Human errors and their prevention in healthcare

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Abstract

Human errors form a significant portion of preventable mishaps in healthcare. Even the most competent clinicians are not immune to it. Errors in the perioperative period can often have grave consequences, and hence, perioperative clinicians need to be aware of the impact of human errors and how to minimize them. Errors are broadly classified into two kinds: latent and active errors. While active errors need to be addressed at the individual level, latent errors indicate organizational inadequacies. This review describes common errors in perioperative settings, the impact of such errors on healthcare, and preventive strategies to minimize such errors in daily patient care.

Keywords: Active error, cognitive aids, human errors, latent error, medication safety, perioperative safety

Introduction

Patient safety is the primary motto of the healthcare delivery system. Despite being manned and run by qualified personnel dedicated to patient safety, the healthcare sector is not immune to error. Medical errors were reported to be responsible for up to 98,000 deaths and 1 million injuries each year in the United States in 1999. It is still estimated to be the third leading cause of death in the US if it were counted as a disease. About 4–17% of hospital admissions are associated with adverse medical events and nearly two-thirds are preventable.

A report titled “To err is human: building a safer health system” was the pioneer report which alerted the medical community towards errors in healthcare. Since then, healthcare fraternity has been trying to focus on error prevention. Human factors in the context of error causation are extensively studied and preventive strategies have been adopted in healthcare from high-reliability organizations (HROs) such as the aviation industry and nuclear power stations. HROs are organizations working in hazardous conditions under enormous pressure yet have very low or nil catastrophe rates. Hence, they serve as excellent models for the error-resilient system. Many of the safety and quality improvement practices in anesthesiology have been adopted from the aviation industry. Sad as it may seem, there is a lack of awareness about the ways and means of error prevention among clinicians, especially in developing countries. An Indian survey of anesthesiologist’s shows that undesirable practices are common and can have implications for patient safety. Most of the data related to error management are from western countries. The article attempts to address the issue of patient safety in operating rooms. In this descriptive review, common errors in the operating room (OR), their causative factors, and preventive strategies to enhance patient safety will be discussed. An electronic search was performed on Google Scholar and PubMed for original and review articles using keywords “patient safety in OR,” “human errors,” “cognitive errors,” “medication errors,” “cognitive aids,” and “perioperative safety” until December 2018. Full-text articles published until December 2018 were included.

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Defining Error, Near Miss, and Violation in Healthcare

Error is an unintentional deviation from safe practice. According to Reason’s Swiss Cheese model of system accidents, multiple errors can cause the holes in layers of “Swiss cheese” to align resulting in a major catastrophe. ‘Near-miss’ is defined as “an error that has the potential to cause an adverse event (patient harm) but fails to do so because of chance or because it is intercepted.” In simple terms, near-miss is a close call that could easily have resulted in patient harm but luckily did not. Keeping track of near-misses gives insight into loopholes in the system and helps in designing multiple checkpoints to prevent the catastrophe. Errors are unintentional. If the deviation from safe practice is intentional, it is termed “violation.” (e.g. Deliberately omitting anesthesia machine check due to turnover pressure is a violation. Forgetting to complete is an error). Violation is intentional and occurs due to a lack of safety culture and motivational issues at the individual level.

Types of error

Errors are broadly classified into latent and active errors. Latent errors are the ones inherent in the system (system design, administrative decisions, quality of equipment and supplies, etc.). Active error is the actual event that results in harm/causes catastrophe. (Faulty ventilator is a latent error. Failure to check its functioning or detect hypoventilation is an active error. If disconnection of the circuit is identified and corrected before the patient desaturates, it is a near-miss). Behind every catastrophic failure, there is an underlying fault in the system (latent error at administrative level) that is triggered by an act of omission or commission (active error by personnel directly involved in patient care). Errors are further classified as depicted in Figure 1. Their causes and preventive strategies are enlisted in Table 1.

