Human Factors in Trauma Care

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Why the Human Factor Is Always a Factor

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- Definition and importance of human factors in trauma resuscitation
- Causes of Error: flow disruption and active or latent failures
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- Task Based Factors: mastery and the use of checklists
- Human Factors and Teams: pre-briefing and debriefing, communication, and leadership/followership
- Environmental Factors: physical layout, resource utilization, and the Zero Point Survey
- Organizational and System Factors

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Who is in charge of the clattering train?
The axels creak, and the couplings strain.
For the pace is hot, and the points are near,
And sleep hath deadened the driver's ear;
And signals flash through the night in vain.
Death is in charge of the clattering train!
–Edwin James Milliken, 1890

Introduction

When humans, and their systems, are pushed beyond their limits then disasters follow: it is just a matter of time. Milliken's poem was relevant over a century ago when a train crashed due to poor working conditions and distracted drivers. Half-a-century on it was just as relevant when Winston Churchill repurposed it for his history of World War II, *The Gathering Storm.* Fast forward another 50 years and it offers a useful starting point for discussing human performance in modern trauma medicine. It will likely continue to be all too familiar until we humbly accept that 'the human factor is always a factor", and adopt a culture of constant reflection and improvement. Having hopefully captured your precious cognitive band-width, we now offer practical insights that can save patients' lives and keep medical teams strong.

Hyperbole aside, it is not difficult to liken the modern trauma bay to a clattering Victorian train: with people in peril and workers straining to halt death. Despite all of medicine's giddy technical advances, it can still be unclear who is in charge.

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There is still every likelihood that resuscitators are sleep-deprived, that judgements are distracted, and that performance is stymied by maddening bureaucracy and dysfunction. "Red flags" go unnoticed, technology can falsely reassure, and chaos can predominate. That is, unless we commit to understanding the good, bad and ugly of human performance. This is because, following major trauma, a patient's aortic dissection, cerebral oedema, and unstable pelvis are certainly a threat to their life, but so are our prehistoric human responses and sclerotic systems [1].

Accordingly, this chapter focuses on non-technical skills, otherwise known as Human Factors (HF). These are often taught under the rubric of Crisis Resource Management (CRM) which contains six subsections: situation awareness, decision-making, communication, task-resource management, leadership and followership, and teamwork [2]. Our goal is to offer insights at the level of the individual, team, task, and environment. Importantly, non-technical competence should not be assumed, or intuited, any more than technical competence. For example, we do not assume you can insert a central venous line without instruction and practise; the same applies to working in complex resuscitation teams. Fortunately, HF knowledge, and CRM skills, can be learnt, mastered and maintained. Like many things in Medicine, improvement starts by giving a damn, and refusing to accept the status quo.

What Are Human Factors and Why Should We Care?

HFs can be broadly defined as the interplay between individuals, teams, tasks and the environment. They are largely synonymous with CRM in that the focus is not on the technical aspects of medical care (i.e. medications and procedures) but rather the ergonomics of how humans identify threats, make decisions, and coordinate activity. HF and CRM are scientific disciplines. However, HF solutions may be little more than codified common sense, or lessons redeployed from everyday life. As such, HF may be the best way to understand why errors occur in complex human systems, and the best way to mitigate their harm. An understanding of HFs also explains why we need regular simulation, and structured debriefs. Once you grasp the importance of HF you are also likely to see medicine not only a science and art, but also a branch of engineering and psychology [3].

Deliberate study of HF and CRM began approximately half-a-century ago. Commercial aviation industry led the way, and because 70% of adverse events were attributable [4]. The percentage of attributable errors is similar in medicine, but we continue to be laggards. Both medicine and transportation should strive to manage people safely and predictably. There is, however, a danger of oversimplifying the comparisons with aviation. After all, resuscitation rarely allows us to delay "take off" until everyone is rested and familiar, or "return to base" if things go awry. As such, low performing trauma teams should look to learn from high performing trauma teams not just Top Gun pilots. You may prefer to compare trauma medicine to symphony orchestras or sports team: it does not matter. What matters is that medical practitioners are open to any translatable insight no matter their source. Aviation represents the best starting point because it has been formally studied, and because, like doctors, pilots face individual stress, unfamiliar players, dizzying technology, and pervasive bureaucracy. Aviation also offers an important reminder that medical patients and practitioners are at the mercy of the very system designed to keep them safe.

Importantly, better resuscitation is not about just replacing humans with computers and checklists, or assuming that humans are an unmitigated liability. Instead HF and CRM are about understanding the strengths and limitations of each component in a system (self, team, environment, patient, technology) and designing better work environments (i.e. more resilient team structures, more sensible work-rosters, and more appropri-

ate fail-safes). It means leveraging ergonomics and psychology and engineering to help humans be more thoughtful, efficient, vigilant, safe and caring. It is about making Safety (with a big S) everybody's business and a system wide imperative; every bit as important as throughput [5]. It means minimizing errors while also accepting that they will inevitably occur in complex systems. It means looking beyond the traditional approach of "name-blame-shame". Clearly, we have work to do.

Factual knowledge still matters and so does manual dexterity. Moreover, healthcare professionals and administrators must still accept appropriate individual-responsibility. However, HF emphasizes the need to also look at the wider system, context and culture. It moves us beyond simplistic questions such as "why did you do that?" and onto "why at the time did that occur and seem appropriate?". It means working on our verbal dexterity and team dexterity. HFs aims to help the individual patient in the here and now, but also to build a medical culture that is mature and just. It is why medical practitioners should see themselves as "culture change agents" not just "all-knowing" clinicians who do discrete shifts. If we fail to learn these lessons then we will continue to make repetitive mistakes in high stake situations, and patients will needlessly suffer [6].

