

PRODUCTION PRESSURE, MEDICAL ERRORS, AND THE PRE-ANESTHESIA CHECKOUT

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Abstract

Medical errors have rightly become an important societal and professional issue. While anesthesiology as a specialty has been at the forefront of the patient safety movement it is also subject to the same pressures for efficiency as any other business. Whether this pressure is at odds with the delivery of safe care is not yet clearly delineated. However, a theoretical framework of unsafe practices as well as a body of literature from other industries such as aviation suggests that production pressure may lead to unsafe practice. Also, it is unlikely that the common pressures encountered in the operating room (e.g., to reduce turnover times) have any positive financial impact for anesthesiology departments unless extra cases can be done each day. We include in this review a potential area for improvement and further research for anesthesiologists, the pre-anesthesia induction timeout. This crucial period of any anesthetic involves a high workload and is often the most hurried; this combination may be setting practitioners up to make errors. We suggest the use of checklists and timeouts to formalize this period and propose a useful seven-point list of crucial items and events needed before each anesthetic.

Introduction

The Institute of Medicine (IOM) estimates that at least 1.5 million Americans are injured annually by medical errors at a cost of over \$30 billion¹. Their report indicated that as many as 44,000 to 98,000 people die in hospitals each year from causes related to medical errors - this would make medical errors the eighth leading cause of death in this country. The anesthesiology community has taken the need for medical error reduction seriously. Since Cooper's landmark studies^{1,2} major strides have been made in error recognition, reporting and prevention. While IOM defines medical error as "the failure to complete a planned action as intended or the use of a wrong plan to achieve an aim" we will include in this definition failures to implement safeguards into a plan of care, since much of anesthesia practice is planning ahead to prevent scenarios which allow adverse events to happen. Despite major strides, there is still a need for comprehensive improvements in patient safety in all medical disciplines, including anesthesiology^{1,3}.

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While errors occur in a complex clinical milieu, the importance of incorrect human actions often receives utmost attention⁴. Examining errors from such a vantage point may assume that unsafe acts occur in isolation of their environment. A small minority of errors falls into this category but most errors involve a combination of both human and environmental factors. James Reason describes human error as being person-based (i.e., arising from aberrant cognitive processes) or systems-based (i.e., arising not from deviant human nature, but from environmental factors) with neither approach being sufficient to account for all errors⁵. He does, however, suggest that the dominant view in medicine is person-based and that this approach is flawed given that well-meaning, well-trained individuals can be set up to make errors by the systems in which they operate. The IOM report emphasizes that most of the medical errors occurring each year are systems-related and not attributable to individual misconduct. Therefore, it is important to consider whether time pressure in the workplace, often applied to anesthesiologists by those who believe it will increase efficiency, is at odds with patient safety.

While much of the medical errors literature involving anesthesiology has focused on critical events and measurable or reportable adverse events, the reality is that many if not most anesthetic errors are probably recovered from and never reported or recorded (e.g., near misses)⁶. These near-misses are errors, nonetheless. Administering anesthesia is intrinsically hazardous but certainly necessary to patients. It is important to accept that the manner of anesthetic delivery, not the pharmacologic agents themselves, tend to cause errors. Hence, the goal of a zero error rate is probably not achievable given the human element involved. One area for improvement in the common anesthetic is the pre-anesthetic induction period. This crucial period should occur in a non-stressful setting and bolster the anesthetic induction. The induction of anesthesia is involved, the workload is high and the potential for errors is great. While this period is brief in the scheme of the workday, it is often the most hurried and likely more prone to human error.

Theories of Unsafe Practice

Before one considers the importance of production pressure (i.e., the pressure on personnel to work more quickly as a higher priority than working more safely) to the relation of medical errors in anesthesia, a brief review of the theories surrounding unsafe practices is important. Epsin et al⁷ give an excellent review of this framework. They point out that unsafe practice persists because it is a functional response to professional, psychological and organizational pressures. An improved understanding of these factors is an important step towards correcting them. Four central concepts must be considered:

The first concept is the “vulnerable system syndrome” as described by Reason⁸. This concept considers a cluster of organizational flaws that interact to make systems prone to unsafe practice and therefore adverse events. These flaws include denial, blame, and the pursuit of productivity rather than safety excellence. The result is a system that ignores systemic causes of adverse events and fails to invoke necessary reforms. Epsin et al point out that pressures to work more quickly are highly correlated to failures to observe standards of practice⁹. Time pressure has been cited in the past as a significant source of tension amongst OR teams⁹ and likely adds to the “vulnerability” Reason theorizes. Any time a system is pushed past its capacity limits, a suboptimal level of performance will result (the speed/accuracy tradeoff described in computing technology)¹⁰ and the system becomes vulnerable to errors.