Approach to error prevention

Traditionally, errors were attributed to the incompetence of individuals, and emphasis was laid on individual training (personal approach of error prevention). This approach is flawed because errors are not always due to incompetence. As enumerated in Table 1, errors are multifactorial and even a competent individual can commit an error in certain scenarios. Hence, the emphasis has now shifted towards “system approach” wherein the focus is on introducing practices that make the entire system error resistant. (e.g., Noninterchangeable filling ports eliminate the possibility of filling the vaporizer with a wrong volatile agent. This is a better preventive strategy than a personal approach that focuses on training the concerned personnel to recheck the type of agent before filling).

Error prevention should target the cause. Slips and lapses can be tackled by providing optimal working conditions for the anesthesiologist. Cognitive aids are suggested to aid memory and decision making and cognitive forcing strategies help in avoiding fixation errors. While the above strategies mainly target an individual, certain proposals can be implemented as institutional policies. Techniques to foster communication among team members, reporting systems to identify latent errors, protocols to prevent medication errors, and effective training and simulation workshops are some of the strategies that can be adopted at the institutional level.

Targeting optimal working conditions

Long working hours, fatigue, noise and distractions in the operating room can significantly affect the anesthesiologist’s performance. Anesthesiologists are notorious for their long and stressed working hours which are often sleep-depriving. Sleep deprivation is found to be associated with increased reaction time, lapses in concentration and decreased probability of detecting alarms. People who have stayed awake for 17–19 h had shown deterioration in cognitive and motor performance to a level equivalent to that of a person with a blood alcohol concentration beyond legal limits. Accreditation council for graduate medical education in America imposes a limit of 80 h per week averaged over 4-week period, and daily maximum limit of up to 24 h. However, there is no uniformity in working hour recommendations. Hence avoiding long shifts, minimizing unnecessary conversations, beeps and pagers, and other such distractions in the OR are important for optimal performance. Strict implementation of “sterile cockpit” (no irrelevant talk/noise during critical phases) will help the OR personnel perform well.

As the number of patients treated is still the most commonly used performance indicator and has implications on remuneration, it is not surprising that everyone is under pressure to perform more. Performance pressure will decrease the quality of patient care and can make the clinician error-prone. In this context, it has been suggested to consider the number of safety practices adopted as a performance indicator. (pay-for-practice instead of pay-for-case) This could eliminate the focus from
patient turnover (thus relieving performance pressure), and encourage clinicians to concentrate on adopting a greater number of safe practices thus improving the overall quality of care. “Pay for performance (P4P)\textsuperscript{19} as it is commonly called, is a value-based payment model wherein financial incentives/cut downs are used to encourage certain desired practices as a means to achieve quality improvement and/or cost reduction. However, the initial results are not encouraging, \textsuperscript{21} and a recent Cochrane review does not show any significant difference in patient outcome.\textsuperscript{22} Further, revisions of this model are necessary to make a significant impact.

**Cognitive aids**

In the face of acute emergency/crisis, time and cognitive resources are limited. Omitting key steps, inability to recall or fixation to a single diagnosis can occur to even the competent clinicians who are stressed. “Cognitive aid” is the tool intended to guide stressed clinicians through a series of sequential steps that need to be undertaken without omission/fixation. Types of cognitive aids and their purpose are listed in Table 2. An ideal cognitive aid should be based on an existing guideline, must incorporate relevant information for the situation in question, eliminating unnecessary elements, presented in the correct sequence, in a simple and comprehensible manner. Improperly designed cognitive aid can mislead clinicians into wrong decisions or cause unnecessary delays in execution resulting in more harm. Hence, they need to be tested for fallacies in terms of content, design, presentability, and relevance. Also, the users need to be adequately trained before incorporating it in routine practice.\textsuperscript{10} Checklists are the commonest example of cognitive aids [Table 3].