An understanding of HFs also offers a road map for the future; even a healthcare revolution. This is because it helps us understand that complexity outstrips any individual, and that resuscitation is now a team pursuit [7]. It explains why experts (especially experts) ask for help, incorporate double checks, and insist on closed loop communication. It means building a system where simulations are not a luxury, nor a soul-crushing embarrassment. HFs is about making team members feel safe, and communicating that we are all lifelong learners and change agents. HFs are also not about buzzwords, or endless meetings, but rather building a system where the best practitioners want to work, where the best administrators want to help, and where you would want your mother cared for.

Causes of Error

General Principles

As stated by Alexander Pope, in the 1700s- and repeated by the Institute for Health Improvement in 1999- "to err is human". In other words, humans are not perfect, life is not perfect, and therefore trauma care is not perfect. Therefore, mistakes (typically understood as decisions that turn out to be wrong) and errors (typically defined as actions that go against accepted rules or norms) will occur. Our job is to minimize their likelihood, severity and consequence. Medical errors-also understood as predictable human errors that occur in a medical setting- are more likely when situations are convoluted and people are unfamiliar, distracted or biased. The consequences increase when patients are frail (i.e. they lack physiologic reserve) and when systems are stressed or dogmatic (i.e. they lack administrative reserve). Consequential mistakes and errors are more likely when teams consist of individuals from different backgrounds and experience levels, especially when if humans fail to check inherent biases, egos, or put others ahead of their needs.

Trauma is inherently risky. It comes with diagnostic uncertainty, high stakes, time pressure, unsociable hours and even uncooperative patients. Regardless, the majority of trauma-associated errors are not from insufficient technical proficiency, but rather non-technical issues. These include CRM deficits such as ineffective situational awareness (i.e. a lack of a shared mental model; team members not being on the same page), poor decision making (i.e. cognitive overload and insufficient cognitive offloading), inappropriate communication (which can be subdivided into verbal, non-verbal and paraverbal communication), poor task resource management (i.e. insufficient prioritization, allocation, delegation, mobilization), insufficient leadership (i.e. poor role clarity and diffusion of responsibility), insufficient followership (i.e. failing to ascertain how we can be most helpful) and insufficient teamwork (after all, "a team of experts is not an expert team") [2, 8].

The "swiss cheese model of error"—usually credited to James Reason- explains why, when mistakes and errors occur, we often "get away with it" [9]. This is because, for an error to become a bad outcome, several "holes" need to line up in time and place. In other words, not all errors lead to bad outcomes, but bad outcomes are usually multifactorial. Similarly, it explains why higher functioning (i.e. more resilient) systems have numerous safeguards and fail-safes. It is why a single shortcoming (i.e. sleep-deprived team members), or even two shortcomings (sleep-deprived team members plus faulty equipment) need not result in disaster. Importantly, the swiss chess model also emphasizes why we should not to equate being "lucky" with being "good".

These ideas also explain why safety reviews are not witch hunts but rather core business. We should be reviewing cases that go badly (so called "safety-one"- see below) but also the greater number that go well (so called "safety-two"- see below). In other words, a robust system learns from failure but understands the mechanics of success. As outlined, when root causes are explored, it is common to identify numerous issues [10]. Accordingly, substantial improvements are often the cumulation of multiple marginal gains [11]. System weaknesses (and successes) can be understood by looking at how, when, where and why errors (and successes) occur, and minimizing (though not ignoring) the "who" [12]. It means that errors (and successes) are rarely unpredictable or random. Every system really does produce the results it is "designed" to.

Flow Disruptions

Flow disruptions are deviations from the predictable chain of events. These threaten safety because they create confusion, complexity and inefficiency [12]. Within trauma care, flow disruptions are most likely to be aberrations in coordination, communication, or equipment. Importantly, these are more likely to occur in 'ectopic' areas (i.e. radiology departments or operating rooms (OR), rather than comparatively controlled environments (i.e. Intensive Care Units (ICUs) or Emergency Rooms (ERs) [12]. Catchpole et al. showed that implementing HF interventions that focused on reducing flow disruptions- for example, having the Radiology Department pre-alerted to traumas or having a structured OR handover- was associated with shorter hospital stay. In other words, standardization can help, and simulations should occur throughout the hospital. The importance of flow disruptions highlights the importance of addressing the patient's entire journey, including potentially perilous handovers from one team or location to the next. After all, relay races are usually won or lost on the baton pass.

Active and Latent Failures

As the term suggests, active failures are committed by those in closer patient contact. They are also more likely to have an immediate and obviously detrimental effect [1]. This, in turn, means that active failures are often easier to identify and more likely to be addressed [13]. An example is when an intubator inserts an endotracheal tube into the oesophagus. In short, everyone from the intubator to the most junior nurse likely knows an error occurred. In contrast, latent failures occur more at a system level, and, therefore, may be harder to identify and attribute. It may also take longer for latent failures to be linked to bad outcomes. Latent failures typically, lay in waiting and require the right trigger [1]. An example is having the difficult airway cart far from patients, not clearly marked, or inconsistently stocked. This could result in staff being unable to find the right equipment, which in turn means they attempt intubation despite suboptimal conditions. As such, the endotracheal tube still ends up in the oesophagus and the patient suffers the same consequence. By addressing both active and latent failures a system increases its resilience, closes more "holes in the swiss cheese", and become more proactive. There is also an increased sense of shared responsibility and, hopefully, less finger-pointing [13].

Key Points

- Trauma resuscitation can be error prone due to its chaotic environment, diagnostic challenges, and high stakes nature.
- Flow disruptions introduce multiple threats to patient safety and team resilience.
- Active failures have an immediate adverse effect, while latent failures are more difficult to identify and are deeply rooted within a system. Both need to be addressed.

