Smarter Clinical Checklists: How to Minimize Checklist Fatigue and Maximize Clinician Performance

Eliot Grigg, MD

Widespread use of clinical checklists is relatively new to health care. Anesthesiology has borrowed lessons from aviation safety since the late 1970s, but checklists only reached a tipping point after the World Health Organization (WHO) Surgical Safety Checklist was introduced in 2008.[1,2] Suddenly, checklists are appearing everywhere from routine (normal) patient handoffs to critical (non-normal) events during an anesthetic.[3–9] There are a variety of types of checklists, and they serve multiple functions, from team member activation to shared situational awareness to procedural compliance, but most serve as cognitive aids to ensure that providers do not forget crucial steps during either routine, mundane tasks or dynamic, emergent events.[10,11] Having proven wildly successful in certain situations, checklists are now being inserted into various points in the clinical process without appreciating them all in combination.[12,13]

A single anesthetic could soon require a dozen checklists: one for setting up the operating room (OR) and a second for complex infusions, 3 for the WHO Checklist, another for a central line insertion, more for handoffs to and from the intensive care unit or during a lunch break, another for an intraoperative emergency, and so on. Providers may soon be swimming in a sea of checklists without a coherent way of navigating them all. The primary purpose of checklists is to avoid unintentional harm by accounting for mental fallibility. Checklists in their current incarnation, however, have the potential to consume too many mental resources, which undermines compliance and effectiveness.

There are a number of potential strategies to mitigate the impending problem of too many checklists, including (1) reduce their number, (2) design them more carefully, or (3) make health care culture more accepting of them. The simplest solution to a mountain of checklists is to use fewer of them in a more targeted manner. While appealing on its face, this remedy would likely overlook a number of opportunities to improve patient care. Experts from Degani[14] to Tufte[15] to Gawande[11] have produced considerable literature regarding choosing the correct type of list and optimizing the visual layout. However, even thoughtfully designed lists will ultimately succumb to provider fatigue if too many are implemented unsystematically.

The cultural hurdles to implement checklists in health care have been previously described.[11,16,17] In the move toward "high reliability" status, providers will likely have to accept a flatter hierarchy and some reduction in autonomy.[18] Even accepting a cognitive aid like a checklist requires a certain amount of humility in a profession known for independence and authority. Today, flight school starts with checklists emphasizing standardization and safety; medical school, in contrast, starts with a white coat ceremony.[19,20] Not all barriers to improved safety, however, are inevitable cultural concessions. There are important structural differences between aviation and medicine. Airplanes are interchangeable mechanical systems with largely predictable failure modes that do not arrive unexpectedly in the emergency department. Malfunctioning planes are grounded, and flights can be canceled while patients by definition are all experiencing some sort of "mechanical failure" during a medical encounter.

In addition, there are deliberate trade-offs made by any profession seeking to improve safety. Chemical engineering and road safety, for example, have yet to achieve the safety records of aviation or nuclear power not because of lack of tools or competence but rather because of conscious compromises to maintain certain performance goals.[21] The safest roads would only allow professional drivers, but as a society we accept the risks of road travel in the name of productivity and personal freedom. The complexity of health care will always require a level of efficiency and adaptability at odds with standardization and predictability, so a health care solution for checklists will likely look different from aviation.

Ultimately, the continued success of checklists in health care requires solving an interaction design problem. Today a series of laminated cards may be sufficient, but these simple analog checklists will not scale effectively going forward. Checklists need to be seamless, to minimize inconvenience and ensure compliance, yet stimulating enough to not become mindless and lose meaning. They must be at once innocuous and thought provoking, which means that they cannot live passively on an inanimate list. Checklists should be short, relevant, and effortless. They should augment providers rather than oppose them. Instead, providers forget to do them, skip certain elements, or hunt for a companion to run the list, so they end up requiring more

From the Department of Anesthesiology and Pain Medicine, University of Washington, Seattle Children's Hospital, Seattle, Washington.

Accepted for publication May 9, 2014.

Funding: None.

The author declares no conflicts of interest.

Reprints will not be available from the author.

