

Review Article

Surgical checklists: A detailed review of their emergence, development, and relevance to neurosurgical practice

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Abstract

In the fall of 1999, the Institute of Medicine released “*To Err is Human: Building a Safer Health System*,” a sobering report on the safety of the American healthcare industry. This work and others like it have ushered in an era where the science of quality assurance has quickly become an integral facet of the practice of medicine. One critical component of this new era is the development, application, and refinement of checklists. In a few short years, the checklist has evolved from being perceived as an assault on the practitioners’ integrity to being welcomed as an important tool in reducing complications and preventing medical errors. In an effort to further expand the neurosurgical community’s acceptance of surgical checklists, we review the rationale behind checklists, discuss the history of medical and surgical checklists, and remark upon the future of checklists within our field.

Key Words: Checklist, complications, medical errors, neurosurgery, surgery

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INTRODUCTION

In the fall of 1999, the Institute of Medicine released “*To Err is Human: Building a Safer Health System*,”^[39] a sobering report on the safety of the American healthcare industry. The publication revealed between 44,000 and 98,000 patients died each year in the United States as a result of preventable medical errors, with an estimated cost between \$17 billion and \$29 billion per year. Despite these rather harrowing data, within the report’s title lies the basis of a somewhat encouraging point: Medical errors were most often the manifestation of universal human fallibility and not unique to the world of healthcare. The report cited that the highest error rates were found in high-intensity settings, namely intensive care units (ICUs), emergency departments, and surgical operating rooms (OR). These complex settings require the highest awareness of human factors to achieve overall safety.^[1,14]

Considering approximately 234 million operations are performed worldwide every year,^[78] the potential – and necessity – of improving safety in surgery by addressing medical error is unequivocal.

Studies show that adverse events in surgery account for between one-half and two-thirds of all such events in hospitals.^[29,41,72,80] It is estimated that around one-half of these events are preventable.^[29,37,73,80] Other high-risk, high-intensity industries have attained much better safety ratings by counteracting the processes that lead to errors.^[36,67] Professionals in these fields are supported by standardized practices that aid in cognition and recall, reducing error to infinitesimal levels. They provide organized systems for identifying and rectifying hazards in both immediate and long-term circumstances.^[24,32,36] Adopting these practices toward error represents a potential mechanism for preventing the serious

consequences of surgical errors. Among these strategies, one of the most readily adapted tools for combating the dangers of surgical error is the operative checklist.

Checklists are cognitive aids that function both as mental notes and standardized protocols.^[32] As opposed to forcing the operator through a series of actions to a pre-determined conclusion, checklists enhance existing knowledge that may be blurred by fatigue^[26,75,81] or overmatched by the sheer number of required actions.^[21] The combination of fatigue and stress, so common in the operating room, has been associated with a decline in cognitive performance,^[2,3,26,30,32,67,81] representing a substantial contribution to the mechanism of error. Also, the volumes of medical know-how that professionals learn over their years of training test the limits of human memory during day-to-day practice. In his book *The Checklist Manifesto*,^[28] Dr. Atul Gawande recounts the story of the first B17 bomber designers vying for a governmental production contract. The demonstration flight of their superior product was undermined by their pilots' inability to cope with the complexity of running the state-of-the-art machine. Unfortunately, the lack of recognition of these cognitive limitations resulted in an explosive crash and the loss of the pilot's life. Only when a flight checklist was widely used for the first time did the production of the B17 proceed on a scale large enough to affect the Second World War. Surgical patients can similarly ill afford ignorance of cognitive limitations. Medicine has evolved to the point where even ultra-specialization cannot completely compensate for the limits of memory recall; checklists represent one method of preempting mistakes.

Over the past decades, checklists have been developed, tested, revised, and even mandated to better ensure the safety of every patient under the care of medical professionals. Unfortunately, however, the subject of checklists is poorly represented in the neurosurgical literature. With the practice of medicine aimed toward quantifying the quality of care provided and pay-for-performance physician reimbursement, we feel an understanding of surgical checklists is important to the neurosurgical community. It is with this fact in mind that we present a historical review of medical and surgical checklists and provide insight into how checklists may enhance the quality of care provided by the neurosurgical community in the future.

