Review

A Review of Recent Advances in Perioperative Patient Safety

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Abstract

Major complications in surgery affect up to 16% of surgical procedures. Over the past 50 years, many patient safety initiatives have attempted to reduce such complications. Since the formation of the National Patient Safety Agency in 2001, there have been major advances in patient safety. Most recently, the production and implementation of the Surgical Safety Checklist by the World Health Organisation (WHO), a checklist ensuring that certain 'never events' (wrong-site surgery, wrong operation etc.) do not occur, irrespective of healthcare allowance. In this review, a summary of recent advances in patient safety are considered – including improvements in communication, understanding of human factors that cause mistakes, and strategies developed to minimise these. Additionally, the synthesis of best medical practice and harm minimisation is examined, with particular emphasis on communication and appreciation of human factors in the operating theatre. This is based on the resource management systems developed in other high risk industries (e.g. nuclear), and has also been adopted for other high risk medical areas. The WHO global movement to reduce surgical mortality has been highly successful, especially in the healthcare systems of developing nations where mortality reductions of up to 50% have been observed, and reductions in patient complications of 4%. Incident reporting has long been a key component of patient safety and continues to be so; allowing reflection and improved guideline formation. All patients are placed at risk in the surgical environment. It is crucial that this risk is minimised, whilst optimising the patient's outcome. In this review, recent advances in perioperative patient safety are examined and placed in context.

Introduction

Over 230 million operations are performed annually worldwide.[1] The World Health Organisation (WHO) estimates that in industrialised countries, major complications occur in 3–16% of surgical procedures, with death rates between 0.4–0.8%.[2] This data is contradicted by a worrying recent prospective study of over 46,000 surgical patients across 498 hospitals in Europe (including the United Kingdom), that found a mortality rate of 4% for all non-cardiac, neurosurgical, or obstetric inpatient surgical admissions.[3] With a mortality rate in developing countries of up to 10%, and seven million people worldwide harmed annually by complications related to surgery, improving patient safety is an issue for all healthcare systems.[2] Given the poor infrastructure and supply of vital equipment and medicines in developing countries, higher mortality figures come as little surprise. In response to such figures, the WHO instigated a global movement to promote safe surgery, and in doing so created the Surgical Safety Checklist (SSC) that has been shown to reduce mortality by up to 50% ($p=0.03$) and reduce complications from 11% to 7% ($p<0.001$).[4]

With the first publication of *Anaesthesia* in 1946 came diverse improvements in anaesthetic practice.[5] Since the invention of pulse oximetry in 1972, and its wider implementation from 1981 onwards, there has been a steady decline in anaesthesia associated complications and mortality.[6] A Cochrane review summarised that pulse oximetry substantially reduced the extent, and improved the resolution, of perioperative hypoxaemia.[7] Despite use of pulse oximetry, it has not been observed to reduce the overall rate of perioperative complications.[8] As with all monitoring, pulse oximetry is simply a tool, and one that can be misinterpreted without appropriate training.

Since the widespread use of pulse oximetry, and the use of end tidal carbon dioxide monitoring before that, there have been limited steps in improvement of patient safety.[6] Recently, the concept of Enhanced Recovery After Surgery (ERAS) programmes has developed. These aim to speed recovery by using a combination of proper pre-surgery optimisation, perioperative measures, and post-operative planning to ensure early mobilisation, oral intake of fluid, and ambulation.[9,10] Such programmes have been used widely in colorectal and orthopaedic surgery, demonstrating a significant reduction in morbidity, hospital stay, and required intravenous fluid for colorectal surgical patients.[11]

In 2011, National Institute for Health and Clinical Excellence (NICE) created a group looking into the use of monitoring systems to allow assessment of the depth of anaesthesia.[12] These systems use assessment of brain electrical activity whilst under anaesthetic to try and establish how deeply anaesthetised the patient is. The group recently published their guidance, stating "[use of the monitors] was associated with lower general anaesthetic consumption and shorter recovery times" – potentially a useful tool for those on ERAS type pathways.[12] A further recent technological advance has been that of non-invasive blood flow monitoring such as oesophageal Doppler

monitors.[13] These have the capacity to demonstrate changes in central circulation without need for intervention, such as placement of a central venous catheter – thereby reducing length of stay and post-operative complications, whilst allowing high quality monitoring perioperatively.[13]

Goal Directed Therapy is the use of therapy to attain certain physiological goals. It has been used extensively in critical care medicine, most notably in the Surviving Sepsis Campaign.[14] A recent stratified meta-analysis of perioperative fluid management found that use of Goal Directed Therapy was associated with lower risk of pneumonia and extended hospital stay compared to liberal fluid therapy.[15] All of these measures have allowed monitoring and optimisation of patients, especially those in high risk surgery (the oesophageal Doppler is currently recommended for those undergoing Major/High risk surgery).[10,11,13]

The availability of such equipment, medications, and information has improved worldwide. Currently, general anaesthesia is associated with a mortality rate of 1 per 250,000 inductions in developed healthcare systems.[16] The focus of best practice has previously been to reduce patient risk perioperatively; it now also encompasses maximising perioperative patient safety. Technical and non-technical skills alike are improving patient safety, preventing avoidable mistakes. The use of checklists, communication, simulation, and universal skills such as advanced life support (using drilled, algorithmic problem solving) increase the likelihood of optimal outcomes.[17]