Address correspondence to Eliot Grigg, MD, Department of Anesthesiology and Pain Medicine, University of Washington, Seattle Children's Hospital, 4800 Sand Point Way NE, MS 9824, Seattle, WA 98105. Address e-mail to egrigg@uw.edu.

DOI: 10.1213/ANE.0000000000000352

mental expenditure than necessary. Checklists need to be smarter so that providers do not have to work so hard to realize their benefits.

The goal of "smart checklists" is not to threaten provider autonomy but to mentally offload the many repetitive tasks in health care that must be completed in a largely predictable sequence.[22,23] The human mind is well suited for creative thinking during unpredictable circumstances with imperfect information; it is not so well suited for memorization or repetitive tasks while subject to fatigue or distraction.[24,25] Details will be forgotten occasionally, and the system needs to be able to accommodate these oversights. If bad things are going to happen to patients, they ought to be due to external factors, "bad weather," rather than provider omissions. By freeing up mental bandwidth, smart checklists would allow providers to focus more on the complex decision making they spend so many years training to refine.

Attempts have been made to mechanize checklists, but much like computerized physician order entry, a simple, direct translation of tasks from analog to digital often entails an increase in reliability and safety at the expense of decreased efficiency and user satisfaction.[26–28] Checklists need to present the right list at the right time with the right content without providers having to search for and filter information themselves. To be used more efficiently, checklists need to adapt to contextual information. Contextual elements may include (1) progress in the case, (2) what tasks have already been completed, (3) what equipment is available, (4) provider location in the OR, (5) proximity of other providers, (6) status of the patient, and (7) age of information. Many of the necessary technological components exist to make checklists more context aware; the challenge is putting them together in a cohesive system.

For checklists to gain acceptance, it is just as important to consider what they do not display as what they do. If checklists routinely present irrelevant or not applicable information, users become accustomed to deviating from the norm, and the whole process becomes delegitimized.[29] The central line insertion checklist developed at Johns Hopkins has been successful, in part, because it is very specific to a single procedure so that each element is consistently relevant.[30] The WHO Surgical Safety Checklist, in contrast, is much more broadly used, for all surgeries, but inevitably many elements are not applicable to any given procedure. If checklists were smarter and customizable on the fly, then they could all be more specific, timely, and relevant. For example, if the machine check has already been performed, then the anesthesia workstation should communicate with the OR setup checklist and eliminate that step from the list. When a provider and a patient arrive in the recovery room, the handover checklist should automatically become available and only list items relevant to that case. If a patient monitor detects a physiologic disturbance indicative of a critical event, then the appropriate cognitive aid should appear to guide clinicians.

There are groups already laying the foundation for this transition to smarter checklists, and challenges have been identified. In 1996, Boeing implemented their first electronic checklist system in the 777, designed primarily to avoid user-related errors when using paper checklists, such as choosing the wrong list or skipping items.[31,32] The semi-automated machine check is a staple of modern anesthesia workstations; however, these automated systems are not comprehensive and are often not completed, and providers' ability to detect faults remains in question.[33] More recent systems are beginning to respond to external factors. At the University of Washington, the Smart Anesthesia Messenger system reminds users to administer prophylactic antibiotics only when induction is complete and antibiotic administration has not been documented.[34] Fitzgerald et al.[35] created a trauma decision support system that guides providers through different resuscitation algorithms depending on the state of the patient. However, algorithms that interpret and filter information to offset mental workload inevitably entail a level of automation that is not without pitfalls. A report released by the Federal Aviation Administration in 2013 regarding Flight Path Management Systems found that automation may lead to degradation of pilot knowledge and skills, and the complexity and interdependence of such systems have created a new set of problems that can lead to errors.[36] Understanding the state of the automated system, communicating effectively, and knowing when to intervene are critical for success. This is why commercial airlines still have human pilots.