ESTABLISHING THE VALIDITY OF MEDICAL CHECKLISTS

In ICUs across the United States, catheter-related bloodstream infections (CR-BSIs) are a routine complication due to the high rate (48%) of catheterized patients.^[48] The 15 million days that patients spend with a central venous catheter (CVC) every year in

ICUs in the USA lead to approximately 80,000 cases of CR-BSI.^[47,48,51,60] It has been shown that 5% of all ICU patients with a CVC will develop an infection after 8 days.^[64] Although some trials note a minimal difference in mortality between ICU patients with CR-BSIs and matched controls,^[10,19,69] other studies associate a significant risk of death (up to 28%) with infection.^[20,55,68] Survivors average up to 22 days longer in the hospital and between 8 and 20 days longer in the ICU.^[60] It has been estimated that CR-BSI costs hospitals between \$279 million and \$2.3 billion in the USA every year.^[47,52]

However, CR-BSIs are very often preventable.^[33] Dr. Peter Pronovost and a team from Johns Hopkins proved this when they implemented a checklist aimed toward ensuring evidence-based practices for catheter insertion procedures.^[8] The checklist was simple, comprising a one-page sheet administered during every CVC or arterial line insertion. It prompted the staff to wash their hands; clean the procedure site; drape the entire patient; wear sterile gloves, hat, mask, and gown; and apply a sterile dressing once the line was inserted. An observation period at the beginning of the study revealed that only 62% of procedures incorporated every step. Once the intervention phase began, nurses were given the authority to stop a procedure if a step was missed, which occurred in 32% (12/38) of cases in the first month.

At the conclusion of this study, the investigators had effectively eliminated the incidence of CR-BSIs in their study ICU. The rate of infections had decreased from 11.3/1000 catheter-days in the first quarter of 1998 to 0/1000 catheter-days in the fourth quarter of 2002. The control ICU noted no significant changes. The potential of the checklist was perhaps most clearly stated by the statistical projections; the authors estimated they had prevented 43 CR-BSIs, 8 deaths, and \$1,945,922 in additional costs per year.

The group from Johns Hopkins continued to look for specific aspects of care in the ICU that could benefit from similar interventions. They designed checklists for patients on mechanical ventilation^[7] and for the delivery of pain medication,^[25] with a similarly astounding impact. Starting in 2003, the State of Michigan incorporated a number of these interventions in a project that became known as the Keystone Initiative.^[57] This large-scale test of checklists was accompanied by a comprehensive safety program that included staff education on quality interventions, coordination with team leaders at each ICU, and monitoring and reporting of quality standards each month. This undertaking was significant in both scope and results, as the median rate of CR-BSIs per 1000 catheter-days in 103 hospitals was reduced from 2.7 to 0 in just 3 months. Reductions were observed in both small and large hospitals, and they were sustained at 4 years post-intervention.^[56] The Johns Hopkins Team has

since moved on to checklist implementations in ICUs in New Jersey, Rhode Island, and Spain. It is important to note that in these studies, checklists did not stand alone. The authors emphasized the essential management considerations in appropriately implementing the checklists and noted a significant positive trend in the safety culture of the participating ICUs that could have played into the elimination of preventable errors.^[58] The role of these other quality interventions is impossible to differentiate. Nevertheless, whether checklists combat collective human limitations or simply serve as the vessel of a safety culture, the results of the Keystone Initiative legitimized a powerful tool in ensuring consistent, evidence-based care on a large scale.

THE DEVELOPMENT AND PROLIFERATION OF SURGICAL CHECKLISTS

Although the genesis of modern medical checklists lies in critical care, worldwide attention has come to include checklists for optimization of safety practices in surgery. In a field that stresses individual competence, checklists are encouraging a team mentality toward safe procedures. Like the initial trials in ICU checklists, surgical checklist studies have reported significant reductions in mortality and morbidity by enhancing staff focus on the most common and preventable sources of error.

