Quality and safety in pediatric anesthesia: how can guidelines, checklists, and initiatives improve the outcome?

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Purpose of review
Cognitive aids are tangible or intangible instruments that guide users in decision-making and in the completion of a complex series of tasks. Common examples include mnemonics, checklists, and algorithms. Cognitive aids constitute very effective approaches to achieve well tolerated, high quality healthcare because they promote highly reliable processes that reduce the likelihood of failure. This review describes recent advances in quality improvement for pediatric anesthesiology with emphasis on application of cognitive aids to impact patient safety and outcomes.

Recent findings
Quality improvement encourages the examination of systems to create stable processes and ultimately high-value care. Quality improvement initiatives in pediatric anesthesiology have been shown to improve outcomes and the delivery of efficient and effective care at many institutions. The use of checklists, in particular, improves adherence to evidence-based care in crisis situations, decreases catheter-associated bloodstream infections, reduces blood product utilization, and improves communication during the patient handoff process. Use of this simple tool has been associated with decreased morbidity, fewer medical errors, improved provider satisfaction, and decreased mortality in nonanesthesia disciplines as well.

Summary
Successful quality improvement initiatives utilize cognitive aids such as checklists and have been shown to optimize pediatric patient experience and anesthesia outcomes and reduce perioperative complications.

Keywords
checklists, cognitive aids, initiatives, pediatric anesthesia, quality

INTRODUCTION

Quality improvement methods bring the best clinical practice as identified by research to consistent widespread delivery in clinical care to create optimal outcomes for patients locally. The need to provide safe, effective, patient-centered, efficient, timely, and equitable care continues to ring as true today as when the Institute of Medicine (IOM) created these categories of quality in 2003 [1]. How to best accomplish this improvement work is still being determined, but recent work suggests that cognitive aids may prove effective, initiated on the local level, then spread nationally, and even globally. This review discusses recent advances in quality improvement in pediatric anesthesiology emphasizing the application of cognitive aids to impact patient safety, outcomes, and experience.

NOTABLE QUALITY IMPROVEMENT INITIATIVES

Healthcare has traditionally utilized quality assurance, the evaluation of a product or service outcome, in an effort to optimize results. Quality assurance involves analyzing a defect and recommending a change without regard to the effect that change may have on the organization as a whole [2]. Continuous quality improvement (CQI), on the

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KEY POINTS

- Successful quality improvement initiatives require repeated measuring of the performance of a system, the setting of specific aims as well as global goals, the involvement of clinical staff, and the support of leadership.
- Checklists are an effective tool that, when used appropriately and consistently, can create highly reliable processes of care.
- The use of cognitive aids, such as checklists and algorithms, has been associated with improved outcomes, both in the operating room and afterward, including decreased morbidity, fewer medical errors, improved provider satisfaction, and decreased mortality.

other hand, proactively modifies processes and encourages a view of the system as opposed to individual point of care errors [2,3]. CQI measures and revises processes based on data and strives for the best possible outcomes, safety, and service at the lowest possible cost, creating high-value care [3,4▪▪]. CQI seeks to promote stable processes, in which specific variation attributed to specific components within the process is eliminated, and only random variation, that is, the 'background noise', remains [3]. Successful initiatives share features including the measurement of performance, the setting of specific aims as well as global goals, the direct involvement of clinical perioperative staff, and the support of leadership.

Successful CQI features were demonstrated in two recent reports of improved patient flow and more efficient and timely care [5▪,6▪▪]. Both Mahmoud *et al.* [5▪] and Varughese *et al.* [6▪▪] discuss the use of multidisciplinary teams and preinvestigational discovery periods to determine actual versus perceived causes of delays. They also report setting specific aims with clear end dates, standardizing processes including the proper alignment of staff resources, and improving communication to achieve goals of starting on time for patients scheduled to receive general anesthesia in an MRI suite, and starting and ending on time for a pediatric surgical service. Both authors report that their success occurred only after system improvements rather than individual improvements. For example, the key driver diagram utilized by Varughese *et al.* [6▪▪] (Fig. 1) demonstrates interventions in surgical scheduling, preoperative nursing and anesthesia processes, preoperative and postanesthesia care unit (PACU) nursing staffing, and improved communication between perioperative teams to achieve their goal of improving starting and end times.