Individual Factors

Example

Imagine it is your first week on the trauma service: whether as a nurse, registrar, or student. You are 15 hours into a busy shift, having hardly eaten or used the bathroom, and the trauma team has just been called overhead. You have only participated in one other trauma resuscitation, you believe it went badly, and you felt you were "in over your head". You are petrified that you are going to make another mistake. You have little obvious backup, and you are working under a senior doctor who is known to be patronising and influential. You enter the room and see that CPR is in progress and you are handed a laryngoscope. You hear that the patient has multiple life-threatening injuries that will require simultaneous emergent intervention—some of which you have never done before. Perhaps we can start with a simple but fundamental question: How do you feel? ◄

Stress and Adverse Physiologic States

An old medical maxim asserts that before checking the patient's pulse you should check your own. In other words, stress affects our performance and needs to be managed. A small "dose" of stress is helpful, as it usually focuses attention. Manageable stress also propels humans beyond denial and deliberation into deliberate action. Most people need "physiologic arousal" in order to engage, but, excessive stress impairs performance. This is because excess physiologic arousal impairs higher-level thought and action. Excessive stress causes "attentional narrowing", meaning it impairs our ability to step back, and appraise the larger situation. Rather than apply innovative thinking we are more likely to fall back on what we did before. In extreme cases we simply freeze.

Excessive stress impairs global situational awareness and creates tunnel vision. This means we can miss important peripheral clues. Stress can also create "tunnel action", and perseverance. In other words, overstressed people persist in the same action and same thoughts, whether right or wrong. It means we tend to do the same old things, even if unwarranted, and because they offer us comfort, control and familiarity. A mea culpa example is when we simply wish to intubate, insert central lines, or fire up the echo machine…regardless of whether the patient will benefit or not [14].

The "goldilocks" of stress ("not too much, not too little") is illustrated by the Yerkes-Dodson curve [15]. While perhaps an oversimplification, it is the "sweet spot" where we avoid under arousal (associated with disengagement) and also avoid hyperarousal (which threatens task execution, especially requiring fine motor skills or nuanced judgement) [7]. Importantly, stress is subjective- what some people find exhilarating others find terrifying. Stress also depends on prior experience and personality traits such as risk-tolerance and rule-adherence [7]. It can be improved by stress inoculation training. This is where deliberate, graduated repeated and realistic exposure is used to inoculate the resuscitator to stress. Incorporation of stress inoculation is also one way to prevent simulations from becoming predictable and unrealistic. In short, it is a simple, cheap and profound way in which to improve performance. As such, we highly recommend you give it a go [14].

Stress also matters because perception becomes reality. If an individual (or team or organization) assesses that their resources are insufficient then they are more likely to perform poorly. This could include not thinking that they are

capable, not believing they have the appropriate help or equipment, or not accepting that they work in a culture that "has their back". Obviously, these beliefs may be valid. The issue is that feeling stressed makes it difficult to execute higher level task because you are burdened by excessive tachycardia, elevated catecholamine levels, and general sympathetic overactivity [16]. It stands to reason that it is more difficult to resuscitate trauma patients with sweaty, shaky hands, and a nagging (and often self-fulfilling) sense of dread.

Myriad physiologic states can worsen human performance. In addition to excessive subjective stress, providers can be ill, intoxicated, or taking medications [13]. Fatigue is also a substantial risk factor, akin to intoxication [17]. We may be able to function in the moment when sleep deprived, because adrenaline kicks in, but this cannot be maintained for ever. Not surprisingly, long cumulative hours and shift work have both been shown to compromise higher cognitive skills and bespoke decision making in the short term. Sleep deprivation also impairs mental and cardiovascular health in the longer term [18]. The fact that our profession continues to blithely ignore the importance of sleep shows we have a long way to go in understanding even the basics of HFs.

The acronym "IM SAFE"—which stands for illness, medication, stress, alcohol, and fatigue-offers a useful acronym for self-reflection and self-improvement. It was developed by the aviation industry and is readily translatable to trauma team members [19]. We recommend a self-check before starting a shift, during the hospital commute, or when taking the elevator down to the trauma bay. After all, to do well you must be well.

Managing Stress and Increasing Cognitive Readiness

If you work in trauma then you will be exposed to stress: no ifs, ands or buts. We may not be able to wholly eliminate high-stakes decision-making, diagnostic uncertainty, or unsociable hours. We can, however, increase cognitive readiness and decrease sympathetic nervous system overload [20]. Three effective strategies are breathing techniques, self-affirmation, and mental rehearsal [20]. All are easy to learn and cost-free. Perhaps the only obstacle is giving yourself permission in the midst of chaos. Even just feeling your feet on the ground and your chest rising and falling can help you feel "centered" and more in control.

Controlled breathing simply involves four steps: slow deep inspiration, then breath holding, then slow full expiration, then breath holding. Each is done for four seconds, hence this is also known as square breathing. These can be done prior to, during, or after stressful events [5]. It will be familiar to anyone who has tried meditation. Fortunately, it should be familiar to anyone who has breathed in and out during regular life: in other words, every one of us can do this.

The second stratagem is self-affirmation or positive self-talk. Reminding yourself that "I've done loads of chest tubes" can decrease doubt and help you to cognitively reframe [7]. Thirdly, athletes mentally or pre-imagine their moves prior to big events, and we should too. Mental rehearsal, aka mental imagery, aka cognitive imagining is associated with higher confidence, greater sense of control, and better performance [16]. In other words, the human brain is a great simulator, so use it. Mental practice may not always make perfect but it does mitigate panic. Mentally preparing for success can make it more likely to happen. We believe you would have to be out of your mind not to use this!

Cognitive Bias

Beliefs and behaviours are influenced by prior experiences; for good and bad. Especially in stressful situations, we tend fall back on what we have seen before and done before. This is summarized as the Gestalt effect or pattern recognition. These can be immensely beneficially because is reduces delays (so-called 'analysis paralysis') and means not ever solution has to be built from the bottom up. The danger is that even when not fatigued we tend to favour inappropriately simple answers to complex problems [21].

In other words, we may see patterns where we should not, and we need self-discipline not to be lazy.

Other common biases include premature closure (downplaying contradictory evidence), availability heuristics (favouring those ideas at the forefront of the mind), anchoring heuristics (staying with initial assumptions), and fixation errors (ignoring evidence that points us in another direction) [21]. Once again, these HF principles emphasize that errors are often driven by unconscious or semi-conscious processes. They are rarely deliberate of insufficient factual knowledge or lack of moral fibre.