The WHO surgical safety checklist

As part of the “Safe Surgery Saves Lives” project,^[63] the World Health Organization (WHO) developed and tested a perioperative surgical checklist designed to minimize the risk of adverse events during non-cardiac surgery. The trial of the WHO Surgical Safety Checklist^[35] constitutes the most comprehensive evaluation of checklists in surgery to date. After a thorough development process,^[28,77] the Safe Surgery Saves Lives Study Group generated a 19-item checklist that addressed surgical issues orally at three time points. The “sign-in” (before anesthesia induction) addressed the patient’s identity, surgical site and procedure, airway patency, allergies, pulse oximetry, and probability of needing blood and fluids. The “time-out” (before skin incision) re-addressed these procedural concerns and included the vocal introduction of every professional. The surgical, anesthesia, and nursing staff would review the procedure and detail foreseen complications. They would also confirm both the availability of required imaging and that prophylactic antibiotics had been given less than 60 minutes before incision. Finally, the “sign out” (before the patient exited the operating room) included a count of surgical materials and a full-staff review of recovery concerns for the patient.

Eight clinical sites were chosen across the world to reflect the efficacy of the checklist in any surgical environment, from overwhelmed third-world hospitals to state-of-the-

art academic centers. After baseline quality statistics were collected, use of the checklist was documented in 3955 consecutive surgical patients. The study authors noted an overall decrease of 4.0% (11.0–7.0%; $P < 0.001$) in surgery-related complications and a reduction of 0.7% (1.5–0.8%; $P = 0.003$) for total in-hospital deaths. These results could not be attributed to any single site, although the reduction of in-hospital deaths for high-income sites was not significant ($P = 0.18$). Although the authors discussed a few possible confounding factors, including a Hawthorne effect of observation, the results of the study stirred international attention.

In January of 2009, the United Kingdom National Patient Safety Agency released an alert mandating the implementation of a version of the WHO checklist within the entire National Health Service. Over the course of a year, the checklist was integrated into the British healthcare system, with room for modification within localities or specialties.^[59,65] A pilot study^[74] in two British hospitals performed just prior to this alert demonstrated that the implementation of this checklist was not a simple process. Encouraging compliance required considerable administrative influence and modifications to customary practices and attitudes in the surgical theaters. The authors did not observe the same decline in morbidity in mortality as the WHO study, although their quality statistics were very low at the start. They mentioned an improvement in safe practices, such as timely prophylactic antibiotics. Other beneficial effects of implementing the checklist included the enhancement of team communication and preparation for adverse events.

A recent publication^[76] addressed perhaps the greatest challenge^[30] in utilizing the WHO surgical checklist: The emergent setting. In the same spectrum of hospitals as the original WHO checklist evaluation,^[35] outcomes from 1750 consecutive urgent surgeries were recorded. The latter 908 surgeries employed the safe surgery checklist. Again, the checklist exhibited significant utility: A 6.7% reduction in major complications (18.4% pre, 11.7% post; $P = 0.0001$) and a 2.3% reduction in mortality (3.7% pre, 1.4% post, $P = 0.0067$) were observed. The proportion of procedures that incorporated six common safety precautions increased from 18.6 to 50.7% ($P < 0.0001$). The checklist seemed to function effectively even under these “crash landing” conditions, decidedly its most demanding application to date.

Other surgical checklists

Other groups have developed efficacious checklists that accomplished similar improvements in surgical safety, albeit on a somewhat smaller scale. They serve to validate the results of the WHO studies, as surgical checklists developed under disparate conditions have collectively exhibited utility.

The United States Veteran's Health Administration (VHA) incorporated surgical checklists as part of an overall patient safety initiative.^[22] Early program implementation^[53,54] showed how each of the 74 institutions used a few guiding principles to design their own checklist. At 4 months, 98% of the facilities were using a checklist for preoperative briefings and postoperative debriefings. The method of checklist deployment (i.e. paper, electronic, etc.) and the number of checklist elements (mean = 19.5) were not associated with differences in utilization. Compliance significantly increased for appropriate antibiotic prophylaxis ($92.1\% \pm 1.5\%$ pre to $97.0\% \pm 0.1\%$ post; $P = 0.01$) and deep vein thrombosis prophylaxis ($85.1\% \pm 4.6\%$ pre to $95.7\% \pm 0.8\%$ post, $P = 0.05$).

