The role of the anesthesiologist in perioperative patient safety

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Purpose of review

Despite the benefits of rapidly advancing therapeutic and diagnostic possibilities, the perioperative setting still exposes patients to significant risks of adverse events and harm. Anesthesiologists are in midstream of perioperative care and can make significant contributions to patient safety and patient outcomes. This article reviews recent research results outlining the current trends of perioperative patient harm and summarizes the evidence in favor of patient safety practices.

Recent findings

Adverse events and patient harm continue to be frequent in the perioperative period. Adverse events occur in about 30% of hospital admissions, are associated with higher mortality, and may be preventable in more than 50%. Evidence-based recommendations are available for many patient safety issues. No magic bullet practices exist, but promising targets include the prevention and limitation of perioperative infections and of complications of airway and respiratory management, the maintenance of achieved safety standards, the use of checklists, and others.

Summary

Current research provides growing evidence for the effectiveness of several patient safety practices designed to prevent or diminish perioperative adverse events and patient harm. Future investigations will hopefully fill the numerous persisting knowledge gaps.

Keywords

adverse events, anesthesia, patient safety, perioperative management, safety practice

INTRODUCTION

Anesthesiologists have been among the very pioneers of patient safety. According to a definition by Charles Vincent, patient safety is ‘the avoidance, prevention and amelioration of adverse outcomes or injuries stemming from the process of healthcare’ (p. 31) [1], rather than from the patient’s underlying medical condition [2]. During the last decades, the risks associated with anesthetic care have been dramatically reduced [3]. Yet anesthesia takes center stage among acute healthcare services, and from a patient’s perspective, anesthesia-specific risks cannot be meaningfully isolated from perioperative and peri-interventional risks. In this article, we review the current epidemiological scale of patient safety impairments in adult noncardiac anesthesia and perioperative care, and the evidence supporting interventions to prevent or reduce them. The emphasis of this review is placed on safety issues with increasing occurrence, which can be addressed by effective strategies.
KEY POINTS

- Despite low anesthesia-specific risk, anesthesia management has important impact on perioperative risk and perioperative outcomes.
- Perioperative adverse events remain frequent and occur in about 30% of hospital admissions, may be preventable in more than 50%, and show increasing trends according to current research results.
- Evidence-based recommendations are available for many patient safety issues.
- Targets include, among others, the prevention and limitation of perioperative infections and of complications of airway and respiratory management, the maintenance of achieved safety standards, and the use of checklists.

NO REASON FOR COMPLACENCY: RECENT DATA ON PERIOPERATIVE PATIENT HARM

Even more recently, perioperative adverse events do not seem to decline. Analyses of large national US databases identified increasing trends of major in-hospital complications despite decreasing in-hospital mortality for patients undergoing total knee and hip arthroplasties (1998–2008) [8], and for major cancer surgery [9,10]. Because of shorter hospital stays, some of the mortality may have shifted to intermediate care facilities [8]. Importantly, most types of these adverse events may be influenced by anesthetic and perioperative care. Further, adverse events were also found in 38.1% of hospital discharges from 2007 to 2011 [11]. Adverse events related to surgery represented the largest category (40.5%) [11], and most were preventable. Moreover, in a recent US study of the records of over 60 000 Medicare patients (2005–2011) [12**], overall trends for 21 different adverse event measures were declining for patients with acute myocardial infarction and congestive heart failure, but not with pneumonia or conditions requiring surgery [12**]. Adverse events in surgical patients were significantly increasing over the study period, occurred in 36.8% of hospitalizations [12**], and were associated with a significantly higher risk of death as compared with patients without adverse events [12**]. Interestingly, postoperative cardiac events and venous thromboembolic events were significantly declining over the study period, potentially due to extensive cardiovascular quality improvement campaigns in the US [12**]. In contrast, rates for events associated with intravenous heparin as well as for postoperative pneumonia increased significantly [12**].

EUROPEAN PERSPECTIVE ON PERIOPERATIVE PATIENT HARM

Recently, a Swedish study using the GTT confirmed these US findings [13*]. Adverse events, preventable in 71%, were identified in 20.5% of discharges [13*], and no decline was noted over 4 years [13*]. Hospital-acquired infections, almost all preventable, represented 47% of adverse events in surgical patients [13*]. Furthermore, the European Surgical Outcomes Study documented an unexpectedly high mean surgical mortality of 4% before discharge, with pronounced disparities between 28 European countries [14]. In addition, a systematic review found – mostly preventable – surgical and anesthetic adverse events to contribute to 19.3–52.2% of unplanned ICU transfers [15].

ANESTHESIA-SPECIFIC MORTALITY: HIGHER THAN WE THOUGHT?