In this digital age, it is worth emphasizing that humans are capable of genius, abstraction, nuance, deep thought and emotional connection. Accordingly, it is not time for a wholesale replacement of humans in healthcare. However, all humans- including your authors- can be unpredictable, irrational, distractible, and fatigable. This is why metacognition- namely taking time to think about thinking- is important. Each of us needs to put in the work to make the unconscious conscious: otherwise we will be lousy teachers. We also need to accept our fallibility, but then use that to spur ourselves towards constant iterative improvement. We need to recognize those triggers that make us more prone to error. Now that we are primed as individuals, it is time to shift to the task at hand.

Key Points

- Stress, and other adverse physiologic states, can substantially impact human performance
- Breathing techniques, self-talk and mental rehearsal can optimize stress levels (not too little stress, not too much)
- Awareness of one's own cognitive biases is imperative to minimize error

Task Factors

Good trauma resuscitation means being able to complete myriad tasks swiftly and safely. Importantly, there is a difference between taskwork (those actions required to complete a task: in other words, "the what") and teamwork (the extra work that enables members to function collaboratively: in other words, "the how") [7]. Failure to appreciate the difference is another reason why we over rely (and over blame) individuals. It is also why we refuse to attribute success and failure to teams and systems.

The next lesson is that by 'overlearning' we can save more lives. In other words, we should practise well beyond the point of mastery. Honing our reflexes, such that some responses are subconscious, frees up cognitive bandwidth for other tasks (i.e. it improves task work), and communicates a sense of calm to the team (i.e. it improves team work). This should mitigate chaos and increase the sense of control, both internal (in the individual's brain) and external (i.e. to all team members). The only caution is that automaticity should not mean inflexibility or laziness [7]. We do simple things in the same predictable ways in order to free up time and bandwidth so we can tackle the more complicated. This segues into the good, bad and the decerebrate of checklists.

Checklists

Relying solely on our memory can be dangerous, especially during stress. As a result, there is a strong argument for cognitive aids. These aide memoires typically come in the form of checklists (a series of key items), and mnemonics (a memorable word, phrase or letters that also summarizes key items). These can be used both during crisis care, and routine endeavours. The most important thing is to test whether they make us smarter or dumber. Understand that checklists can save lives, but do not assume we need a checklist for everything. Moreover, do not assume that once a checklist is created then the work is done. It needs to be stress-tested and stress-finessed.

An example of an evidence-based checklist is the Surgical Time Out, developed by the World Health Organization (WHO). This has been associated with improve mortality, especially in the developing world. It has since been widely adopted [22]. Checklists are intended to increase

team communication, improve delegation, and flatten the social hierachy [22]. Importantly, however, checklists are only a tool, and like any tool will only be as good as the people that use them. After all, a hammer can be used to build things or smash things.

Checklists should be "dosed". In other words, just like our other therapies they should be administered at the right time by the right people and in the right situation. Importantly, they appear to be best when limited to seven or fewer items (just like phone numbers), and when they demand answers (what will you do when…) [23]. In other words, a 20-item checklist is not fit for task, and nor is the human tendency to mindlessly tick boxes. Cognitive aids should justify the extra time that they consume. They should be incorporated into simulations, posted in highly visible common areas and be co-created by both senior and junior team members [22].

After the Surgical Time Out, The WHO developed a Trauma Care checklist, in order to complete the primary and secondary survey plus other key steps [24]. In the same vein, Fitzgerald et al. (2019), developed a Trauma Team Time Out. This is intended for the first thirty minutes of trauma resuscitation. Once again, the goal is not to replace humans, nor is it to replace human judgement. Instead cognitive aids should ensure that we do not miss critical steps. They should free the brain up for higher level thought, and unite the team [25].

Team Factors

Trauma teams need to assemble quickly and be ready for coordinated action. Teamwork is more than just the sum of its parts; it is a larger integration of mental, manual, and social expertise [26]. As mentioned, a team of experts is not automatically an expert team [27]. In addition to the individual task skills discussed above, the success of the trauma resuscitation relies equally on the interpersonal functioning of the trauma team [26]. Not surprisingly, Cohen et al. (2018) found that success and failure are substantially influenced by the team's communication, coordination, and planning [13].

Justice Potter Stewart famously opined that while he couldn't define pornography he knew it when he saw it. The same could be said of the less salacious topic of teamwork. We all know a high functioning team when we see one: to reference our opening poem it resembles a well-oiled machine devoid of creak and strain. Regardless, effective teams have well-defined structures (i.e. the team knows how to give and take instructions, and knows how to confirm instructions were heard and completed). Nowadays, it involves "more we and less me". Empathic teams also perform hot debriefs (immediately after in order to address emotions) and cold debriefs (after a short lag to address what could be done better). All of this cross monitoring promotes better team resilience in the longer run [8]. Importantly, however, there are ways to improve performance before the patient even arrives. Welcome to the prebrief…

Don't Just Debrief, Prebrief

It has been argued that failing to prepare is like preparing to fail. Regardless, generations of healthcare professionals have been taught that all resuscitation begins with the primary survey or ABCs: airway, breathing and circulation. This is not always true. The primary survey is still fundamental, but, as will also be discussed under the section entitled the "Zero Point Survey" [14], we need not wait until the patient arrives. Instead, preassemble your team, identify the overall leader, and identify each sub-team (i.e. airway team, transfusion team etc.). Ensure that roles are delegated (thereby minimizing 'diffusion of responsibility'). Use this time to explicitly tell team members that you value their presence and authorize everyone to speak up if they have significant concerns. Once you have done this you can add the polite coda that interruptions should be brief and only if necessary for the patient's well-being.