The Surgical Patient Safety System (SURPASS) checklist was recently studied in 11 Dutch healthcare centers. This checklist was more comprehensive than the WHO Surgical Safety Checklist in that it followed each patient from admission to discharge.^[16] The study hospitals all provide highly specialized care and were previously accredited by various Dutch agencies for their safety standards. In the six hospitals that implemented the checklist, the total number of complications per 100 patients dropped from 27.3 to 16.7.^[17] Surgical mortality for all intervention hospitals decreased from 1.5 to 0.8% ($P = 0.003$). Declines were also noted for patients experiencing multiple complications (15.4–10.6%, $P < 0.001$), those experiencing temporary disability (9.4–6.6 per 100, $P < 0.001$) and those needing multiple surgeries (3.7–2.5 per 100, $P = 0.005$). The authors also audited the compliance of individual items on each checklist and found a median rate of 80% completion. Those implementations that completed more than 80% of the checklist exhibited a drastically lower complication rate (7.1 per 100 patients) than those that fell below the median completion rate (18.8 per 100 patients). In a one-center study,^[15] utilization of the SURPASS checklist led to an increase in the essential interval between prophylactic antibiotic administration and incision (23.9 minutes pre-intervention to 29.9 minutes post-intervention, $P = 0.047$). The number of patients that received antibiotics after incision (which is recognized to be less beneficial) decreased from 12.1 to 7.1% ($P = 0.04$).

An Australian group has developed a series of algorithms for anesthesiologists facing patients in acute distress of unknown cause.^[61,62] The resulting "Crisis Management Manual"^[79] has been distributed for years via the internet and hardcopy. The basics of the algorithm are mnemonic checks for various problems, while the 24 sub-algorithms of the manual cover specific actions when needed. The sub-algorithms and an accompanying categorization of urgency are meant to be prewritten and kept in an easily accessed location.^[79] Although a prospective efficacy trial

has yet to be conducted, the continuing validation of this algorithm^[61,62,79] in simulations based on anesthetic incident reports shows that it can provide a working diagnosis in 99% of cases. In 60% of cases, the manual would lead to a corrective action in 40–60 seconds.

Neurosurgical checklists: a science in its infancy

The past 10 years have seen the development of early efforts to apply the value of checklists to neurosurgical care. These studies are important efforts to utilize checklists in neurosurgical procedures in an effort to improve the quality of care. Further implementation efforts and continued education of the neurosurgical community are certainly required; however, these early efforts are critical contributions to the growth of systems science in our field.

In 1999, the editor of *Surgical Neurology*, James Ausman, published a series of editorials entitled "The Business of Surgery," which called for the use of business principles in improving preoperative planning and operating room efficiency during neurosurgical procedures.^[46] He argued the total risk of any procedure is the sum of each part of the procedure, and through an intense focus on improving efficiency and reducing risk in every detail of the surgery, procedural outcomes can be optimized. Furthermore, he argued for the importance of preoperative "strategic" planning during even the most routine procedures. This planning includes reviewing images in detail before the surgery, multidisciplinary meetings with anesthesiologists or other surgical subspecialties prior to the day of procedure, ensuring adequate equipment is available for the surgery, review of preoperative laboratory results, and others in an attempt to optimize all aspects of the surgical procedure and nullify operative risk. Although a formal surgical checklist was not proposed in this series, the principles and objectives offered by Dr. Ausman in this brief series are visible, in one form or another, in all modern surgical checklists used today.