Checklist enlists the set of actions that need to be performed at the given clinical scenario, to ensure none of the steps have been forgotten.\textsuperscript{23,24} Various types of checklists are depicted in Table 3.\textsuperscript{10} Embedding them into electronic information management systems might make them simpler to use. Their use is most studied in anesthesiology\textsuperscript{25} as tools aiding memory and decision making. They are found to improve the quality of hand-offs\textsuperscript{26} with a marginal increase in time taken to finish (less than a minute extra).\textsuperscript{27,29}

| Error in planning (missing an essential task while planning) | Slips | Fatigue | Sleep deficit | Distractions | Noise | Performance pressure | Optimal working conditions | No long hour shifts | Minimal interruptions/distractions | No turnover targets (pay per safe practice instead of pay per case) | Less reliance on memory | Cognitive aids algorithms checklists visual aids |
| Errors in execution | Mistakes | Knowledge-based | Wrong plan | knowledge gap | lack of skill/training | Fixating on one hypothesis (not able to think alternate solutions) | Training and Simulation | Cognitive aids | Cognitive forcing strategies |
| Communication-related (LATENT ERROR) | Inadequate and unstructured communication between involved team members | Aids for structured communication | Talkbacks | Alert Phrases | Checklists |

**Table 2: Cognitive aids**

| Type of cognitive aid | Purpose | Feature | Example | Remarks |
|----------------------|---------|---------|---------|---------|
| Algorithm            | Help in developing an individualized treatment plan | Presented as flow chart depicting the sequence | ASA Difficult airway algorithm | Usually function as aids in decision making |
| Checklists            | Prevent omission of key steps and act as a Memory aid | Set of actions to be completed with or without sequence | WHO surgical safety checklist | Compliance is low. Too many checklists can lead to checklist fatigue |
| Mnemonics             | Memory aid | | LEMON | |
| Computerized prompts  | Real-time prompts as memory aids | Integrated into anesthesia monitoring systems | E.g. the correct dose of drug prompt | Alerts will be customized to patient's needs, makes the use of this cognitive aid effortless |

WHO- World Health Organization. ASA- America Society of Anesthesiologist. LEMON- Look-Evaluate-Mallampati-Obstruction-Neck mobility mnemonic for difficult airway assessment
However, benefit from a checklist will be maximal only with adequate compliance and recordings. Incomplete or fallacious recordings will violate the purpose of a checklist and render it useless. Besides, the use of too many checklists can result in checklist fatigue\(^{[22]}\) further decreasing the compliance.

**Cognitive forcing strategies**

Cognitive forcing strategies (CFS), also called “debiasing strategies” or cognitive self-monitoring strategies\(^{[11]}\) is a technique that helps the clinician to avoid bias or fixation and force him to pause and think. CFS involves a “trigger” and “reasoning process.” Use of this strategy should be triggered by a scenario with a potential for cognitive error. The error can be avoided by incorporating rational reasoning into decision making. One example of CFS is the “rule of three.” It involves considering at least three alternative explanations before coming to a diagnosis and reassessing the diagnosis if the first three treatment interventions do not work (for example, intraoperative hypotension and tachycardia are not always due to fluid deficit. Considering other alternative explanations [e.g., anaphylaxis or embolism or anemia] if there is no satisfactory response to the initial fluid challenge can prevent fixation on a single diagnosis, thereby missing out on other rare but important entities).

**Communication**

Communication is an aspect of critical importance in the context of patient safety in the operating room. Ensuring that all the necessary information is appropriately and timely conveyed to the OR team (comprising of nurses, surgeons, anesthesiologist, and OR technicians) is challenging. This is mainly due to the difference in educational background, level of comprehension, and works culture among the team members. Addressing certain crucial aspects of communication, with the help of certain tools and techniques [enlisted in Table 4]\(^{[30,31]}\) goes a long way in better information transfer, thereby minimizing error.