The pre-brief is the first opportunity to build the team, to apportion tasks, and to develop a shared mental model. Ideally, everyone should have the opportunity to verbalize what they know, what they are concerned about, and their pro-

posed solution (aka Plan A) [7]. This team huddle allows the team to own the plan. It bolsters both teamwork and taskwork and gives everyone a structure to rally around if chaos builds. Done right it creates a team that provides updates and cross monitors. Done right and a group of relative strangers can become nimble enough to manage complex trauma, overcome human biases, and put aside interpersonal concerns.

Team Structure: Leadership and Followership

Attend enough lectures and somebody will eventually highlight the importance of culture. The problem is they rarely go on to define what 'culture' actually means. A deep dive is beyond the remit of this chapter but the Dutch Psychologist, Geert Hofstede offers a good place to start [28]. In brief, his group outlined six indices of culture. These are: Power Distance Index (i.e. how the powerful and less powerful accept their status); Individualism (i.e. loyalty vs everyone for themselves); Masculinity vs Femininity (i.e. money-focus; self-centeredness); Uncertainty Avoidance (i.e. comfort with uncertainty; reliance on rules vs style); Long Term Orientation (i.e. persistence, and the importance of shame), and Indulgence vs Restraint (i.e. individual freedom vs societal norms).

In broad strokes, building a better medical culture means hard work over years rather than the typical trauma timescale. It means ensuring that empathy is cultivated and shared, and that workplace toxicity or complacency is not tolerated. It means accepting that hierarchy must exist but balancing that against creating the creation of a safe and respectful work environment. This is because we need to structure but also to leverage everybody's knowledge and skills [26]. It means making team members feel safe. This is done by committing to team members' longer-term career development rather than casting people aside after one mistake. It means understanding that those actively talking (i.e. resuscitating by voice) are as important as those actively listening [26]. It means understanding that while team leaders may be largely responsible for setting the dynamic, we all own culture.

Better leadership improves team performance, satisfaction and efficiency [8]. However, just like culture, leadership can be hard to define. An effective leader knows when to be hands-on (explicit leadership) and when to step back and delegate (implicit leadership) [26]. Leadership is hard and cannot always be intuited. Leaders have to simultaneously earn the team's trust, present an acceptable shared mental model, centralize information flow, coordinate tasks and overcome emotions (their own and other's) [29]. They manage and monitor the overall situation, and they accept disproportionate responsibility (i.e. including when it is not even their fault). Leaders step up and get their hands dirty when required. Leaders also teach, mentor, and set a standard for the whole team [8]. This is why hierarchy matters- you earn the right to lead; it isn't just awarded on day one.

Importantly, followership skills are no less important than leadership skills, even if this is not reflected in the literature. To date, there are 60 publications on leadership for every one publication on followership [30]. Moreover, there is likely still a stigma associated with self-identifying as a follower (i.e. a relative subordinate), even though 85% of healthcare workers are better understood to be followers. Healthcare simply could not function without skilled followers, and once again these skills can and should be taught [2]. Effective followers are able to step up when required and not taking it personally when they need to step back. In short, followership is an advanced impressive skill and should be valued as such.

Followers are able to self-manage and use their emotional intelligence to size up what they can and should contribute in any moment [26]. Clearly, the binary ideas of leader versus follower is outdated. Instead, members of the trauma team move in and out of leadership and followership roles. Therefore, it is better to simply talk about high functioning team members, who, in turn, are those with the dexterity to adapt to *what* (rather than *who*) is right. As outlined, effective leaders and followers also cross monitor. This means that

while we manage ourselves, we also remain vigilant to the needs of others. Part of being a good trauma team member is having that 'sixth sense', where you size up a situation and step up or step back in whatever way best serves the patient and team.

Complex resuscitations often require sub teams. In HF terms, this minimizes task overload and ensures cognitive offload. While each team member maintains a global perspective, sub teams divide up the work and can thereby narrow their focus [7]. Examples include an airway team, or vascular access team. This breaks the resuscitation into more manageable chunks, and enables the leader to maintain a more supervisory role, or 'thousand-foot view' [7]. This mirrors the two attention types seen in nature types. System-1 is a focused spotlight gaze. This is exemplified in nature by the predator who focuses on only what truly matters, namely catching prey. System-2 means scanning from stimulus to stimulus. In nature, this is the potential prey who must avoid fixating on one spot and instead moves their attention constantly [8].

Shared Mental Models

Situational awareness consists of three parts: how we absorb cues, synthesize these into meaning, and predict what will happen next [8]. If all three steps occur then teams are better able to perform 'adaptive coordination'. In aviation terms this means we "fly ahead of the plane". In trauma terms it means not letting the patient go anywhere that your brain has not already been, and modifying errant behaviours well before disaster strikes [2, 7]. For the team to able to adapt, members need to be on the same page especially as things evolve. In other words, they need a robust but adaptable shared mental model. This is usually managed by the team leader, and strengthened and/or modified by team members sharing information. Trauma team leaders promote adaptive coordination by seeking input from others and then providing regular updates [7].

A mental model, or psychological map, includes an understanding of the task, context and resources [5, 21]. While we should avoid excessive noise, the process of "thinking out loud" keeps team members on the same page as the trauma progresses. This should optimize stress, enhance situational awareness, and communicate the team's priorities and each individual's role [31]. Hierarchy is important in managing the shared mental model. If excessive it discourages subordinates from speaking up. If inadequate it can lead to diffusion of responsibility. Experienced trauma teams often use a low authority gradient (also known as horizontal authority). This is where team members speak up and the leader says less [29]. In contrast, less experienced teams often need more explicit coordination and a more vertical authority gradient, akin to command and control [2].

Communication

Just as manual dexterity is needed to insert a chest tube, verbal dexterity is essential in complex trauma care [26]. Too often words that are meant are not said, words that are said are not heard, words that are heard are not understood, and words that are understood are not done. As such, it takes time, humility and commitment to become an expert communicator. Moreover, it takes skill to hear and to shut up [32]. Silence is not always golden, but nor is cacophony [29]. Three pillars of effective communication are closing the loop, verbalizing thoughts and plans, and maintaining a "sterile" resuscitation bay.