When the Institute of Medicine declares that 98,000 people die every year as a result of preventable medical errors, the majority of these errors occurs during normal, routine care.[37,38] A solution that helps to more skillfully integrate a large number of normal checklists into daily practice will help to prevent the more mundane, but arguably inexcusable, clinical errors. Non-normal or emergency checklists, however, face an additional set of challenges, given the dynamic, time-pressured nature of critical incidents.[39] Creating a better way to interface with non-normal checklists during an emergency is more difficult but equally important, and the same issues of accessing the right information at the right time apply. Conceivably, a solution that addresses the added challenges of non-normal checklists would work for normal ones as well. In fact, once checklists become smart, adaptable, and accessible enough, the division between normal and non-normal may become less relevant. The current distinction between the 2 may, in part, be an artifact of inanimate lists with crude interfaces. The more similar and familiar the 2 systems, the more likely users will use checklists effectively during an emergency.

Aviation has been using checklists since the 1930s, and the field is still improving how to interact with them, so additional time and research will be needed to skillfully adapt checklists to health care.[40,41] The current trajectory of adding more and more checklists using existing design principles is not sustainable, but a number of problems will have to be solved before making checklists more interactive and context aware.

First, the various devices and software systems in the OR must communicate with one another. Efforts are under way to improve interoperability, but gains have been modest to date.[42] All devices in the OR ought to come equipped with a USB port, wireless capabilities, and/or a common language for communicating their current state. The benefits of true 2-way communication, which is routine among consumer electronics, would extend beyond checklists. Anesthesia information management systems could potentially control all aspects of an anesthetic in a single interface, moving toward the dream of an integrated "anesthesia cockpit," rather than simply documenting what has already happened. Additional sensors for personnel (e.g., wireless identification badges) and analog devices (e.g., radiofrequency identification–equipped laryngoscopes) would help to identify their locations and current states. Short of an industry-wide communication consensus, at the very least a checklist system ought to integrate with the anesthesia information management system, which already gathers data about vitals, medications, the ventilator, and progress of the case.

Second, a hardware system to seamlessly interact with smart checklists needs to be defined. The world of wearable computing is evolving quickly with heads-up displays, like Google Glass, and the burgeoning field of "smart watches" increasing information accessibility. Natural language interfaces, like Google Inc.'s Google Now and Apple Inc.'s Siri, are becoming increasingly sophisticated. In the near future, people will speak to wrist-worn devices that know their location, schedule, and personal preferences. The ability to access checklists effortlessly and interact with them in the most frictionless way possible is critical for their flexibility, scalability, and long-term appeal.

Finally, the most important aspect of smart checklists is to develop the algorithms that synthesize incoming data and decide when to present what information. Sophisticated Bayesian models will be required to provide the "brains" behind smart checklists. This will be the richest avenue of future research to determine the benefits and failure modes of software systems filtering checklists in real time.

While there are still a number of unanswered questions, the goal is clear: checklists need to adapt to their changing environment to achieve greater efficiency and user acceptance. Initially, they must be relevant to time, place, and circumstances. Eventually, they could even adapt to individual users or combinations of users over time. Then checklists can achieve their true potential of consistently enhancing individual performance rather than simply preventing infrequent errors. Checklists must become intelligent, adaptable companions rather than clumsy roadblocks to address the looming problem of checklist overload and maximize their clinical potential.

DISCLOSURES

Name: Eliot Grigg, MD.
Contribution: This author prepared the manuscript.
Attestation: Eliot Grigg approved the final manuscript.
This manuscript was handled by: Sorin J. Brull, MD, FCARCSI (Hon).