The anesthesia-specific mortality has been substantially reduced over the last decades [3] and is estimated to be overall about 1/100 000 cases [16]. A recent analysis of a large German national surveillance database identified a risk of 10 per million anesthetics for death or other serious complications from anesthesia in a sample of American Society of Anesthesiologists (ASA) class I and II patients [17*]. This number approaches the previous estimate of overall anesthesia-specific risk [17*]. Forty percent of anesthesia-related deaths were due to airway problems [17*]. If higher ASA classes have higher risks, and the proportion of multimorbid surgical patients with higher ASA class is increasing, the findings of this study suggest a higher overall anesthesia-specific mortality than previously estimated [16,18]. Furthermore, according to the Fourth National Audit Project (NAP4) in the UK, 5.4 deaths per million general anesthetics were estimated to result from airway complications. Because of under-reporting, true mortality rate may have been four times higher in this population [19], and also...
substantially higher in the German study population [17]. Anyway, the true airway-related mortality according to NAP4 (about 20 deaths per million general anesthetics) would readily be double of the traditional all-cause anesthesia-specific mortality of 1 : 100 000. Furthermore, future investigation of long-lasting effects of anesthesia-related perioperative hypotension on long-term mortality may question the previous estimate of anesthesia-related risk [20]. From a patient’s perspective, however, overall perioperative risk seems more important than speciality-specific risk.

CAN WE TRUST THE DATA?
Data from routine quality or voluntary adverse event reporting should be interpreted cautiously, as underreporting is common and may be quite pronounced (reporting bias). For example, only 5 [11] to 6.3% [13] of adverse events identified with the GTT were also reported with voluntary routine reporting instruments. In contrast to systematic routine reporting, voluntary reporting systems for adverse events or critical incidents cannot be used to measure error or event rates, to compare organizations, or to measure changes over time [21]. However, they are important to understand the nature of events and to analyze root causes.

PERIOPERATIVE SAFETY AS A SHARED RESPONSIBILITY OF SURGERY AND ANESTHESIOLOGY
Both surgery and anesthesia contribute to patient harm in the perioperative period. Accordingly, perioperative harm should largely be considered a shared responsibility of surgery and anesthesia. Obviously, patient safety practices should target avoidable patient harm and should be assessed, irrespective of the discipline, as carefully as any other healthcare intervention regarding their effectiveness, potential direct and indirect undesired effects, and cost-effectiveness. A review supported by the US Department of Health and Human Services’ Agency for Healthcare Research and Quality examined 41 patient safety practices. Ten practices were ‘strongly encouraged’, and additional 12 practices were ‘encouraged’ for adoption [22,23]. A selection of practices relevant for increasing safety issues in perioperative care is presented in Table 1 [24–32, 33,34,35].

POSTOPERATIVE INFECTIONS: A TARGET FOR ANESTHETIC AND PERIOPERATIVE SAFETY EFFORTS
Postoperative infections remain an area of concern in surgical patients, despite evidence for decreasing mortality from infectious complications [10,12,13]. Increasing trends were noted for postoperative pneumonia, catheter-associated urinary tract infections, ventilator-associated pneumonia [12], and bloodstream infections and sepsis [8–10]. The rate of postoperative pneumonia has been significantly increasing to 3.3% from 2005 to 2011 [12]. Evidence for effectiveness to reduce postoperative pneumonia has been found for a multidisciplinary, multiform pulmonary care program [36] and for neuraxial blocks when used instead of general anesthesia or in combination [37]. Surgical site infections (SSIs) have been reported to occur in 13.5% of surgical patients [38]. Effective strategies to reduce SSI include timely administration of the correct prophylactic antibiotic, maintenance of normothermia, hand hygiene, and bundles to prevent venous access infections, checklists, and standardization [38]. The evidence supporting effectiveness of intraoperative hyperoxia is conflicting [38].

Bloodstream infections and sepsis are increasing [8], and may affect more than 2.5% [9] of major cancer surgery patients. General preventive strategies are presented in Table 1. Central line-associated bloodstream infections have been successfully reduced by a number of safety practices, approaches, and technologies [39].