Talkbacks and alert phrases are communication aids adapted from the aviation industry,\(^{[18,32]}\) especially important in dealing with paramedical and non-medical members of the OR. After giving verbal instruction to any of these team members, they can be

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### Table 3: Different types of checklists used in healthcare\(^{[8]}\)

| Type of checklist | Example |
|-------------------|---------|
| Static parallel   | Nonsequential list. The same person reads and completes |
|                  | E.g., Preanesthesia machine check |
| Static sequential with verification | The sequence is important. One person reads, the other performs the task and confirms |
| Static sequential with verification and confirmation | One person reads and multiple team members verify. |
|                  | WHO SS checklist, anesthesia time out |

WHO-SS checklist- World Health Organisation- Surgical Safety checklist. Adapted from ‘Marshall S. The Use of Cognitive Aids During Emergencies in Anesthesia: A Review of the Literature. Anesth Analg. 2013 Nov; 117 (5):1162-71.’

### Table 4: Effective communication strategies in healthcare

| AREA OF FOCUS | TOOLS/EXAMPLES | DESCRIPTION | Remarks |
|---------------|----------------|-------------|---------|
| Involvement of all team members | E.g. WHO Surgical safety checklist | Sign-in, time out and sign out (All parts to be filled out at appropriate times) | All the involved team members should participate. To be read out aloud and marked only after the verbal confirmation. |
| Standardized handoffs | E.g. SABR, SABR (R), checklists | Situation, Assessment, Background, Recommendation | Example of a structured handoff. No components are missed. SABR (R) is a modification where the listener should “read back” the conveyed information. Especially useful while communicating with paramedical and non-medical members of the team. Ensures that there is no wrong/inadequate communication Used to convey the seriousness/urgency of the event (e.g., desaturating patient or cannot ventilate/cannot intubate scenario). Standard alert phrases ensure that help arrives as early as possible. |
| Ensuring that the message is conveyed | Talkbacks, Alert phrases | Repeating the instruction given to them. E.g. “This is serious” “High alert” | |
| Communicating to superior (speaking up/ pointing out to people in power) | PACE, CUS | Tools to politely stop a superior and discuss it. Being assertive in a graded manner, PACE is an excellent way of discussing any practice that can potentially harm the patient. Probe (“Do you see that...?”) Alert (“Can we re-evaluate the...?”) Challenge (“Please stop a moment & discuss”) Emergency (“STOP NOW!”). “I am Concerned”, “I am Uncomfortable”, “This is Serious or there is Safety issue” These phrases can be used to broach the topic and open a discussion Voice the safety concern twice and the team leader must verbally acknowledge that the issue has been addressed. |
asked to “talkback” (also known as read back/speak back)\[32,33]\ i.e., to repeat the instruction given to them. This will minimize the probability of being misunderstood, and wrong orders being carried out. Communications in case of an emergency can utilize standardized alert phases such as “This is serious” to convey the urgency and seriousness of the event, thereby minimizing delays in recruiting help. “Code blue” is an example of a standard alert phrase. As soon as the word is announced, personnel drop everything at hand and run to help in resuscitation. Similarly, standard alert phrases can be adopted in institutions in certain time-limited crises (e.g., Desaturation and bradycardia in a child, or “cannot ventilate/cannot intubate scenarios”) to alert people what kind of help is needed.

If the anesthesiologist changes during the surgery, or when a patient is transferred from the OR to the ICU, proper hand-off between the concerned teams is of paramount importance. Structured hand-offs ensure that all the relevant information is conveyed at all times and minimize variability in the quality of hand-offs. SABR\[30\] (situation, assessment, background, recommendation) is a tool that is long since used to standardize hand-offs. (SABR[R], its modification, includes a ‘Read back’ where the person listening to the handoff is required to speak-back the information in his own words. This will ensure that there had been no wrong understanding or misinterpretation of the conveyed message).\[31\]