Varughese *et al.* [7▪] use similar principles to improve timeliness and efficiency through a Nurse Practitioner program in an anesthesia consultation clinic. They report a process of preinvestigational discovery (including the use of a Failure and Effects Mode analysis), the creation of a time-bound specific aim statement, key driver diagram, and several series of plan–do–study–act (PDSA) cycles in a project to improve resource utilization and reduce costs while maintaining safe and effective care. Similarly, McDonnell [8▪] relates an initiative to decrease the incidence of unanticipated calls for 'difficult to manage laryngospasm' to improve the delivery of safe care. According to McDonnell, this initiative did not change clinical practice *per se*, but changed expectation of well tolerated care by defining what should be considered an acceptable complication rate. McDonnell describes a time-bound specific aim statement and a key driver diagram that led to the creation of a recurring knowledge translation tool (a safety handbook) given to all new departmental members, including trainees, to decrease special cause variation in the incidence of 'calls for help' because of laryngospasm.

THE USE OF CHECKLISTS IN PEDIATRIC ANESTHESIA

Cognitive aids can be defined as memory tools designed to aid in decision-making and in the completion of a complex series of tasks [4▪▪,9▪▪,10]. Checklists are a type of cognitive aid that can be used to create highly reliable systems of care. Checklists and other cognitive aids are useful because they reduce the likelihood of failure within an initiative [11] or when carrying out guidelines, lengthy evidence-based documents that describe ideal actions that should be taken when performing a task [9▪▪]. These tools help us act on information that we know, but can have difficulty remembering – from forgetting a step or getting confused about how to conduct the step [12▪▪]. More broadly, cognitive aids can aid team functioning, team cohesion, and facilitate a culture of safety [13].

Checklists, in particular, can have varied formats including 'read and do', for instance when checking equipment; 'challenge and response' that is classically used in preflight checks to confirm a series of tasks have been performed; and 'aide memoires' which can be used to structure briefing and debriefing conversations [14,15]. The WHO Surgical Safety Checklist has been shown to decrease mortality and complications in many institutions around the world and has become the standard of care in most hospitals. Because of its power, many argue that checklists are becoming the standard of