In 2010, Lyons^[46] published a summary of experiences with a neurosurgical checklist at the Department of Neurological Surgery of the Mayo Clinic in Phoenix, AZ. The checklist has been used in 99.5% of the department's procedures over the past 8 years. It emphasizes prevention of severe, though relatively rare, errors like patient identification or wrong procedure/site incidents. Also included are items shared with the WHO checklist, such as the presence of correct imaging studies and antibiotic prophylaxis. There had been no wrong site, wrong procedure, or wrong patient mishaps during the 8-year scope of the study, and although specific data on mortality and morbidity were not reported, the author repeatedly noted the ability of the checklist to encourage a culture of safety in his neurosurgical unit.

A checklist for reducing error during deep brain stimulation (DBS) operations for movement disorders

has been developed by Connolly *et al.*^[12] as part of a comprehensive standardized procedure.^[40] Because the efficacy of stereotactic DBS is dependent on the precise orchestration of a long chain of procedures, errors during these surgeries can both limit therapeutic benefits and increase cost. The average incidence of errors detected by the checklist in 13 consecutive observed DBS surgeries was two errors per case (1.15 major errors and 0.85 minor errors per case). The authors judged that the remediation of errors by checklist deployments would significantly reduce the overall complications of DBS.

Taussky *et al.*^[70] have proposed a checklist for the management of aneurysm perforation during endovascular coiling procedures. This checklist covers the management of one of the most critical complications facing interventional neurosurgeons, addressing the characterization of the perforation, clinical examination of the patient, medical and endovascular treatment decisions, and closing procedures. The criteria under each subheading reflect the overarching purpose of checklists: Standardization of commonly accepted, efficacious practices. Although no data have been reported, this is an example of individual institutions interpreting the power of checklists and developing their own iterations to enhance patient safety during specific events.

Finally, at our institution, a checklist for placement of external ventricular drains has substantially reduced ventriculostomy infection rates over the last few 5 years (unpublished data). An institutional multi-specialty task force was created in 2006 after quality control measures identified a 9.2% infection rate of ventriculostomy catheters. A protocol was devised to correct areas that were identified as needing improvement and a checklist was mandated for residents performing bedside ventriculostomy procedures. Two months after implementation of the checklist and other infection countermeasures, the infection rate declined markedly to 2.7%. Since that time, further improvements and strict adherence to the protocol have led to our current infection rate which resides at less than 1%. The success of this protocol was in part due to the device itself and in part due to the commitment to improvement expressed by the nurses, physicians, and ICU staff. In this case, having everyone on board and committed was essential to the checklist's effectiveness.

DISCUSSION

This relatively new, but rapidly expanding body of literature suggests that checklists can significantly improve outcomes for surgical patients. Checklists are a functional, consistent method of combating human errors before they occur, and they can be adapted for use in a wide range of environments. However, establishing an efficacious checklist is not simple. A sheet of paper

will never contain or convey the ability to prevent surgical mishaps. Many checklist programs mentioned in this summary incorporated an extensive level of administrative effort and/or staff education.^[42,53,54,57,58,65,77] Therefore, comprehension of the mechanisms of a checklist's effects should dictate the support that each implementation receives.

COMMUNICATION ENHANCEMENT

Dysfunctional communication in a surgical environment has been repeatedly shown to negatively affect patient care.^[13,30] Lower self-reported communication rapport between physicians and OR staff has been correlated with increased rates of morbidity and mortality.^[13] A 2003 survey^[30] of surgeons at Massachusetts teaching hospitals examined 146 error reports, 33% of which resulted in permanent disability and 13% of which resulted in death. A communication error was cited in 43% of these accounts and 70% of incidents involved contributions of two or more clinicians. One of the major working assumptions when developing the WHO Surgical Safety Checklist was that communication was the greatest contributor to surgical errors.^[71]