Language should be concise and precise. It should also be commonly understood, so avoid jargon, or words known only to your specialty. We also need to avoid vague statements, aka mitigating phrases. There really is no room for maybes or perhaps-es; instead be concise and direct. Moreover, every request should be amplified by somebody confirming that it was heard and confirming again when it is done (this is known as closed loop communication). Mitigating lan-

guage is so dangerous that it the number one reason that commercial planes crash. It is often because we are afraid to offend, lack confidence, or are embarrassed [29]. However, one need not be rude to be clear. An example of communication that is closed loop and mitigation-free could be as simple as:

Example

Trauma team leader: Anaesthesia, please intubate the patient, and confirm when successful (NOT "Would someone be able to intubate the patient").

Anaesthesia resident: I am going to intubate the patient now.

Anaesthesia resident: The patient has been intubated successfully. ◄

As seen above, the three steps of closed loop communication include directing a request to a specific individual, verbal acknowledgment of that request, and confirmation that the request has been successfully completed [7]. Graded assertiveness is also important when overcoming authority. A useful approach is using the Concerned-Uncomfortable-Safety rule [7]. Using the above example, this is how to CUS:

Example

Trauma team leader: Anaesthesia, please intubate the patient, and confirm when successful.

Anaesthesia resident: I am concerned that this will be a difficult airway due to facial trauma.

(Then, if response received is not adequate)

Anaesthesia resident: I am uncomfortable intubating this patient without assistance and advanced equipment. ◄

If neither of these red flags are acknowledged, a safety threat can be declared. Because both members of the team understand the CUS model, it should simultaneously decrease reluctance and offense. Another method to advocate and raise concerns is to use a five-step approach. Developed by the aviation industry, it involves: i) an attention getter, ii) statement of concern, iii) statement of the problem as you see it, iv) a solution, and v) a request for agreement [29]. This would look like:

Example

Excuse me Dr. Smith. I am concerned that this airway is difficult. I do not believe I have the equipment to manage it successfully. I think we should obtain the difficult airway cart and get anaesthesia backup. Do you agree? ◄

As outlined above, it helps to verbalizing thoughts and plans (i.e. the leader asks 'what am I missing" during a floundering cardiac arrest), and to double check that potentially dangerous actions are indicated (i.e. a nurse announces they are giving a medication). This not only promotes sharing, but allows for confirmation, and reassessments [29]. In emergency situations, this type of communication needs to be dispassionate and direct. The most important messages/questions should come first ("Nurse, does she have a pulse?") followed by why the message is critical ("The end tidal CO_2 is dropping he may be about to arrest") [31].

Effective communication is less likely when messages are excessively complex or if there is distraction from noise, emotion, and time pressure [32]. These increase the likelihood of misinterpretation and results in "channel overload". This is why we should strive for a "sterile" resuscitation environment. Team members must speak up when required, while recognizing that critical moments (like intubation) should be silent. During these moments, the leader is given extra temporary power such that everyone else's comments are held, and those being silenced cannot take offense [29].

The word communication means sharing meaning and make understanding common. Accordingly, it is the most important HF and the best way to identify a high functioning team. Importantly, communication is more than just delivered words. Delivery can be divided into verbal (what is said), paraverbal (how it is said) and nonverbal (eye contact, facial expression, hand gestures). Just as expert teams know when to share key pieces of information[31] they are skilled (whether consciously or unconsciously)

in each type of communication. They also ensure that it is consonant, not dissonant. This means that words (verbal) match tone (paraverbal) and both match facial expression (non verbal). This is because words are actually the least important of the three communication subtypes. Saying "I don't need help" but in a tone that suggestions otherwise simply increases confusion and danger. Just ask for help if you want it.

As outlined, equally important to what is being said is how it is delivered. Four main tones have been outlined: aggressive, submissive, cooperative, and assertive [10, 33]. The problem with excessively aggressive or submissive language is that it shifts the focus from what the patient needs to the status and ego of various team members. Modern clinicians are increasingly expected to use more cooperative/assertive styles, and further fine tune based on the situation's urgency and the team's maturity.

In short, communication (or lack thereof) is the important nontechnical skill in medicine, and the largest hole in the swiss cheese of medical error. It is insufficiently taught [34], and too often left to chance. We need to get better. This means we need to commend good communicator and condemn bad communicators. We cannot say it any clearer than that.

Handovers and Debriefs

If communication matters then it follows that the handover from one team to another can be equally perilous. This is why we need to practice and perfect handovers, every bit as much as handwashing. As patients make their way from pre-hospital, to the emergency room, to the operating room and beyond—each creates an opportunity for error, akin to that children's game of broken telephone. SBAR (Situation, Background, Assessment, and Recommendation) is a widely recognized, effective strategy. It was developed by the military and ensures that handover is delivered succinctly and comprehensively. Importantly, its structure is widely known. For example, this means those of the receiving end will recognize when the last component (i.e. the all-important recommendation) is missing. Having the deliver and receiver familiar with the same communication tool can be the difference between aggression- "so what the **** do you want me to do?" versus polite redirection "so, are you calling for advice or transfer?" [29].

Another handover tool is the 'ATMIST' mnemonic, which was designed for trauma and showed its usefulness in Camp Bastion, Afghanistan [35]. Sequentially, it includes i) age of patient, ii) time of incident, iii) mechanism of injury, iv) injuries (head to toe), v) vital signs, and vi) treatments given so far. It is similar to the more familiar AMPLE mnemonic which incorporates i) allergies, ii) medications iii) past medical history iv) last meal v) events surrounding the trauma. Whichever handover system is chosen, it should be concise and logical with a sequential structure. Once again it should be familiar to both deliver and receiver. We need to be on eth same wavelength.

Debriefings allow teams to explore and highlight what went well and what did not. They are an opportunity to learn, and to identify when a formal quality or review is required [25]. They are also a time to let off steam, share emotions, bond, and work through ethical or moral concerns [35]. Debriefing should be routine rather than exceptional, should be non-threatening, and should take place soon after the linked event. They used to occur in the pub. If this is no longer deemed appropriate then we need to find other ways.

