to monitor neuromuscular blockade • Rushing and mistiming

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).

The 5th National Audit Project (NAP5) [16] 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 (RSI) 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 NAP5 are described in Table 3.

The Difficult Airway Society (DAS) guidelines for unanticipated difficult airway 2015 [17] 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 cannot intubate, cannot oxygenate (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 before the start of each anaesthetic, particularly between anaesthetist and operating department practitioner (ODP) is also considered to be good practice, and encourages thinking about specific challenges and checking availability of appropriate equipment.

The DAS guidelines for the management of tracheal extubation [18] recognised that human factors compound problems related to tracheal 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

Teamwork

The term 'teamwork' describes a number of behavioural 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 teams consist of individuals, it is important to work towards maximising 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

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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].

Communication

It is estimated that communication failures account for 43% of errors in the operating theatre in the USA [25]. Communication failures can be categorised as follows: the provision of insufficient information; poor timing of the communication (e.g. 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 impart critical 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 towards, 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, which needs to include the following: the introduction of all team members by name and role; a briefing as to what is expected to happen; and allocation of tasks. An example of this is the World Health Organization (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, and is also vital in emergency patient 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 do not feel sufficiently empowered during interactions with senior doctors. Factors responsible for this include: hierarchy; sex; differing patient care responsibilities; differing perceptions of requisite communication standards; and differences in the training methods [35].

Situational awareness

Situational awareness is the continuous monitoring of the task, detection of events, and changes in the environment. Almost all aspects of anaesthetists' intra-operative tasks rely heavily on their vigilance and situational awareness skills [36]. Situational awareness can be 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 seen on the monitors, the rest of the operating theatre team and other technology are vital to inform situational awareness [38]. The importance of a shared situational awareness 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 situational awareness and an error taxonomy are described in Table 4.

Human error

It is reported that there is an average of one 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 the following:

- Careful inspection of labels before a drug is drawn up or injected.
- Optimise label legibility and contents on syringes, according to agreed standards.

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Table 4 Levels of situational awareness and error taxonomy – adapted from Endsley [37].

Level 1 situational awareness: failure to correctly perceive the situation 'Where have we come from?'	• The data are not available
	• The data are 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 situational awareness: failure to comprehend situation 'Where are we now?'	• Lack of or a poor mental model • Use of the incorrect mental model • Over-reliance on default values in the mental model • Individual memory failure
Level 3 situational awareness: failure to project situation into the future 'Where are we going?'	• Lack of or a poor mental model
General	• Failure to maintain multiple goals • Habitual schema

- Formal organisation of drug drawers and workspace.
- Second checker for labels before a drug is drawn up or administered.
- Thorough reporting and review of intravenous drug administration errors.
- Manage drug inventory to focus on minimising 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]. In Reason's classical 'Swiss cheese' model, this is thought to be due to 'holes' appearing in the multiple levels of the system, and that 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 minimising any deficiencies in routine practice. In this analogy, small shavings from the cheese occur every time our practice contributes to substandard practice; 'with each shave – no matter how small – we remove from the whole', thereby decreasing the chances of optimal patient outcome [43].

Observable team errors may be classified into five basic types.

1. Task execution – an unintentional physical act that deviates from the intended course of action.
2. Procedural – an unintentional failure to follow mandated procedures.
3. Communication – a failure to transmit information, failure to understand information or failure to share a mental model.
4. Decision – a choice of action unbounded by procedures that unnecessarily increase hazard and
5. Intentional non-compliance – 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, standardisation of design and maintenance of machines).
- Staffing (adequate staffing and skills).
- Communication (work-directed communication, openness, interrelation and atmosphere).
- Training (training for machines, procedures and team training).
- Teamwork and team training (team performance).
- Procedures (presence of protocols and adherence to protocols).
- Situational awareness (awareness of present situation, own tasks and future developments).
- Incompatible goals (balance between goals and safety).

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Table 5 Emergency department contributory factors to poor critical decision making, delayed diagnosis and missed injury. To be considered before delivery of high risk anaesthetic interventions.

Patient factors	Evolving pathophysiology (medical and surgical) Altered level of consciousness – inability to take a history Haemodynamic and respiratory compromise Minimal clinical assessment completed so far Distracting injuries Multiple injuries Child vs. adult Urgency of clinical problem
Provider factors	Lack of knowledge, inexperience Failure to adapt (low to high mental work-load) Lack of skilled assistance Complacency Fatigue Emotive case Practical difficulties and frustration Failure to re-assess Confirmation bias Poor team dynamics Ineffective communication • Hierarchical gradients [46] • Loss of situational awareness • Poor followership
Environmental factors	Unfamiliar clinical environment Increased auditory and physical distractions • Raised noise levels – crowd control • Multiple equipment alarms [47] • Increased staff observation & movement Ergonomic design – visibility of patient monitor Equipment familiarity and maintenance Remote from specialist anaesthetic equipment Remote from immediate senior anaesthetic support Delayed access to specialist surgical support and imaging Standardised operational procedures and cognitive aids

- Planning and organisation (process of care).
- Housekeeping (hygiene).