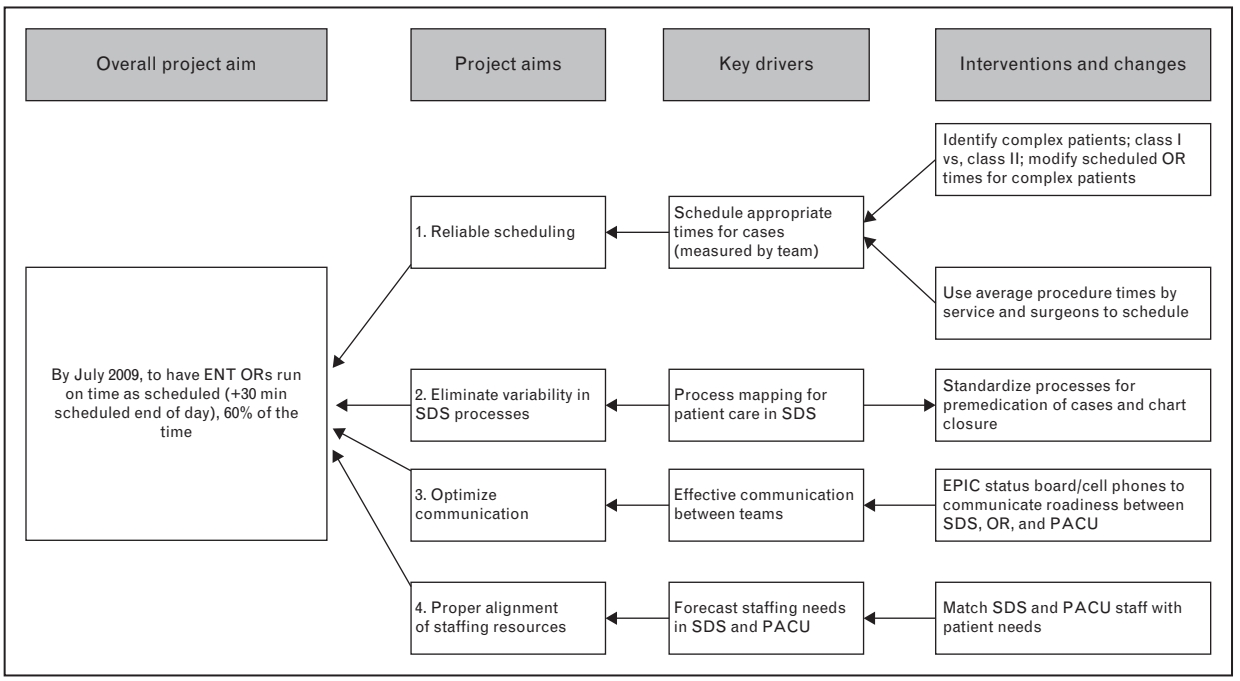

FIGURE 1. Key driver diagram with emphasis on system improvements. ENT, ear, nose, and throat (otolaryngology); PACU, postanesthesia care unit; SDS, same day surgery. Reproduced with permission from [6▪▪].

care for a number of anesthetic and surgical processes [16].

Critical event checklists

Perhaps the most recent influential report regarding the use of checklists is that of Arriaga *et al.* [17▪▪] who evaluated a cognitive aid designed to improve the execution of evidence-based best practices in an adult patient population during critical events in the operating room. Although critical incidences are rare for individual practitioners, the impact of such a checklist can be great because the sum of critical events in one institution can be significant. For example, a national dataset of 20 pediatric anesthesiology departments has shown the incidence of critical events to be 1.4 of 1000 anesthetics administered [18]. If the average Certified Registered Nurse Anesthetist (CRNA) performs 500 anesthetics per year, and the anesthesiologist performs 1000 anesthetics per year, then the CRNA will experience a critical event about once every 4 years, and the anesthesiologist will experience a critical event about once every 2 years. It is difficult to remember the steps to treat critical events given the infrequency of the event. Checklists facilitate the memory and increase the reliability of performing steps.

Arriaga *et al.* evaluated multidisciplinary operating room teams consisting of anesthesiology, nursing, surgical, and operating room staff of varying levels of training and career years in a simulation environment during crisis situations. They observed a 75% reduction in failure to adhere to critical steps during a crisis in those teams that had access to crisis checklists [17▪▪], even though the participants had minimal training on the use of the checklists [19].

A similar series of 17 operating room crisis checklists for the pediatric population was published by the Society of Pediatric Anesthesia (SPA), Quality and Safety Committee [20]. With the consideration that many anesthesiologists care for both adults and children, they chose to publish these checklists in a format similar to those examined by Arriaga *et al.* (Fig. 2). The SPA website provides free access to this checklist at http://www.pedsanesthesia.org/newnews/Critical_Event_Checklists.pdf, and as a free app for smartphones.