Key Points

- Successful team perform pre-briefs, and develop and cultivate shared mental models.
- A strong leader is able to anticipate team members needs and make team members feel safe.
- Followership skills are no less important than leadership skills but have been underemphasized to date.
- Effective communication involves closing the loop, verbalizing thought processes, and maintaining a "sterile resuscitation bay".

- Handovers should be practiced and perfected, and critical events should be followed by deliberate debriefs.

Environmental Factors

The Zero Point Survey

The Zero Point survey, shown in Fig. 1.1, uses the mnemonic STEP UP to prepare Self, Team, Environment and Patient [20]. It is also a practical way to improve ergonomics (i.e. the interaction between the work environment and the worker). The first three steps precede the patient's arrival, and precedes the primary survey. Personal readiness includes seemingly mundane iterative improvements, such as using the toilet or obtaining a snack before a long resuscitation. After the team has been prepared the focus turns to optimizing the resuscitation environment. This means appraising whether space and equipment restrictions will compromise patient management. If so then we need to move things before the patient arrives. Examples include creating space around the patient, ensuring adequate lighting, and implementing crowd control [20]. It might mean moving things out of the way (so that patients can be rushed to the Operating Room (OR), or closer (so that the Difficult Airway Kit is at hand).

Physical Layout

As outlined, there is more to safe resuscitation than just clever people and shiny equipment. Halls should be wide enough, obstacles removed, kit nearby and elevators free and functioning. We should ensure that phones (and any other communication devices) are strategically placed and actually work (for example, land lines may be needed in lead lined areas such as Radiology Departments or ERs). It means knowing that security personnel are available. The trauma bay itself should have adequate lighting, visible monitors, supplies, and enough room for the team to function. On the other hand, it should not to so large that team members cannot see or hear one another.

Inadequate space, misplaced equipment and haphazard wires and tubing can all be latent threats [7, 13]. Key anatomic areas, such as the patient's head and thorax should also be kept clear. The location of equipment and how it is labelled should be known by all in order to minimize delays. Team members should familiarize

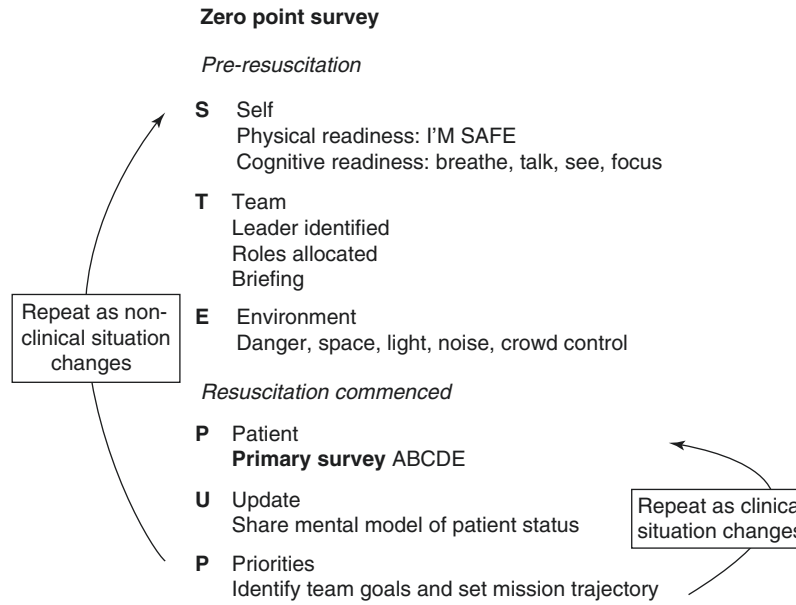

Fig. 1.1 The STEP-UP approach to the Zero-Point Survey, preceding and commencing with patient arrival [20]

themselves with the physical environment and location of equipment prior to patient arrival. More recently, courtesy of COVID-19, it has become necessary to delegate somebody not only to crowd control, but to supervising during donning and doffing of personal protective equipment: the so-called "dofficer" [7].

Resource Utilization

In practical terms, resource utilization is about how we help or hinder ourselves and how well we prioritize tasks. Importantly, "more" does not always mean "more". For example, eight people might be optimal number of staff members around a patient's bed (the so-called Dunbar's number- named after the psychologist Robin Dunbar). In contrast, larger teams can create distraction, excessive noise and the bystander effect (i.e. humans are less likely to help when others are present). This means that it can be appropriate during resuscitation to remove unnecessary personnel. However, it is usually best to have them close (i.e. just outside of the room) in case you need a "go-for" (to grab supplies), a procedural expert (in case that airway is difficult) and a cognitive resource (in case the trauma becomes more complex than expected).

Key Points

- Using the Zero Point Survey can improve the likelihood of success even before the patient arrives.
- Attending to the physical layout of the trauma bay can further optimize individual and team performance.
- Resource utilization matters: It's important to find the optimal balance between too much and too little help.

Organizational and System Factors

To ensure that there is a consistent, iterative, proactive approach to safety, there must also be support from the overarching system. The system or organization should also understand HF, and for the simple reason that healthcare is still run by humans and for humans. The organizational climate encompasses its vision, policies and culture [13]. All three should be informed by regular feedback and from all levels: frontlines and backrooms. A useful example is the Massive Transfusion Protocol used in trauma resuscitation [36]. Mangers who are visible and approachable are equally important [36]. Trauma team members are unlikely to respect desk jockeys.

Safety-I and Safety-II

Patient Safety is often fallaciously understood as just the absence of failure. Similarly, an "error-is-everywhere" mindset has led to idea that all we need is minimal variation and maximal compliance. This has also meant that Safety (with a big S) has been largely defined by administrators, regulators, and external mandates [37, 38] It has led to a "find and fix" strategy and relies on adverse events to guide safety, without acknowledging the irony of this approach [38]. This approach- now known as Safety-1—largely assumes that systems are bimodal (i.e. things go right or wrong) and decompostable (i.e. complexity can be broken down into individual repairable parts). Safety-1 is more likely to see humans as a liability, because we introduce variability into a system that would work perfectly if we just followed the protocol [38]. This "scooby-doo principle"- namely, "it would be fine if it wasn't for those meddling kids"- is short sighted.