The second concept important to an understanding of medical errors is the concept of “migration of boundaries”, which considers the forces which lead to an individual purposefully functioning outside of established zones of safe practice¹¹. This model describes how and why competent, well-meaning individuals recurrently work around regulations that exist to safeguard care. This migration outside of safe boundaries is hastened by the combination of the system’s need for increased performance and the worker’s search for individual benefits. Financially, a business benefits by optimizing the ratio of input to output. Hospitals are no different. In similar fashion, any individual within a system will naturally seek to increase his or her quality of life through ease of

work and to also increase financial gain if possible. Taken together, these two variables may lead to the intentional omission of important steps meant to ensure patient safety but which the person migrating from the standards perceive as leading to more free time (by finishing their cases faster) and/or more money (by being able to do more cases). Such shortcuts may in turn lead to devastating events.

Another important concept is that of “first-order problem-solving” as described by Tucker and Edmonson¹². They argue that hospital workers respond to problems with readily available (first-order) solutions that support productivity but do not address underlying causes, therefore allowing problems to recirculate through a system. For example, a practitioner may discover that his/her anesthesia machine does not pass the checkout before the start of the workday. Instead of reporting the failure to facility managers in order to address the problem, he simply bypasses the checkout and starts the workday. Second-order problem-solvers seek out underlying causes of problems and inform responsible or interested parties when they occur. First-order problem solvers are well-liked in the system, however, because they “fly under the radar,” working through their problems independently and without involving others. In this fashion, they do not question systemic values or operational standards that underlie the difficulties they may face. In short, they keep potential catastrophes or missteps to themselves and try to handle or even hide them before others realize they exist or they manifest as patient harm.

A fourth concept important to our examination of the relationship of production pressure to medical errors is Epsin et al’s “relational coordination” between members of the OR team⁹. The authors argue that the first three concepts, while examining individual and organizational psychology, do not take into account the importance of the personal relations between members of a team which make the overall unit operate safely. The reality of staffing shortages and fluxes means that the same OR nurse, surgeon and anesthesiologist will not likely work with one another each and every workday. Therefore, many teams that might otherwise function in a safe manner never form in the first place. In a sense, the team starts *de novo* each workday. In this situation, the interactions may be tense and may

serve to hamper safe practice by stifling effective team behavior. A hypothetical example of how these frameworks apply to a production pressure-driven unsafe scenario can be found below (Figure 1).

Fig. 1

Before the workday starts, the surgeon insists he has to finish by early afternoon to see his office patients. He repeatedly states he needs to move fast, putting time pressure on the OR team.	Vulnerable system syndrome
In his preoperative evaluation, the anesthesiologist discovers the patient ate a small meal five hours ago. So as not to delay the case, he proceeds with the anesthetic induction. Upon laryngoscopy, he notes vomitus in the airway.	Migration of boundaries
Not wanting to ask for help (as this would expose his error), the anesthesiologist intubates blindly. The intubation is successful and nobody is aware that an aspiration may have occurred.	First-order problem solving
The case proceeds without difficulty and the anesthesiologist, fearing conflict with the surgeon, says nothing. He rationalizes the situation to himself as a “near miss.”	Relational coordination

Medical error examined using the four conceptual models of error

Gaba et al¹³ state that safety is compromised when production pressure 1) leads to violations of practices necessary to maintain safe operations and 2) induces haste, which can increase errors in judgment and performance, especially when haste interacts with other error-inducing factors (e.g., fatigue). To this end, much work has followed to examine the relationship of increased workload and medical errors in the non-operative setting¹⁴⁻¹⁶. Communication breakdown, as well as increased workload and competing tasks, pose the greatest threats to patient safety in the operating room according to one prospective observational study¹⁷. Whether such relationships are always true for anesthesiologists is not yet clear, but a combination of factors such as those described in the hypothetical scenario above could clearly lead to errors.