The 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 are generalisable into other areas of clinical anaesthesia.

Emergency department

Anaesthetists are frequently called to support critically unwell, time-critical patients in the 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 of 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 5).

There are increased distractions, mental workload and cognitive pressures in ED that further increase the risk of team errors. These include in particular deviation from standardised operating procedures, not using cognitive aids (checklists), violations of formal procedures or regulations and intentional non-compliance [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 a number of stages.

Initial handover

Pre-hospital teams should give a pre-alert notification for admission of all critically unwell patients to the ED. This allows time to assemble appropriately-skilled resources and can trigger several defined protocols for preparation of key interventions and additional logistical, specialist support (e.g. activation of trauma vs medical cardiac arrest teams, major haemorrhage protocol, paediatric and obstetric teams, and ensuring an emergency theatre is on stand-by to receive). On

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Table 6 Elements of the AT-MIST pre-alert and handover.

Trauma	Medical
Age (include name for handover)	**A**ge (include name for handover)
Time of incident	**T**ime of onset
Mechanism of injury	**M**edical complaint/history
Injuries top to toe	**I**nvestigations (brief examination findings)
Vital **s**igns (first set and significant changes)	Vital **s**igns (first set and significant changes)
Treatment	**T**reatment
Additional pre-alert information: Estimated time of arrival Mode of transport Specialist resources standing by	Additional pre-alert information: Estimated time of arrival Mode of transport Specialist resources standing by

arrival, the handover must be delivered in a standardised manner. Although there is variability among services, many use the AT-MIST acronym (Table 6). Early and robust decisions are required from the team leader, often in conjunction with the anaesthetic team and other specialties present. A formalised handover process ensures that the team is prepared and 'switched on' to receive crucial information in complete silence, and ready to assimilate this 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 healthcare' [49].

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 re-assessments are vital for the management of complex critically unwell patients. This process permits shared understanding (especially important in evolving pathophysiology), the formulation of clear mental models and supports subsequent critical decisions. Failure to perform re-assessment promotes cognitive bias and may impact on critical decision, for example, computed tomographic (CT) imaging vs. immediate surgical intervention, or critical care support vs. recognition of futility and palliation.

Communication for critical decisions

Best practice management of critically unwell patients in the ED requires a multidisciplinary 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 be suboptimal 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], and the main elements are described in Table 7. The key features of the Command Huddle (described below) could be applied within NHS practice to all ED medical and surgical resuscitations. Following initial assessment and resuscitation the team leader should have formulated their own mental model and plan. Before 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.

Emergency department rapid sequence induction

During the command huddle, the anaesthetist needs to justify why an ED RSI of anaesthesia is required, and complete their own risk vs. benefit analysis (Table 8). 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 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

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Table 7 The Trauma World Health Organisation checklist.

Command Huddle	Following the primary and secondary survey the team leader uses 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	Before 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 min there will be an update or 'sit-rep', usually when additional information is known. The acronym STACK acronym can be used to facilitate this. • S = Systolic BP • T = Temperature • A = Acidosis • C = Coagulation • K = Kit (Including blood products used)
Debrief	At a convenient moment when the case has finished there will be a debrief for all team members.

device insertion have failed [17], however, this may not be possible for patients receiving an RSI for indications 1–3 (see below), and requires careful discussion and planning.

Improving safety requires engagement. Emerging evidence regarding 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 in other high-reliability organisations [45]. Without this, the effectiveness of human factor training and awareness would necessarily be limited. Safety culture, specifically for the use of ED RSI checklists, has increased since the implementation of the 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 9.

It is not uncommon to perform complex procedures in ED (e.g. emergency resuscitative thoracotomy), or to undertake prolonged resuscitation before 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.

The operating theatre

The operating theatre is recognised 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 [54]. 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 multidisciplinary team and where individuals are frequently placed out of their own comfort zones.

Handover

The use of checklists and protocols has been shown to improve the routine handover of patients [55]. In an evolution of these, electronic handovers have been tested and also found to be useful [56]. Failed communication upon transfer of care may lead to adverse events [56]. 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 [57].