Unfortunately, Safety-I can be highly attractive to some administrators and programmers, especially those far from frontline care. Complex healthcare is often so nuanced, and its components are so intertwined, that they cannot be broken down or summarized on a one-page linear algorithm. This means that we may be better looking at complexity theory (as attributed to Gloubermann and Zimmermann) or chaos theory (often attributed to Lorenz). Regardless, when things are unpredictability it is hard to dictate a single way, or precisely define 'ideal behaviour'– except in the most basic cases. This means that Patient Safety means we also need to understand

how humans get things right most of the time. This in turn means empowering humans and respecting gestalt and experience. This study of 'how most things go right' is known as Safety-II, and is a profound advance in terms of highlighting the importance of humans (and their HFs), and exposing the shortcomings of computers.

Safety-II is the study of success rather than failure. It relies on the adaptation, improvisation, tenacity, and everyday problem-solving skills of practical people. Accordingly, "expertise" is recognized and rewarded. It means respecting intuition, and accepting that some are better able to deal with unpredictability and chaos. Safety-II aims to learn how teams adapt, and sees humans as an essential resource because of their flexibility, practicality and experience [38]. In means the excessive standardization can be a liability (not a state of administrative nirvana) if it prevent necessary adaptability and creativity. Safety-II, does not forgive error, or human laziness, or human inexperience. It also does not give humans maverick license to do as they please. Instead, Safety-II matures our understanding of what humans bring to healthcare. It helps explain adverse events as transient phenomena at a specific time and place. It reinforces the idea that improvements come from numerous iterative everyday adjustments [38].

Going forward, our understanding of HF will need to combine the two paradigms: with Safety-I predominating for simple matters, and Safety-II predominating for the more complex. Importantly, this updated understanding also adds extra nuance to why so many report burnout and frustration [37]. Without oversimplifying complex HFs like wellbeing and resilience, most healthcare workers will be familiar with feeling despondent because a Safety-1solution (i.e. another unnecessary delay) was implemented without their input, when a Safety-2 solution would have been better (i.e. a senior clinician could have been empowered). If we continue with a Safety-I focus there is every likelihood that front-liners will be disproportionally blamed and disempowered, and forced to endure wrong solutions, rather than just creating workarounds.

Examples of Safety-I versus Safety-II thinking abound. For example, doctors are (rightly) accused of illegible handwriting, and this is needs to stop. However, it likely results from doctors having to write too many orders: after all we weren't selected for bad handwriting; it developed because on the job. A Safety-1 solution would be to force doctors to type all orders, but with the result that we become even less efficient and even more distracted. A Safety-II solutions include allowing more verbal orders, have scribes assigned to busy doctors, or more default orders. Safety-I means we often face numerous security-stops when one, but done properly, would allow doctors to care for patient: Safety-II. The erstwhile focus on Safety-I can mean we overly rely on one laboratory findings (i.e. the SOFA score) rather than a face-to-face assessment of the patient (i.e. how quickly we should get off the sofa) i.e. Safety-II.

Systems that obsess over Safety-I and ignore Safety-II may lead exhausted and frustrated healthcare workers to quit clinical work [37]. After all, anyone who understands even basic HF appreciates humans can only take so much moral distress. We want humans to do the right thing because of the system not despite it. A greater use of Safety-II thinking might help dedicated humans feel valued and able to craft systems that are not only safer but more human-focused. Keeping experienced people engaged means we keep their wisdom in the system, rather than just their wrath. System-II could also mean a more nuanced understanding of the emotional and cognitive demands of working in healthcare, and the (in)human experience of being a patient. After all, none of us wants to be treated like a mere cog in a clattering train.

Summary

The more chaotic and unpredictable the situation, the more that HFs become the difference between success and failure, in both the short and long term. The individual must be equipped to overcome stress and their own biases. Communication, a shared mental model, and mutual respect must

underpin every leader, and, just as importantly, every follower. The working environment should be ergonomically designed and the team should be poised for action that is safe, logical and practised. The system in which this occurs should also be supportive and adaptive and should see its humans as resources not liabilities. When these things occur, Death is no longer in charge of the clattering train, and resuscitation is a life-affirming, life-saving and rather wonderous thing.

Questions

1. Stress is an important individual human factor that can be optimized to an appropriate level. Which of the following is NOT an appropriate way to manage stress?
   (a) Self affirmation through positive self talk
   (b) The four steps of controlled breathing
   (c) Self medication with anxiolytics
   (d) Mentally rehearsing the task ahead
2. Which is true regarding effective team structure for a resuscitation?
   (a) Effective leaders are always hands-on and never delegate
   (b) Hierarchy must never exist
   (c) Those actively talking are more important than those listening
   (d) Effective followers know when to speak up and when to step back
3. Highly functioning teams use all of the following communication methods EXCEPT for:
   (a) The use of mitigating language
   (b) "Closing the loop"
   (c) Maintaining a "sterile communication environment"
   (d) Verbalizing thoughts and plans
4. When does the Zero Point Survey ideally start to take place?
   (a) When care is being handed over to another service
   (b) When first alerted that a patient is en route
   (c) Immediately prior to the primary trauma survey
   (d) When debriefing team members after the resuscitation
5. What is the difference between the Safety- I and Safety-II paradigms?
   (a) Safety-I focusses on patient related factors, and Safety-II on system related factors
   (b) Safety-II looks at events taking place after initial resuscitation
   (c) Safety-I focuses on what went wrong, while Safety-II explores what went right
   (d) Safety-II has replaced Safety-I entirely in analysing adverse event

Answers

1. c
2. d
3. a
4. b
5. c

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