Production Pressure and Medical Errors in Anesthesiology

Efficiently run operating rooms make fiscal sense and are therefore in the best interest of hospitals as long as medical errors and their resultant financial consequences, in the form of litigation and potential added patient care requirements, are minimal. A

survey of the literature reveals multiple studies related to operating room (OR) efficiency and strategies by which this goal can be achieved¹⁸⁻²¹. Still, the benefit of increased efficiency is not clear if it leads to increased haste to start and turn over cases. Some evidence indicates that reducing both turnover times and delays in first-case-of-the-day starts generally provide little reduction in OR costs²². Unless another case is done in a given OR, no increased financial benefit is realized. Amalberti et al²³ argue that the emphasis in health care on productivity in the face of chronic staff shortages must be overcome if rapid progress is to be made towards ultra-safe health care. Nonetheless, production pressure is a real entity to the practicing anesthesiologist and numerous studies have demonstrated that anesthesiologists practice in a stressful environment²⁴⁻²⁸. The demand for more efficient healthcare provision is ill-advised if the real cost of iatrogenic harm is not appreciated.

Production pressure makes speed and output, not safety, the primary objective of personnel within a system. Time pressure implies the same demands but adds the importance of accomplishing tasks quickly. Such pressures have been identified as important in catastrophic events in non-medical industries such as aviation, space flight, nuclear energy production, and long-haul trucking²⁹⁻³³. It has been estimated that half of all healthcare adverse events occur in the operating room³⁴⁻³⁶. This has led to a questioning of the current climate of the average OR. Numerous studies suggest that poor teamwork between disciplines may be a key factor in surgical error and that the safety climate in hospitals is poor, especially in the operative setting^{37,38}.

While the medical literature is fraught with studies on the mechanisms of errors, it often ignores the work conditions under which they occur. Work overload, especially time pressure, increases occupational accidents and job dissatisfaction in non-medical settings^{39,40}. Only a few studies have addressed the direct relation of time pressure to medical errors, generally showing a clear correlation⁴¹⁻⁴⁴. Given Reason's model for error, it follows that such pressure could lead to increased errors if it erodes human judgment and attention⁴⁵⁻⁴⁷. Indeed, the psychological literature provides examples of how time pressure can alter the decision-making process, showing that

stressors induce simple decision-making strategies, stereotypical thinking and a failure to use complex hypotheses and solutions⁴⁸.

Croskerry⁴⁹ states that, "... the academic/research position still appears to retain a statistical, formalized... notion of how people make decisions i.e., that they use quantitative formulas and techniques... in an environment where there is no lack of resources, no throughput pressures, no interruptions or distraction...". A high workload (i.e., the interaction between task requirements, environmental factors and operator abilities) is expected in anesthesiology especially during critical events (e.g., the difficult airway). As such, residents in training prepare for these incidents by practicing emergency procedures (e.g., laryngeal mask airway insertion) in controlled situations and in many programs, on human patient simulators. However, much of the workload which anesthesiologists experience does not come from critical events but from the undue day-to-day pressures of expediency (see Figure 1).

If these pressures are allowed to affect tasks which are normally non-stressful (e.g., pre-anesthesia checkout), crucial steps intended to increase patient safety may be overlooked, forgotten or intentionally ignored. A survey by Gaba et al¹³ asked about internal (i.e., self-imposed) and external pressures experienced by 647 anesthesiologists. The highest internal pressures reported were avoidance of case delays, avoidance of litigation and maintenance of relationships with surgeons. The highest external pressures noted were from surgeons to proceed with cases rather than cancel them and from OR administrators to reduce turnover time. Forty-nine percent of respondents witnessed unsafe actions by other anesthesiologists including elective surgery in patients who had not been adequately evaluated or in those with significant contraindications to surgery. Sixty three percent suggested they themselves had made errors because of increased workload. A similar survey by Healzer et al⁵⁰, involving anesthesia residents, reported they had proceeded with elective cases despite inadequate monitoring and/or venous access (72%), insufficient evaluation (94%) or significant contraindications to surgery (69%).