PERIOPERATIVE RESPIRATORY AND AIRWAY-RELATED COMPLICATIONS
The NAP4 project in the UK provided an occurrence estimate of severe airway complications [19]. Airway management was judged poor in three-quarters of cases, indicating room for improvement [19]. This audit reveals important aspects of patient safety. Despite challenging situations, no ‘plan B’ had been made in most cases. Moreover, well proven technology (e.g., fiberoptic bronchoscopy, capnography) had been disregarded, and well established protocols for airway management had not been followed [19]. Furthermore, difficult intubations as well as aspirations have increasing shares among US closed claim cases. Difficult airway situations occur beyond induction of anesthesia during surgery, during extubation, and during recovery [40]. From closed claims analysis, it is also concluded that a surgical airway should be attempted early in difficult airways, that laryngeal mask airway should not be regarded as a fail safe, and that extubation of the difficult airway remains a significant patient safety issue [40]. Furthermore, residual neuromuscular paralysis occurs in about 30% of patients at risk [41], may be clinically inapparent but associated with increased risk of postoperative adverse events [42], exposes patients to respiratory complications...
Careful neuromuscular monitoring [adductor pollicis (thumb), not eyebrow] is more important than indiscriminate use of reversal agents. Sugammadex has been associated with adverse effects, such as allergic reactions, transient increase in prothrombin time, and reparation in 2% [41].

**Table 1.** Safety practices encouraged by the Agency for Healthcare Research and Quality for the prevention of increasing substantial perioperative safety issues

| Patient safety issue | Rate (percentage of hospitalizations at risk) | Encouraged safety practice [23*] | Advantages | Problems (all: varying implementation problems) |
|----------------------|---------------------------------------------|----------------------------------|------------|-----------------------------------------------|
| **Clinical issues**  |                                             |                                  |            |                                               |
| Ventilator-associated pneumonia | 10.6% [12**]                           | Bundles: head-of-bed elevation, sedation vacations (holds), oral care with chlorhexidine, and subglottic-suctioning endotracheal tubes [++] [24] | Evidence for effectiveness (evidence): moderate to high [as bundle: synergism] [24] | (Low to) moderate costs [24] |
| Catheter-associated urinary tract infections | 3.7% [12**]                          | Interventions to reduce urinary catheter use: catheter reminders, stop orders, or nurse-initiated removal protocols [++] [25] | Evidence: moderate to high; low cost [25] | Low risk: premature removal [25] |
| Healthcare-associated infections (HAI) in surgery | Specific fields: 10.5% [10] | Hand hygiene [++] [26] Barrier precautions, patient isolation, and routine surveillance [++] [27] | Low evidence for harm, low cost [26] Evidence: moderate [27] | Low strength of evidence for effectiveness [26] Moderate evidence for harm [contact isolation] [27]; Moderate-to-high cost |
| Central catheter-associated mechanical complications | 3.5% [12**]                          | Use of real-time ultrasonography for central line placement [++] [28] | Evidence: strong; negligible harm [28] | Moderate cost [28] |
| **System issues**   |                                             |                                  |            |                                               |
| Adverse events per hospitalization | 36.8% [12**]                           | Preoperative checklists and anesthesia checklists [++] [29] Rapid-response systems [+] [30] Use of simulation for patient safety efforts [+] [31] Team training [+] [32] Monitoring patient safety problems [e.g., chart reviews; critical incident reporting systems] [++] [34] Outcome measurements [+] [35] | Evidence: high, low cost, negligible harm [29] Evidence: moderate; low harm [30] Evidence: moderate to high [31] Evidence: moderate, low harm [32,33**] Negligible harm [34] Evidence: moderate to high, low harm [33**,35] | Multiple implementation issues [29] Moderate costs [30] Moderate costs [31] Impl. moderate to difficult; moderate costs [32] Evidence low; high costs [34] Moderate costs [35] |

This selection presents patient safety issues with the following characteristics: first, they are relevant for anesthesia and perioperative management; second, they have increasing trends of occurrence despite evidence for their partial or extensive preventability; third, safety practices supported by sufficient evidence exist for their prevention. Agency for Healthcare Research and Quality (AHRQ), Department of Health and Human Services, USA. (+) = strongly encouraged; (++) = encouraged practice. Data origin: see references [12**,22**,23*].

**INTRAOPERATIVE HYPOTENSION AND ORGAN INJURY**

Analysis of a large perioperative database suggested an association between intraoperative hypotension below 55 mmHg mean arterial pressure even for short periods of 1–5 min and the occurrence of postoperative acute kidney injury and myocardial
injury [43]. Hypotension has also been associated with the perioperative occurrence of stroke [44*]. Although no absolute and generalizable lower limit of systemic blood pressure to avoid organ injuries has been defined yet, clinical working definitions are widely used and often represent institutional standards [45]. Some problems interfering with the realization of such standard hemodynamic goals in daily practice may impair patient safety. For example, hemodynamic adverse events are frequent during in-hospital transfers of complex, critically ill patients [46]. Furthermore, unrecognized or inadequately managed drug combinations leading to interactions in the perioperative period may result in severe intraoperative hypotension [47]. In addition, the beach chair (semi-recumbent) position used for shoulder surgery has been associated with risk of perioperative stroke [44*,48]. Failure to consider the hydrostatic pressure gradient resulting from head elevation in this position when interpreting blood pressure measurements has been proposed as one reason for inadequate intraoperative cerebral perfusion contributing to perioperative stroke [48,49]. Other examples of adverse process-related impact on the clinical management of hemodynamic events include the temporary silencing of audible alarms [50] and distractions or interruptions that may result in delayed or impaired patient care [51–53].