Another important aspect of communication is “speaking up to power”.\[30\] Junior members of the OR team, on recognizing the actual or potential danger to the patient, might be hesitant to speak up and point it out to those in power. (e.g., reasons such as hierarchy, fear of being shouted at, intimidated or ignored.) It is obvious that it has serious safety implications and needs to be addressed. P.A.C.E protocol, an adaptation from the aviation industry,\[30,32\] is a model of graded assertiveness that can be used while speaking to superiors. It translates as Probe (“Do you see that…”), then Alert (“‘Can we re-evaluate the…”), then Challenge (“‘Please stop a moment and discuss…”), and Emergency (“‘STOP NOW!’”). This serves as an excellent tool of communication to prevent patient harm and should be taught to all clinicians in general, anesthesiologists in particular. “CUS” acronym, another adaptation from\[16,30\] the aviation industry, involves the use of phrases “I am Concerned,” “I am Uncomfortable,” “this is Serious or there is a Safety issue” while communicating to superiors. In the case of a suspected safety breach, the “two challenge rule” involves voicing the safety concern at least twice to the team leader. The leader should verbally acknowledge that the concern has been addressed.\[16\] Sadly, hierarchical culture is rooted in healthcare. It is time to take steps to change the system and empower junior members of the team to speak up freely about perceived safety concerns.\[34\]

**Reporting system**

Every institute should have an adverse event reporting system to record every “critical event” occurring during patient care, which might or might not have led to harm. It will help to find a pattern of errors, perform root cause analysis, and make changes at the institutional level. It also helps in surveillance by providing statistics.

Confidentiality is mandatory to encourage reporting. Adverse events are underreported for the fear of tainted reputation, intimidation, and medico-legal implications. Option for anonymous reporting and immunity from medico-legal and job-related implications will encourage everyone to report a maximum number of “adverse” and “near miss” events. This will help in making the system error redundant and improve the quality of healthcare.

Global initiatives include anonymous reporting systems like AIRS (Anesthesia Incident Reporting System),\[35\] from Anesthesia Quality institute of ASA, and webAIRS\[36\] (from Quality and Safety, Australian and New Zealand Tripartite Anesthetic Data Committee owned and funded by ASA, ANZCA and NZCA). One incident from AIRS is chosen and published in every issue of the ASA newsletter with critical comments. Similarly, critical analysis of incidents from webAIRS is published in Anesthesia and intensive care journal. Such incident monitoring systems are required in India.

**Medication errors**

The operating room is a place where a single person is responsible for the selection, preparation, administration, documentation, and monitoring of medications. Hence, medication errors are imperative in the OR. One in 211 anesthesia cases involving medication errors is reported.\[37\] One in 20 medication administrations resulted in either error or adverse drug events in an institute equipped with barcode labeled syringes and electronic anesthesia record systems. Of these, 79% were preventable,\[38\] and this number can go high without these facilities. Up to 80–85% incidence of errors and near-misses are reported in anonymous surveys. According to ASA closed claims database, the most common type of error is the administration of incorrect dose (the second being syringe or ampoule swap) and the most common type of drug involved is succinylcholine (followed by epinephrine).\[39\] Self-reporting (often not effective), chart reviews (time-consuming and cumbersome), mandatory incident reporting systems, and computerized surveillance are the options to identify the magnitude of the problem.

Anesthesia Patient Safety Foundation (APSF),\[40\] an organization committed to patient safety gave a standard
plan to prevent medication errors in the perioperative period involving technology solutions, standardization, pharmacy solutions, and improvements in institution culture. The summary of their proposals along with certain other strategies for medication safety is discussed in Table 5.\cite{40-42} Some of their proposals that can be easily implemented are discussed here. Technology solutions\cite{40} include barcode-assisted labeling and administration. (Barcoded label is scanned before administration of a drug. The computerized system displays allergy alerts if already stored in patient’s records or reminders to dilute if vasoactive agents are loaded). Though effective, it involves certain operational costs, additional time, and requires anesthesia information management systems (AIMS) that are not universally available at all centers.