Freund and Posner⁵¹ reported increased OR

productivity by anesthesiologists without significant rises in critical incidents or patient injury rates. They did, however, observe an increased rate of human errors in one earlier study and noted that their research demonstrated increased rates of critical incidents at higher productivity levels⁵². One significant weakness common to their studies was the use of physician reporting in the detection of critical incidents and patient injury rates, which may have lead to underreporting. Also, the assumption that an increase in human errors is acceptable as long as no increases in patient injury are detected does not lessen the fact that more errors were made but recovered from in a way which prevented *detectable* patient injury. The errors could have led to patient injury. Hence, it is important to take a proactive stance towards medical errors even if their rarity prevents us from studying them prospectively. We propose one area for improvement in anesthesiology which is worthy of attention below.

The Pre-induction Period

In an Anesthesia Patient Safety Foundation (APSF) newsletter article about the importance of the pre-anesthesia checkout process⁵³, Drs. Feldman and colleagues presented the following frightening scenario:

While chatting with a patient about to undergo a laparoscopic cholecystectomy, you administer an induction dose of propofol and an intubating dose

of vecuronium. The patient loses consciousness and spontaneous respiration ceases. You adjust the mask on the patient’s face to establish a secure fit and squeeze the reservoir bag, only to find that you are unable to deliver a positive pressure breath. A quick visual inspection of the breathing circuit does not reveal the cause of the problem. Can you reliably ventilate this patient before he becomes hypoxic? Is an alternative method of ventilation readily available and functioning? Is there a reliable source of oxygen?

While this scenario is likely a rare one for mindful physicians, its occurrence is feasible if important steps are skipped prior to the induction of anesthesia. Failure to do a proper anesthesia checkout has been implicated in patient injury and near misses⁵⁴. Hence, standards and practices which are intended to prevent patient injury have been adopted. Namely, the 1993 anesthesia apparatus checkout recommendation (AACR) was designed to identify the important steps, which must occur before the safe delivery of an anesthetic⁵⁵. An effort to revise the AACR was initiated by the Committee on Equipment and Facilities at the 2003 annual ASA meeting after recognizing that the 1993 AACR did not apply to modern anesthesia delivery systems. The 2008 AACR recommends that 15 separate items be checked or verified at the beginning of each day (Table 1), eight of which should be checked prior to each procedure. Some of these steps are now part of an automated checkout process in the anesthesia machine and some may be done by technicians and not

*Table 1
Recommended Essential Steps in a Pre-Anesthesia Checkout Procedure*

	Item to be completed	Responsible party
1	Verify Auxiliary Oxygen Cylinder and Manual Ventilation Device (e.g., Ambu Bag) are available & functioning	Provider and Tech
2*	Verify patient suction is adequate to clear the airway.	Provider and Tech
3	Turn on anesthesia delivery system and confirm that AC power is available.	Provider or Tech
4*	Verify availability of required monitors, including alarms.	Provider or Tech
5	Verify that pressure is adequate on the spare oxygen cylinder mounted on the anesthesia machine.	Provider and Tech
6	Verify that the piped gas pressures are ≥ 50 psig.	Provider and Tech
7*	Verify that vaporizers are adequately filled and, if applicable, that the filler ports are tightly closed.	Provider or Tech
8	Verify that there are no leaks in the gas supply lines between the flowmeters and the common gas outlet.	Provider or Tech
9	Test scavenging system function.	Provider or Tech
10	Calibrate, or verify calibration of the oxygen monitor and check the low oxygen alarm.	Provider or Tech
11*	Verify carbon dioxide absorbent is fresh and not exhausted.	Provider or Tech
12*	Perform breathing system pressure and leak testing.	Provider and Tech
13*	Verify that gas flows properly through the breathing circuit during both inspiration and exhalation.	Provider and Tech
14*	Document completion of checkout procedures.	Provider and Tech
15*	Confirm ventilator settings and evaluate readiness to deliver anesthesia care.	Provider

the anesthesiologist per se.

It is important to note that while this recommendation is useful, it is by no means exhaustive. In fact, the AACR checklist is almost entirely devoted to the anesthesia machine and nothing else.