REFERENCES

1. Cooper JB, Newbower RS, Long CD, McPeek B. Preventable anesthesia mishaps: a study of human factors. Anesthesiology 1978;49:399–406
2. Haynes AB, Weiser TG, Berry WR, Lipsitz SR, Breizat AH, Dellinger EP, Herbosa T, Joseph S, Kibatala PL, Lapitan MC, Merry AF, Moorthy K, Reznick RK, Taylor B, Gawande AA; Safe Surgery Saves Lives Study Group. A surgical safety checklist to reduce morbidity and mortality in a global population. N Engl J Med 2009;360:491–9
3. Association of Anaesthetists of Great Britain and Ireland (AAGBI), Hartle A, Anderson E, Bythell V, Gemmell L, Jones H, McIvor D, Pattinson A, Sim P, Walker I. Checking anaesthetic equipment 2012: Association of Anaesthetists of Great Britain and Ireland. Anaesthesia 2012;67:660–8
4. Neal JM, Mulroy MF, Weinberg GL; American Society of Regional Anesthesia and Pain Medicine. American Society of Regional Anesthesia and Pain Medicine checklist for managing local anesthetic systemic toxicity: 2012 version. Reg Anesth Pain Med 2012;37:16–8
5. Tobin JM, Grabinsky A, McCunn M, Pittet JF, Smith CE, Murray MJ, Varon AJ. A checklist for trauma and emergency anesthesia. Anesth Analg 2013;117:1178–84
6. Society for Pediatric Anesthesia. Pediatric Critical Events Checklists. 2013. Available at: http://www.pedsanesthesia.org/newnews/Critical_Event_Checklists.pdf. Accessed June 29, 2014
7. Treadwell JR, Lucas S, Tsou AY. Surgical checklists: a systematic review of impacts and implementation. BMJ Qual Saf 2014;23:299–318
8. Salzwedel C, Bartz HJ, Kühnelt I, Appel D, Haupt O, Maisch S, Schmidt GN. The effect of a checklist on the quality of post-anaesthesia patient handover: a randomized controlled trial. Int J Qual Health Care 2013;25:176–81
9. Ziewacz JE, Arriaga AF, Bader AM, Berry WR, Edmondson L, Wong JM, Lipsitz SR, Hepner DL, Peyre S, Nelson S, Boorman DJ, Smink DS, Ashley SW, Gawande AA. Crisis checklists for the operating room: development and pilot testing. J Am Coll Surg 2011;213:212–217.e10
10. McConnell DJ, Fargen KM, Mocco J. Surgical checklists: a detailed review of their emergence, development, and relevance to neurosurgical practice. Surg Neurol Int 2012;3:2
11. Gawande A. The Checklist Manifesto. New York: Metropolitan Books, 2009
12. Hales B, Terblanche M, Fowler R, Sibbald W. Development for medical checklists for improved quality of care. Int J Qual Health Care 2008;1:22–30
13. Treadwell JR, Lucas S. Preoperative checklists and anesthesia checklists. In: Shekelle PG, Wachter RM, Pronovost PJ, Schoelles K, McDonald KM, Dy SM, Shojania K, Reston J, Berger Z, Johnsen B, Larkin JW, Lucas S, Martinez K, Motala A, Newberry SJ, Noble M, Pfoh E, Ranji SR, Rennke S, Schmidt E, Shanman R, Sullivan N, Sun F, Tipton K, Treadwell JR, Tsou A, Vaiana ME, Weaver SJ, Wilson R, Winters BD, eds. Making Health Care Safer II: An Updated Critical Analysis of the Evidence for Patient Safety Practices. Evidence Reports/Technology Assessments, No. 211. Rockville, MD: Agency for Healthcare Research and Quality, 2013
14. Degani A. Cockpit checklists: concepts, design, and use. Human Factors 1993;35: 28–43
15. Tufte E. Envisioning Information. Cheshire, CT: Graphics Press, 1990
16. Fourcade A, Blache JL, Grenier C, Bourgain JL, Minvielle E. Barriers to staff adoption of a surgical safety checklist. BMJ Qual Saf 2012;21:191–7
17. Walker IA, Reshamwalla S, Wilson IH. Surgical safety checklists: do they improve outcomes? Br J Anaesth 2012;109:47–54
18. Makary MA, Sexton JB, Freischlag JA, Holzmueller CG, Millman EA, Rowen L, Pronovost PJ. Operating room teamwork among physicians and nurses: teamwork in the eye of the beholder. J Am Coll Surg 2006;202:746–52
19. Rogers J, Gaba D. Have we gone too far in translating ideas from aviation to patient safety? BMJ 2011;342:c7310
20. Gordon S, Mendenhall P, O'Connor BB. Beyond the Checklist: What Else Health Care Can Learn from Aviation Teamwork and Safety. Ithaca, NY: IRL Press, 2012
21. Amalberti R, Auroy Y, Berwick D, Barach P. Five system barriers to achieving ultrasafe health care. Ann Intern Med 2005;142:756–64
22. Hales BM, Pronovost PJ. The checklist—a tool for error management and performance improvement. J Crit Care 2006;21:231–5
23. Winters BD, Gurses AP, Lehmann H, Sexton JB, Rampersad CJ, Pronovost PJ. Clinical review: checklists—translating evidence into practice. Crit Care 2009;13:210
24. Hawkins J, Blakeslee S. On Intelligence. New York: Henry Holt and Company, 2004