MAINTAINING ESTABLISHED SAFETY STANDARDS

Decreasing trends of some safety issues may be due to successful implementation of effective strategies, or to shifts in their occurrence. For instance, postoperative cardiac events and thromboembolic events have significantly declined from 2005 to 2011 [12**]. Despite decreasing trends, the absolute number and severity of these complications mandate constant vigilance. For clinicians, it will thus be important to retain what has been gained. In the face of limited resources and increasing production pressure [54**], prioritization of emerging safety standards should be accompanied by active upkeep of established, successful safety practices that may otherwise be gradually downgraded [54**,55–57].

SAFER SURGERY CHECKLIST: CHECK, BUT HOW?

Individual studies [29,58,59], reviews [60], and a number of systematic reviews have documented the efficacy of surgical checklists to improve surgical mortality and morbidity [61,62*,63**,64], teamwork and communication in the operating room [62*,63**,65,66], and compliance with safety measures [62*,63**]. Surgical checklists have been widely recommended [18] and adopted [29]. Some inconsistent evidence exists about implementation and effectiveness in routine practice and disparate clinical settings [60]. Interestingly, a number of studies have found no or only minor impact of surgical safety checklists on relevant outcomes in clinical settings with pre-existing comparatively high safety standards [67,68,69**]. One explanation has been that checklist implementation in settings with pre-existing high safety standards and check systems may elicit ‘checklist fatigue’ and promote barriers [60]. Another explanation may be confounding, that is, that the benefits documented with use of the checklist are not resulting from the checklist as such, but from concomitant positive effects of implementation on teamwork, communication, and safety culture [68]. Most studies about the effect of surgical checklists on outcomes then have only moderate methodological quality (pre-post evaluations) [58,69**]. The methodologically best investigation, a stepped wedge cluster randomized controlled trial published a short time ago [70*], reported significant reductions in length of hospital stay and morbidity, but failed to reproduce the significant reductions in overall mortality identified in previous studies [70*]. From a clinician’s perspective, however, it seems irrelevant if the benefits of this relatively low cost intervention are causally resulting from the checklist, or just by occasion from concomitant effects of its implementation, if these effects are lasting. It is reasonable to take advantage of these benefits, as recommended by many professional organizations [18,23*,29] and as regulated by law in some countries [69**,70*]. Given the limited scientific evidence, future research should evaluate if the reported effects prevail over time, and investigate implementation issues in individual settings. In terms of perioperative patient safety, surgical checklists are just one piece of many in a comprehensive safety strategy and should not be regarded as a substitute for other important patient safety activities with comparable evidence for effectiveness [33**].

INTERVENTIONS TO IMPROVE SAFETY CULTURE AND COMMUNICATION

Safety culture, as measured by survey-based ratings of surgeons, nurses, and operating room administrators, has been reported to be associated with rates of serious surgical complications [71*]. Interventions to improve safety culture may target leadership, teamwork, or behavior change, examples include interdisciplinary rounding, team training,
Technology, education and safety

encouraging error reporting, and others [72]. Team training [32] and simulation training [31] also contribute to safety culture. Postoperative handovers are important communications, and incomplete information transfer can be hazardous [73**]. No methodological approach has resulted in improving handover outcomes so far, despite evidence for improved information transfer [73**]. Eventually, promising investments in future safety culture are teaching activities to foster knowledge and attitudes among healthcare trainees and medical students [74]. For this purpose, the WHO has provided teaching materials covering all relevant aspects of patient safety [75].

CONCLUSION

Anesthesia has low specific risk, but has important impact on perioperative risk and outcomes. Adverse events in the perioperative period continue to be frequent, occur in about 30% of hospital admissions, and may be preventable in more than 50%. Evidence-based recommendations are available for many patient safety practices. Important practical targets include perioperative infections, airway and respiratory management, maintenance of safety standards despite production pressure, and others. Future research should provide more high-quality evidence about the effectiveness of patient safety practices, deeper insights into common patterns of preventable events, and into implementation issues of surgical checklists and other practices.

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Conflicts of interest

Johannes Wacker is member of the Scientific Subcommittee Patient Safety of the European Society of Anaesthesiology (ESA), Brussels, Belgium. Sven Staender is chairman of the Patient Safety Task Force of ESA. No conflicts of interest are declared concerning this publication.

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