Haynes et al studied the effectiveness of the 19-item WHO Surgical Safety Checklist in decreasing surgical sequelae⁵⁶. This expanded checklist included a “sign in” before anesthetic induction, a “time out” before skin incision and a “sign out” before the patient left the operating room. Anesthetic concerns such as airway difficulty, anticipated blood loss and a functional pulse oximeter were added to this safety tool. Implementation proved neither costly nor time-intensive. The results of this study were impressive, with a decrease in postoperative complication and death rates by 36% on average. If one considers recommendations by the AACR and WHO, most of the anesthesia-related emphasis is on the machine checkout, pulse oximetry and airway precautions. We suggest that the sign in of the WHO checklist be expanded to focus more closely on anesthetic issues. Crucial items such as emergency drugs and airway devices, a working intravenous (IV) line and working set of American Society of Anesthesiologists (ASA) monitors are omitted. If one adds these components to the necessary anesthesia checkout (or “sign in” by WHO standards), a revised and more targeted checklist may be developed (Table 2).

Table 2:
Revised Recommended Essential Steps in
a Pre-Anesthesia Checkout Procedure

	Item to be verified or completed before induction
1	Manual ventilation device present
2	Full machine checkout before the first case of the day
3	Adequate suction/NPO status verified
4	Emergency airway devices present
5	Drugs for case (emergency and anesthetic) present
6	Working IV/Risk of blood loss considered
7	ASA monitors available and working

This checklist is in no way novel to the practicing anesthesiologist. Similar mental checklists which contain these items are taught to medical students and residents in anesthesiology year after year by experienced practitioners in an effort to teach good habits and ensure the presence of key safety items.

What is novel, however, is explicitly stating that key items are in place. No studies have directly examined how often and which of these particular steps is missed prior to surgical procedures. However, if this checklist were presented in the form of a timeout prior to each anesthetic (i.e., read aloud by a circulating OR nurse) the presence of these items could be reinforced through a systems-based effort. This ensures that missed pre-induction steps can be completed, missing items can be secured and that important patient and procedural issues have been addressed. Nuclear industry workers are not expected to remember every crucial step of a complex task, yet physicians often undertake complex clinical situations without any organizational support. This lack of organizational support seems especially applicable to anesthesiologists.

Conclusions

The scope of medical errors in the US is a major concern to patients and healthcare workers alike. While anesthesiologists have done much to improve the reporting and reduction of errors, much work remains to be done. Fiscal realities have led to a healthcare system which needs to be at once efficient and ultra-safe. Whether or not this can be accomplished is still a matter of debate and may never be conclusively answered. However, an understanding of the factors important to medical errors as well as the realities of production pressure is crucial if the next level of quality improvements is to be made in the field of anesthesiology. It is likely that a combination of systems-based support and cultural change in medicine towards one of safety-oriented needs to occur. Cultural change is likely the hardest to accomplish, yet systems-based support has proved relatively inexpensive and simple in comparison.

Omitting one or more key steps in the effort to save time may set up the anesthesiologist for failure in the form of patient harm. For this reason, it makes sense to adopt policies which support the anesthesiologist in the completion of essential tasks. A pre-anesthesia timeout which addresses the presence of key safety components and which is separate from the surgical timeout used commonly in most OR's seems a logical step. The surgical timeout has been widely adopted in an effort to reduce improper side/site surgery. Indeed,

the WHO timeout is the most comprehensive list to date and has been shown to decrease morbidity and mortality from surgical procedures. Checklists like the ones used for surgical timeout support memory, standardize processes and provide a framework for clinical endeavors. As Hales and Pronovost aptly note, the principle purpose of such lists is error reduction and/or adherence to best practice⁵⁷. Still, healthcare has been slow to universally adopt such safeguards due to operational (i.e., some clinical scenarios cannot be easily approached with a checklist) and cultural (i.e., clinicians may view standardized tools as threats to their clinical judgment) reasons.

An anesthetic timeout could potentially slow down the practitioner enough to allow him or her to secure these essential items before inducing anesthesia. This helps to lower the workload on a hurried anesthesiologist and is in line with the “pessimism”

common to highly reliable organizations (e.g., the nuclear industry, aviation) which *expect* individuals to make mistakes and safeguard against this possibility with redundant checks and organizational support^{58,59}. As Haynes et al, have shown, implementation of such safety measures affects outcomes positively and can be added cheaply and without hampering efficiency.

Production pressure is a reality for anesthesiologists. Given the theories of unsafe practice presented in this article, the importance of an optimized work environment is apparent to the practitioner concerned about quality and safety. While research needs to be done regarding the role of production pressure on medical errors in anesthesiology, tools such as the proposed anesthetic checkout should also be studied to assess whether meaningful improvements in quality can be achieved through simple means.

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