Decreasing catheter-associated bloodstream infections

Martin *et al.* [21▪▪] described successful use of checklists to decrease catheter-associated bloodstream infections (CABSIs) among pediatric ICU patients who go to the operating room and other procedural areas under the care of an anesthesiologist. Through a modification in clinical practice and the use of a checklist, they observed a decrease in CABSI rates from 14.1 infections per 1000 in 2009, to 9.7 per 1000 in 2010, to 0 per 1000 in 2011. Hospital-wide CABSI rates also significantly declined during this time from 3.5 per 1000 catheter days

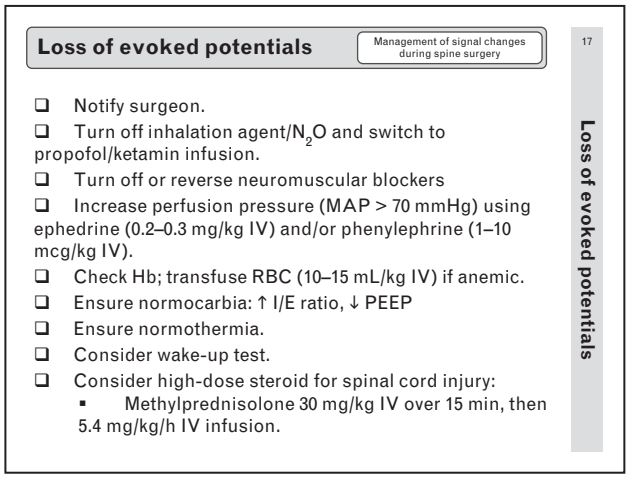

FIGURE 2. An example of a pediatric critical event crisis checklist. Previously published. Society for Pediatric Anesthesia. Pediatric Critical Events Checklists. (http://www.pedsanesthesia.org/newnews/Critical_Event_Checklists.pdf). Accessed 31 December, 2013.

preintervention to 2.2 per 1000 catheter days post-intervention. The countermeasures to decrease potential contamination included level 1 reliability interventions such as education regarding intraoperative hand sanitation, as well as level 2 interventions such as the use of checklists in the cleaning of the anesthesia workspace during operating room turnover, the installation of hand sanitizer in a standard location, the consistent use of a medication manifold in this at-risk patient population, and a change in the configuration of the anesthesia workspace into clean and dirty zones [4▪▪,21▪▪]. The results of this quality improvement initiative demonstrate that the anesthesia team impacts outcomes beyond the operating room and the role of checklists in reducing infections.

Algorithm to reduce blood product utilization

Whitney *et al.* [22▪▪] reported on the successful development and implementation of a cognitive aid (algorithm) to guide blood product transfusion practices for pediatric patients undergoing cardiopulmonary bypass. They established an algorithm based on available evidence within the medical literature as well as agreed-upon practice based on consensus among attending anesthesiologists. The implementation phase of this study involved an iterative PDSA-type approach that revealed the need for a cognitive aid to display the algorithm (Fig. 3) [4▪▪,22▪▪]. They demonstrated decreased blood product use in the operating room and during the first 12 h in the ICU, as well as less blood loss in the ICU, a decrease in predischarge mortality, and less

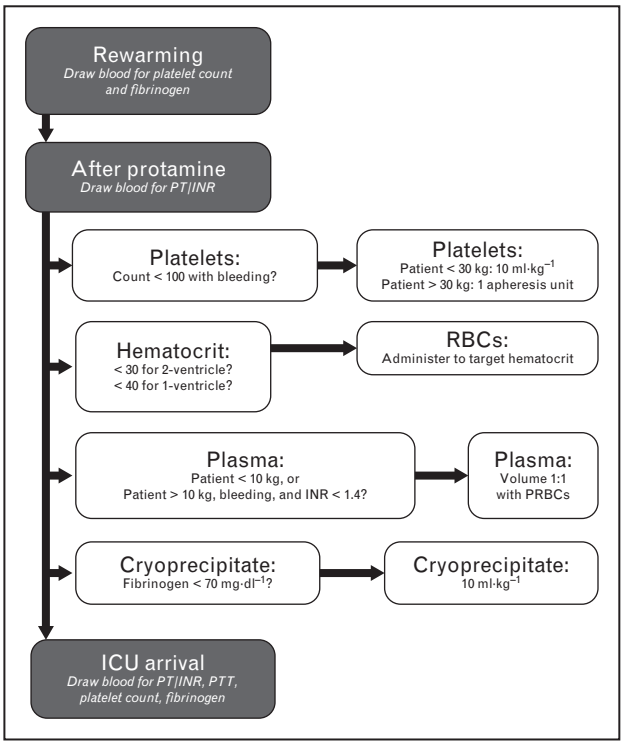

FIGURE 3. An algorithm to guide blood product transfusion in pediatric patients undergoing cardiopulmonary bypass. Reproduced with permission from [22▪▪].