25. Kahol K, Smith M, Brandenberger J, Ashby A, Ferrara JJ. Impact of fatigue on neurophysiologic measures of surgical residents. J Am Coll Surg 2011;213:29–34
26. Holden RJ. Physicians' beliefs about using EMR and CPOE: in pursuit of a contextualized understanding of health IT use behavior. Int J Med Inform 2010;79:71–80
27. Massaro TA. Introducing physician order entry at a major academic medical center: I. Impact on organizational culture and behavior. Acad Med 1993;68:20–5
28. Hart EM, Owen H. Errors and omissions in anesthesia: a pilot study using a pilot's checklist. Anesth Analg 2005;101:246–50
29. Rydenfält C, Ek A, Larsson PA. Safety checklist compliance and a false sense of safety: new directions for research. BMJ Qual Saf 2014;23:183–6
30. Berenholtz SM, Pronovost PJ, Lipsett PA, Hobson D, Earsing K, Farley JE, Milanovich S, Garrett-Mayer E, Winters BD, Rubin HR, Dorman T, Perl TM. Eliminating catheter-related bloodstream infections in the intensive care unit. Crit Care Med 2004;32:2014–20
31. Boorman D. Today's electronic checklists reduce the likelihood of crew errors and help prevent mishaps. ICAO J 2001;56:17–20
32. Mosier KL, Palmer EA, Degani A. Electronic checklists: implications for decision making. Proceedings of the Human Factors Society 36th Annual Meeting. Santa Monica, CA: Human Factors and Ergonomics Society, 1992:7–11
33. Larson ER, Nuttall GA, Ogren BD, Severson DD, Wood SA, Torsher LC, Oliver WC, Marienau ME. A prospective study on anesthesia machine fault identification. Anesth Analg 2007;104:154–6
34. Nair BG, Newman SF, Peterson GN, Wu WY, Schwid HA. Feedback mechanisms including real-time electronic alerts to achieve near 100% timely prophylactic antibiotic administration in surgical cases. Anesth Analg 2010;111:1293–300
35. Fitzgerald M, Cameron P, Mackenzie C, Farrow N, Scicluna P, Gocentas R, Bystrzycki A, Lee G, O'Reilly G, Andrianopoulos N, Dziukas L, Cooper DJ, Silvers A, Mori A, Murray A, Smith S, Xiao Y, Stub D, McDermott FT, Rosenfeld JV. Trauma resuscitation errors and computer-assisted decision support. Arch Surg 2011;146:218–25
36. Flight Deck Automation Working Group, Federal Aviation Administration. Operational Use of Flight Path Management Systems. September 5, 2013. Available at: http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/parc/parc_reco/media/2013/130908_PARC_FltDAWG_Final_Report_Recommendations.pdf. Accessed June 29, 2014
37. Institute of Medicine. To Err Is Human: Building a Safer Health System. Washington, DC: National Academies Press, 2000
38. Leape LL, Lawthers AG, Brennan TA, Johnson WG. Preventing medical injury. QRB Qual Rev Bull 1993;19:144–9
39. Arriaga AF, Bader AM, Wong JM, Lipsitz SR, Berry WR, Ziewacz JE, Hepner DL, Boorman DJ, Pozner CN, Smink DS, Gawande AA. Simulation-based trial of surgical-crisis checklists. N Engl J Med 2013;368:246–53
40. Jablonski E. The Flying Fortress. New York: Doubleday, 1968
41. Roesler A. Interaction design in high stakes domains: the impact of design at the intersection of expertise and technology. Des Princ Pract Int J 2011;5:37–52
42. Rausch TL, Judd TM. The development of an interoperable roadmap for medical devices. Conf Proc IEEE Eng Med Biol Soc 2006;Suppl:6740–3