Despite the impact of these miscommunication errors, elucidating their underlying causal pathways can be difficult. Unfortunately, communication errors are often observable only when they become immediately impactful, such as when a piece of equipment is missing or a medication causes an anaphylactic reaction. This "invisibility"^[43,45] can be combated by proactive discussion that is standardized by a surgical checklist. A pair of studies by Lingard *et al.*^[44,45] identified two versions of communication utility that were facilitated by checklist implementation. "Informational" utility, defined as those actions that had an impact on the team members' specific awareness, takes the form of explicit confirmations, passage of new information, and the correction of erroneous information. It also encompasses opportunities for education. "Functional" utility was ascribed to those interactions prompted by the checklist that led to a procedural change or decision. This includes identifying and anticipating potential problems, perhaps the single most integral element of checklists' effects on patient safety. As opposed to reacting to the dangerous result of a communication error, the error is prevented from occurring at all. In a field observation of these concepts,^[44] the implementation of a preoperative checklist reduced miscommunication events from an average of 3.95 events per operation to 1.31 events per operation ($P < 0.001$). The checklist led to a 64% reduction in miscommunications that specifically caused at least one visible consequence. Of 295 observed checklist utilizations, 100 (34%) demonstrated functional utility.

TEAMWORK ENHANCEMENT

A certain stoicism is often typical among surgical staff. In the traditional view, the influence of individuals within the operating room is mostly dictated by the extent of their education and experience. The hierarchy of the operating room begins with surgeons, while anesthesia teams, OR nurses, radiologists, and other personnel assist the progression of the operation. This schema emphasizes individualism and autonomy, which can be counterproductive for team efficiency.^[1,45] However, because the completion of a checklist requires input from many individuals, the operation's progress becomes democratized among the team and the traditional hierarchy is flattened.^[71] The collective concept of a surgical team is reinforced^[42,45] when each individual is addressed and when their particular contributions to the operation are given due attention. Tending to these details as a group can not only address potential problems, but also allows for smoother and more collegial communication should other problems arise later.

Numerous studies have exhibited the positive effects of checklists on team mentality.^[18,44,49,71] One study^[44] found that 73% of surgical, anesthesia, and nursing staff agreed that a checklist strengthened the operating room team. An employee opinion metric given annually to all OR staff in the same center revealed a large boost in positive perceptions of communication, respect, and teamwork over 3 years.^[71] The only daily intervention implemented within this time frame was the WHO Surgical Safety Checklist. A preoperative briefing accompanied by a short surgical checklist^[18] has been shown to increase the Safety Attitudes Questionnaire (SAQ)^[66] measurements of job satisfaction, perceptions of management, a climate of safety, recognition of stress, working conditions, and a climate of teamwork.

These perceptions of overall team quality can enhance patient safety in a concrete way by reducing staff turnover, especially among nurses.^[18,38,50] As staff are less burdened by preventable problems,^[50] and simultaneously feel more respect and identity within their surgical team, they are significantly more likely to stay at their position.^[38] Because familiarity among staff that have worked together longer breeds team efficiency,^[23,50] surgeries become significantly safer. The effect of teamwork expounds when more familiar teams become quicker, and can thus perform a greater number of safer operations during daytime hours.^[50]

A common theme to many successful checklist implementation strategies is the role of enthusiastic team leaders among staff.^[42,44,53,57,71,74] Referred to in some instances as "champions,"^[44,71,74] these are individuals who perceived the benefits of using checklists and led others to similar sentiments. Their importance in combating

cultural resistance, especially among surgeons, has been common to both small- and large-scale implementations. They allow local investment in checklist projects and dispel the idea that safety implementations dictated "from above" are another episode in a long line of administrative roadblocks. Considering the distinct possibility of organizational mandates in hospitals, states, and countries, allowing physician and nursing leaders at the front lines to be involved in the initiation and implementation of checklists is imperative.