complications including less time of mechanical ventilation, less infections, shorter length of stay, and lower hospital costs [4▪▪,22▪▪].

Handoff checklists

Improved communication using handoff checklists between anesthesiologists in the operating room, on transfer of care from the Doctor of Medicine to the Registered Nurse in the PACU, or from anesthesiologist to the pediatric cardiac ICU team has been described recently. Boat and Spaeth [23▪] detailed the design and implementation of checklists to improve reliability of the handoff within the operating room and to the PACU. Reliability of intraoperative handoffs from 20 to 100% and PACU handoffs from 56 to 95% occurred by incorporating the checklist within the intraoperative electronic medical record, and by providing feedback to individual anesthesiologists regarding improper handoffs. Although not measured in this study, improved handoff between providers can positively affect patient safety, perioperative efficiency (the new care team saves time not having to look for information), patient and family satisfaction with care, and be associated with fewer medical errors. Salzwedel *et al.*'s [24▪] video analysis of postanesthesia handovers to the PACU resulted in a significant

improvement in information transfer from 32.4 to 48.7% with the use of a checklist.

Agarwal *et al.* [25] reported their experience with the design, development, and implementation of a standardized two-step process for transfer from operating room to the pediatric cardiac ICU. The first step involved communication from the anesthesiology team in the operating room to the ICU bedside nursing staff via telephone prior to the arrival of the patient. The second step encompassed a standardized checklist for face-to-face communication between the cardiac anesthesia and surgery teams and the receiving ICU team. With these changes, they observed less loss of information on the handoff – from a preintervention 43% loss of information to 16% postintervention. They also observed increased provider satisfaction, earlier postoperative extubation, less cardiopulmonary resuscitation, less mediastinal re-exploration, and less severe metabolic acidosis during the first 24 h postoperatively.

'Flow checklists' in pediatric ambulatory surgery

Low *et al.* [26▪] described the creation of challenge-and-response 'flow checklists' to occur at four key points in the perioperative process to complement the existing WHO Surgical Safety Checklists. These flow checklists aim to facilitate communication, teamwork, and patient safety. The four high-risk points are common to all surgical patients: first, transfer of the anesthetized patient from the induction room to the operating room; second, entry into the operating room; third, immediately prior to transfer from the operating room to the PACU; and finally, transfer in the PACU. They also described flow checklists for use in patients who are scheduled to receive anesthesia in the MRI scanner, which involves a different set of safety concerns (Table 1). Although they do not report preintervention data, they found that the flow checklists were associated with an error rate of zero in completing the minimum of 24 common tasks that each patient requires to move through the operating room safely, as well as 23 tasks in the MRI pathway. The checklists were easy to perform, took less than 10 s to complete, and were well received by staff. The use of such a checklist by both nursing and anesthesia staff contributed to the development of a safety culture.

Checklists for trauma and emergency anesthesia

Given the recent success of checklists perioperatively, particularly to aid work that may not be routinely performed and is dependent on a list of critical tasks, Tobin *et al.* [27▪] proposed a checklist for trauma and emergency anesthesia. They [27▪] authored 'what should be on a trauma anesthesia checklist [to provide] a nidus for a definitive document' (p. 1178) to guide the emergent induction, operative resuscitation, and communication for the adult trauma patient. Although this checklist project is still in its early stages, such a checklist has the potential to be invaluable, particularly to providers who care for trauma patients infrequently. A similar checklist based on best evidence regarding the care of the pediatric trauma patient could prove to be instrumental as well.