The use of clear and bold labeling and color-coding of lines and extension tubing along with the use of unique, non-interchangeable connectors can be used to prevent wrong route errors. Tall man lettering\cite{42} during labeling is another technique to prevent confusion between drugs with similar-sounding names. (the key differences in the names are to be capitalized for easy identification. E.g. atrOPINE, atrACURium). All the syringes should be labeled immediately after preparation, and the label is to be read before each use.\cite{41}

Standardized arrangement of drug tray\cite{40,41} (and workplace in general) will facilitate the anesthesiologist to quickly pick the right drug in case of an emergency. It also decreases the chances of an ampoule swap. Standardized storage areas in the cart will decrease the time wasted for searching in the face of a crisis. Standardized concentrations of vasoactive agents will help in preventing wrong-dose errors and facilitate easy hand-off amongst anesthesiologists as well as nursing personnel. ASTM\cite{43} has issued standard color coding for various drugs used in the intraoperative period. It has been observed that, during a crisis, the person administering the drug can spare attention just enough to appreciate color.\cite{44} Labels are often not read/misread during crises. Pharmacy solutions\cite{40,41} include the use of barcoded prefilled syringes, pre-diluted solutions, and avoidance of look-alike drug containers. This again involves additional cost and is difficult to implement at all the centers. Last but not the least, promoting the culture\cite{40,41} of active discussion regarding drug errors as well as honest reporting of near-misses can help achieve a gradual reduction in incidence.

**Effective training and simulation**

Periodic training and simulation workshops essentially focus on imparting knowledge and technical skills. Incorporating sessions on error prevention strategies and non-technical skills in these gatherings is essential to foster safety culture. Teaching non-technical skills is shown to decrease the incidence of errors.\cite{45} “Metacognition” and “rationale-based teaching” should be introduced in early anesthesia training. “Metacognition” (thinking about thinking) encourages clinicians to retrospect about how they arrived at certain decisions, and notice patterns in their errors (if any). Once a pattern is noticed, they can formulate certain cognitive forcing strategies or mnemonics to minimize their errors. Similarly, rationale-based teaching should be encouraged over rule-based teaching. (Instead of explaining what to do when a certain scenario arises, explain why).\cite{11} “This will inculcate the habit of using a rationale for decision making.

**Summary and Conclusion**

No one is immune to error. Constant vigilance regarding the possibility of error, optimal working conditions, effective utilization of cognitive (such as algorithms, mnemonics, and

| TYPE                  | SUGGESTED INTERVENTIONS                                                                 | REMARKS                                                                 |
|-----------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Technology solutions  | E.g. Barcode assisted labeling                                                          | Barcode is scanned before administration. The system displays appropriate alerts E.g. allergy alerts (stored in patient records) or reminders to dilute vasoactive agents or crosscheck for interactions Effective. Involve additional cost, Information management systems |
| Standardization       | Standardized arrangement of drug tray                                                    | Helps to pick the right drug quickly during an emergency Decrease time wasted for searching Prevent wrong dosing. Easy handover among OR and ICU personnel. In an emergency, less attention is necessary to appreciate the color than to read the entire label. Avoid errors due to misreading labels. Contrasting background Tall man lettering of similar drugs. E.g. DOPamine, DOBUTamine. Label material should allow writing with ball pen without smudge This along with color-coded and boldly labeled extension lines prevent wrong-route administration. |
| Standardization       | Standardized storage areas                                                              | (especially vasoactive agents) Labeling protocols Non-interchangeable connectors |
| Standardization       | Standard drug concentrations (especially vasoactive agents) (ASTM coding)               |                                                                 |
| Pharmacy solutions    | Barcoded prefilled syringes                                                             | Involves additional cost. Might not be possible at all centers          |
| Pharmacy solutions    | Prediluted infusions                                                                    |                                                                 |
| Pharmacy solutions    | Avoidance of lookalike containers                                                       |                                                                 |

OR- Operating room, ICU-Intensive care unit, ASTM- American Standards of Testing and Materials
checklists), and communication aids (such as SABR, PACE, CUS, two challenge rule talk-backs, and alert phrases) will help in minimizing their incidence. Efficient reporting systems will provide insight into error-prone areas of patient care so that they can be tackled. Effective meticulous incorporation of the corrective strategies, at both individual and institutional levels, will go a long way in enhancing patient safety in OR.

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