CRITICISMS OF CHECKLISTS

The primary criticism of surgical checklists, and indeed for medical checklists, in general, centers around the complexity of medical practice. Flying an airplane or constructing a highrise, although difficult, has a certain inherent predictability, meaning that checklists can be widely applied in these fields.^[32,36] In contrast, entire libraries are devoted to the possibilities of human disease, and from each of these ailments follow an infinite spectrum of possible indications and complications. Checklists cannot possibly encompass every situation in a specific way; autonomy and discretion on the surgeons' part could never be replaced by regulation. However, this does not mean that checklists are dispensable. To be used efficaciously, they must target a specific set of circumstances and work to facilitate the existing abilities of the professionals who use them, not limit them.^[77] When used correctly, checklists actually serve to assist healthcare professionals in confronting such complexity. As an example, the Johns Hopkins' ICU checklist^[8] did not attempt to cure all complications that occur in intensive care. It simply targeted one complication, catheter-associated bloodstream infections, which was already supported by defined evidence-based practices. In this instance, the checklist simply standardized the application of these practices and lessened the role of human error or apathy. The result was a complete reduction in this particular complication.

A more practical concern that is often voiced from staff exposed to checklist programs is that stopping and gathering together before surgery constitutes an interruption to work flow.^[44,45] When checklists are first instituted, staff frequently must adjust their schedules to arrive for the common meeting. However, many studies quote less than 6 minutes for completing a checklist, a time interruption that further improves over many deployments.^[9,12,42,44,50,65,71] Surveys of staff after extended use of surgical checklists show that only about 20% consider the checklists a hindrance to the progress of the operation.^[34,65] An observational study^[50] of surgeries using checklists actually showed a significant reduction of procedural delays, attributed to the preventive checklist discussions.

Another potential detriment of employing checklists on a large scale is “checklist fatigue.” The airline industry has a systematic method for checklist development, evaluation, and distribution, and yet decades of experience show that too many checklists reduce overall compliance.^[31,32] If checklists are too extensive, or are used in too broad a range of situations, their users are apt to abandon efficacious use. The inclusion of only preventable, common sources of error in the WHO Surgical Safety Checklist reflects an attempt to combat exactly this possibility.^[77] Checklist fatigue is also one of the reasons that studies of checklists include a provision for continual re-evaluation even after surgical checklists become standard operating procedure.

Finally, there exists the possibility that checklists may lead to a complacent attitude toward patient safety.^[11] Although generally safety awareness has been encouraged by checklists,^[34] many of these assessments were done just after the checklists were introduced. If checklists are used for years or decades, it is possible that staff will assume a safe surgical environment exists as long as a checklist is completed. This complacency could lead to decreased awareness about the prevalence of human error and an undue dependence on safety interventions like checklists. It is, however, encouraging that the oldest checklist programs have not reported any regression to previous levels, despite being in practice for years.^[56,71]

CONCLUSIONS

While the original B17 bomber test flight was without a doubt a tragedy resulting in the pilot’s death, its contribution to the subsequent recognition of cognitive limitations and appropriate interventions was a breakthrough in systems-improvement science. Unfortunately, high-risk fields such as aviation have adapted crucial systems improvement safety practices much more quickly than medicine.^[32,36,67] However, these preventable medical mistakes are just as dangerous to patients as a malfunctioning plane engine during flight. Medicine must respond and develop appropriate precautionary responses.

Initial trials with checklists have noted cultural resistance to using such a simple safety tool.^[32,44,65,74] This is hardly a problem unique to medicine, but within medicine this resistance is worsened by the general perception that high-quality, highly educated professionals are not susceptible to simple mistakes like forgetting or miscommunication.^[28] Clearly, this is not the case. Dr. Atul Gawande quotes Dr. Peter Pronovost in a 2007 article^[27] on checklists written for the *New Yorker*: “...Insuring [that] therapies are delivered effectively... has been almost totally ignored by research funders, government, and academia. It’s viewed as the art of medicine.” The success of medical and surgical checklists suggests that safe, quality practice

is as much science as it is art. It also suggests that the considerable inherent ability of physicians can be enhanced through directed use of simple tools. Adding the recognition of limitations to the ideal persona of a physician may require difficult cultural evolution, but ultimately may end up saving many lives.