Hierarchy

In emergency situations, it is important that members of the team are empowered to challenge their seniors. 'Speaking-up', or the ability to effectively challenge erroneous decisions, is essential to preventing harm; 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 the following: assumed hierarchy; fear of embarrassment of self or others; concern over being misjudged; fear of being wrong; fear of retribution; jeopardising an ongoing relationship; natural avoidance of conflict; and concern for reputation [58]. In the

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Table 8 Indications for emergency department anaesthesia – a risk vs. benefit analysis of 'hard' (1–3) and 'soft (4–6) indications.

Indication	Consider?	Actions, specialist equipment and additional personnel
1 Actual or impending airway compromise	Ensure mechanism fully understood (blunt, penetrating, burn injuries, anaphylaxis, foreign body, malignancy, infectious etc.)	Videolaryngoscopy Fibreoptic bronchoscope Difficult airway trolley ENT surgeon present
2 Ventilatory failure	Risk stratify patients at high risk of apnoeic desaturation [74].	Optimise patient position, consider adding PEEP, provide apnoeic oxygenation ± positive pressure ventilation pre-intubation.
3 Unconsciousness	Could this be secondary to an unsecured intracranial aneurysm?	Caution with RSI drugs used – avoid hypertensive response to laryngoscopy.
4 Unmanageable and agitated after head injury	Consider 'delayed sequence induction' to improve oxygenation and i.v. access before completing RSI [75].	Use small boluses of ketamine to achieve sedation, preserve airway reflexes and maintain spontaneous breathing.
5 Anticipated clinical course	This rarely applies in a hospital setting. Analyse clinical progression and risk of performing RSI later in theatre.	Continue to improve physiology and re-assess.
6 Humanitarian need	Dependent on patient cooperation.	Consider multi-modal analgesia and sedation for anxiolysis vs. delayed sequence induction to get control.

PEEP, positive end-exporatory pressure; RSI, rapid sequence induction; ENT, ear, nose and throat; i.v., intravenous.
'Code Red' patients: ensure there is large bore i.v. access, that the 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 [76].
Severe metabolic acidosis: often seen in patients with septic shock or metabolic crises (e.g. diabetic ketoacidosis). Consider ventilating these patients through the apnoeic phase, as a mixed respiratory and metabolic acidosis during this time can cause the pH to fall sharply and precipitate cardiac arrest.

Table 9 A systematic approach to the safety of emergency department rapid sequence induction (RSI).

- 'Stop and Think'
- Consider indication for emergency anaesthesia (risk stratification for apnoeic hypoxia)
- Consider RSI drug regime as per a standardised approach
- Use of Emergency Department RSI checklist
- Strict clinical governance

airline industry, the acronym 'CUS'-'I'm concerned,' 'I'm uncomfortable,' and 'this is unsafe or I'm scared' is used to challenge in a crisis situation [59].

Further steps that we think are important in further flattening the medical hierarchy include [60]:

- Encouraging staff to address each other 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.

Checklists

The primary purpose of checklists is to avoid unintentional harm by accounting for mental fallibility [61]. There are cultural hurdles to implementing checklists [62], and acceptance of these cognitive aids requires a certain amount of humility in a profession known for independence and authority [61]. 'Smart Checklists'

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are designed not to threaten provider autonomy, but to mentally offload the many repetitive tasks in healthcare that must be completed in a largely predictable sequence [63]. Displaying cognitive aids during emergencies reduces omissions, time to perform tasks and improves team skills, communication and performance in most instances [64].

As described above, the WHO surgical safety checklist [53] was introduced in 2009 with the primary aim of eliminating 'never events', and has recently been reported to reduce hospital mortality [65]. 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 [66]. During stress, there is an increase in cortisol and other stress hormones, which can lead to cognitive and behavioural changes. This may account for deficiencies in recalling information, missed treatment steps or mistakes in sequential procedures [67]. The use of cognitive aids during simulation scenarios has demonstrated improvements in the management of anaesthetic emergencies such as malignant hyperpyrexia [68] and local anaesthetic toxicity [69]. Individual anaesthetists' decisions 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 [70].

Accepting a cognitive aid like a checklist requires a certain amount of humility. Use of such aids is now seen as a sign of strength, whereas failing to use them may be regarded as a weakness, and of 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 before 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 [71].

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 [72]. The Luer lock connection had enabled the vincristine syringe to be attached to the spinal needle, thereby removing the final safeguard for the patient [72]. Similar tragedies have been reported with chlorhexidine cleaning solution administered epidurally [73]. Although this problem was recognised 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. Although there are other examples of unresolved equipment safety issues, this is perhaps the most serious unresolved equipment risks that anaesthetists regularly encounter.

Conclusion

Recognition of human factors is now firmly embedded into clinical anaesthetic practice, and has been highlighted in several recent national reports and guidelines. We have reviewed the current literature and described the human factor components of 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 ED and the operating theatre.

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