Table 1. Example of a flow checklist to facilitate care of the anesthetized patient scheduled in a MRI suite

Challenge	Response
Metal check	Metal free
Medications	Pump ready
Airway	On the bed
Oxygen	On 2 L
Chart	In basket
Transport bag	In basket
Safety	Strap on
Monitor	Off patient

This checklist ensures that patients are metal-free, medications are properly administered, and objects that contain metal do not enter the magnet room. Reproduced with permission from [26▪].

Checklist implementation

Although checklists and other cognitive aids have proven useful in studies, Conley *et al.*'s [28] examination of the WHO Surgical Safety Checklist in five different Washington State hospitals indicates that merely adopting a checklist and mandating its use are not effective in shaping behaviors to change clinical practices. Their analysis demonstrated that active leadership utilizing multidisciplinary communication, providing reasonable justification for implementation, and offering real-time feedback were key components in the centers that had the most effective checklist implementation. Similarly, Low *et al.* [14] described the collective experience of implementing the WHO Surgical Safety Checklist at three diverse hospitals: Seattle Children's Hospital, Johns Hopkins Hospital Bloomberg Children's Center, and Great Ormond Street Hospital NHS Foundation Trust. They reported that with checklist implementation, it is important to maintain consistency and standardization with checklist procedure, and that hands-on training in how to perform the checklist develops buy-in.

van Klei *et al.* [29] further substantiated the importance of effective checklist implementation in their retrospective cohort study comparing patient outcomes in relation to compliance with the WHO Surgical Safety Checklist. In their study, they showed a significantly lower in-hospital 30-day mortality rate with patients who had completed checklists compared with those patients who had partial or uncompleted checklists.

Remaining questions/checklists in the future

Many questions still remain regarding the role that checklists will play in clinical practice. Clearly, further research in the use of perioperative checklists will be necessary to determine optimal design (including content and organization), medium/user interfaces (i.e. paper versus electronic format), training methods, and accessibility (i.e. specific location of paper or digital content) [12▪▪,17▪▪]. In a recent editorial, Augoustides *et al.* [30] posed the following questions: When do checklists become standard of care? Could *not* using a cognitive aid be considered negligent care? Who should develop and/or vet cognitive aids? Should 'roles' be assigned regarding who 'runs' a checklist? and Should checklists be customized on local levels? Other questions to consider include: How many checklists are too many? and Is there such a thing as checklist fatigue?

As quality improvement projects are implemented to improve patient safety and the quality of care, Taylor *et al.* [31] suggest a standardized approach to reporting these initiatives. They highlight the need for systematic reporting of PDSA cycles within the Standards for Quality Improvement Reporting Excellence format that was specifically developed for the reporting of quality improvement manuscripts. By using standardized and consistent reporting methods, meta-analysis studies will be facilitated. This is especially important considering how difficult it is to study the effectiveness of cognitive aids in both simulation and real settings – including problems with having experienced staff participate in simulation, as well as with problems with selection-biased reporting, and inadequate reporting in real patient care [10]. Gaba [10] argues that because of these challenges, level 1A evidence may never exist for cognitive aids improving patient outcomes. Despite this barrier, checklists have been well adopted by the aviation and nuclear power industries.

Perhaps the biggest challenge to the use of quality initiatives and checklists is the existing medical culture. Medical culture has traditionally valued individual expertise over standardization of care. Culture change is slowly occurring, and effective mechanisms for this include the curriculum in medical student education, as well as what is emphasized in continuing medical education [32].

CONCLUSION

Quality initiatives and cognitive aids facilitate better job performance and positively impact patient experience and outcomes, both in the operating room and afterward, reducing intraoperative and postoperative complications, as well as mortality.

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Conflicts of interest

There are no conflicts of interest.

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- ▪▪ of outstanding interest

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