To date, the use of checklists in the realm of neurosurgery has been limited. As a surgical subspecialty with complex patients, lengthy operations, fatigued residents, costly complications, and low tolerance for medical errors, our patients are particularly vulnerable to human fallibility. Even routine procedures, such as ventriculostomy insertion, represent potential targets where patient care may be enhanced through checklists, particularly in inexperienced practitioners. We encourage the neurosurgical community to investigate, develop, and share such tools to enhance patient care by eliminating preventable human mistakes through simple, systematic checklist devices. In a field driven by remarkable technological advancements in imaging, instruments, and therapies, we must remember that it is often the most rudimentary reminders that keep us, and our patients, out of harm’s way.

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Commentary

Surgical checklists: Considerations for the future

In their review article in this issue of *Surgical Neurology International*, McConnell *et al.* focus on an important but not so popular part of modern (neuro) surgery: the checklist. After the famous report “To Err is Human” was released by the Institute of Medicine in 1999, many attempts have been made to improve safety in medicine. One of the proposed “solutions” was a surgical checklist that has been developed by the World Health Organization under the supervision of Dr Atul Gawande.^[4] Gawande is a surgeon from Boston and the author of several books, the latest being “The Checklist Manifesto” (which I can recommend, also for learning the relation between brown M&Ms and a pop concert’s safety).^[3] It has been reported that the use of checklists significantly lowers morbidity and mortality of (surgical) procedures, and comparisons with other high-risk industries have been made repeatedly.

McConnell *et al.* have done an excellent job in providing a good overview of the existing and relevant literature in this topic. One particular study that is well known but still fascinating in my opinion is the experiment from Johns Hopkins with catheter insertion procedures.^[2] It redefines authority: nurses were allowed to stop the procedure if the staff did not follow one of the prescribed steps, like washing their hands. One may start wondering who is actually in charge of the patient: the hospital, the physician, the team, or the checklist? For elective procedures, this philosophy is in agreement with Amalberti’s negative opinion on “craftsman’s attitude”

to achieve ultrasafe healthcare.^[1] However, I cannot help wondering what happens in an emergency procedure: would a nurse ever refuse to assist a physician in catheter insertion in a dying patient (like after a motor vehicle accident) because the checklist has not been followed stepwise? This may not be the case nowadays, but like everything checklists also should be handled with care. There have been lawsuits where physicians have been found guilty because they followed a protocol, guideline, checklist or whatever in a situation where – so was concluded – the actual situation had demanded otherwise. Who is responsible then? We all know the limitations of evidence-based medicine, and there is no single approach or procedure that works for any individual patient. If this is true, checklists will not be an exception to this rule. Who has the responsibility to overrule a checklist, for example, in an emergency situation where the benefit-harm ratio is considered to be negative? (Note: mathematically it cannot be negative but will be smaller than one.)

Another issue of concern is the balance between effectiveness and completeness. The WHO Safe Surgery Checklist contains only a few items, which is done on purpose. The items that should at least be checked have been included because the intention was to create one list that should be applicable in developing countries as well. Developing local implementations of such a checklist is promoted, but this contains the risk of “over-completeness.” In my personal experience, one of

the greatest dangers in creating a (local) checklist is to include “everything.” In the end, it is not the checklist that does the job, but the human being that is using the checklist. Thinking that a 30-item checklist is better than an 8-item checklist may turn out to be a dangerous assumption and one that can definitely not be classified as evidence-based medicine nowadays.

A last consideration for the future is the implementation of an electronic version of a checklist. It may offer a balance between effectiveness on one side and completeness on the other. In comparison with a paper-based checklist, a computer-based checklist could first ask some basic questions and then some additional questions based on the answers to the first. They could be linked to the patient’s Electronic Medical Record, and after checking whether the correct patient is in front of you, prior medical history, patient medication, and laboratory values might be used to individualize further steps that need to be taken for a particular procedure. Although this might sound appealing from a technical perspective, it also introduces new issues of concern in the context of usability and potential technical failure.

In summary, McConnell *et al.* are to be congratulated for a well-written article on an important topic. The paper can be used as a starting point for further discussion on the optimal implementation of checklists, including some unavoidable questions about authority. If this sounds rather threatening, it may help to visualize oneself lying on that table, waiting for surgery. How would “good enough” be defined if it was for your own health?

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