Patient Safety

The perioperative period is, for all patients, a very dangerous time. Studies show that half of all adverse events in hospitals are related to surgical procedures in the operating department.[18,19] Improvements in anaesthetic and surgical practice have resulted in a significant reduction in complications.[5–7,16,17,20,21] The WHO initiative for emergency and essential surgical care, launched in 2004, focuses on ensuring appropriate access to high-level care worldwide.[2] The guideline report states that the mortality for general anaesthesia in sub-Saharan Africa may be as high as 1 in 150. This initiative came as a part of the broader 'Global Patient Safety Challenges' campaign, which addresses areas of significant risk for WHO member states and their patients.[2]

The ethos of a 'patient safety first approach' to healthcare has long been a part of anaesthetic practice. The confidential enquiry into maternal deaths, first established in 1928 and extended to include anaesthetic related complications in 1955, was the first incident reporting system.[22] In the following five decades, the rate of maternal death has decreased significantly – the use of metrics and surveillance methods in assessing surgery on a global scale have since played a key role in evaluating health system performance. This followed the publication of 6 metrics for surgical surveillance by the WHO in 2009.[23] In current practice, the anaesthesia related to elective caesarean section is now 30 times safer than it was in the 1960s.[22] The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) was established following the confidential enquiry into maternal deaths, and a pilot study into anaesthetic mortality by Lunn and Mushin in 1982.[24] NCEPOD offered a reporting system for anaesthesia related morbidity and mortality, and evolved to become a more widely applicable national reporting and learning service.

In 2001 this patient safety ideology was expanded through the creation of the national patient safety agency (NPSA), with the goal of offering a centralised error reporting and advisory service for the UK.[25] The WHO's World Alliance for Patient Safety in October 2004 further focused attention on patient safety.[2] The NPSA's National Reporting and Learning Service (NRLS) was created in 2003 to offer a unified database of errors and relevant guidelines.[25] It was hoped that reducing individual blame, increasing transparency, and forging a culture of safety would lead to increased incident reporting, in turn resulting in fewer adverse events as new systems could be implemented.[25] They publish regular reports looking at reporting at specific trusts, ensuring reporting of events is adequate and generate reports of such events.[25] Over a two-year period, of more than 12,000 reported anaesthetic errors, 70% resulted in no harm – so called 'near miss' events. Catchpole *et al.* suggest that by reducing the opportunity for harm, and by recognising and managing harm early, less reportable events should occur in the future. However, generic, web-based reporting systems (such as NRLS) are limited by inherent taxonomic limitations and the multi-factorial aetiology of harms. This has led to the requirement for a multi-stage plan and multi-disciplinary team approach to tackle such failures.[26,27]

The recognition of a 'never event' as a concept was a crucial step for patient safety, initially proposed by the National Quality Forum.[28] These are serious, largely preventable, patient safety incidents that should never occur if proper preventative measures have been implemented.[28] Since 2009, the Department of Health has published lists of 'never events'.[28] These lists were expanded in 2011 and many centre on surgical and anaesthetic practice. Each 'never event' should have a preventative system in place. Should a 'never event' nevertheless occur, timely and accurate reporting is crucial, regardless of the impact of the mistake (i.e. it is not necessary for death or harm to have occurred for it to be reportable). 'Never events' include opiate overdose in an opiate naive patient, or wrong-site surgery – an issue specifically addressed by use of pre-surgical checklists.[28]

The Patient Safety Campaign, initiated in 2007 by the Department of Health, included a number of areas for improvement in patient safety. One core topic was reducing harm in perioperative care. This advised utilising two predominant frameworks for improving perioperative patient safety. The first, measures to reduce surgical infection and the second, tools to improve communication and teamwork within the perioperative environment. Both are heavily evidence based interventions, shown to reduce mortality and morbidity.[29] The latter recommended use of the WHO SSC, initially published in 2008, and shown in 2009 to have a significant impact on adverse outcomes in theatres.[4]

Surgical Safety Checklist

It has been widely acknowledged that systems based interventions are often far more effective than those directly targeting individuals.[30] Crew Resource Management (CRM) systems were the first systems to use a checklist type approach to target systematic problems.[31] Their use has become the gold standard in other high-risk industries, such as oil, aviation, and nuclear power.[29,32,33] Other models have underpinned the multi-disciplinary team approach to other areas of medical practice. These include situation maps, where knowledge held by specific individuals is best shared with others to

improve specific situational awareness (otherwise known as a 'shared cognitive maps').[34] Use of a pre-surgical checklist has further expanded these models into the theatre environment. Making critical information available to all, before any problems arise, has been shown to facilitate early, and successful, problem solving.[34,35]

In 2003, The Joint Commission held a summit with a number of professional bodies and concluded that a specific protocol was required to facilitate communication and reduce wrong-site surgery.[36] As part of this, they established a sentinel event database where wrong-site surgery could be reported. A universal protocol, published later that same year, was the basis of a checklist procedure for perioperative patient safety – it established the format of the WHO SSC. This included pre-procedure verification of patient identity, site marking, and a time-out before incision. Zohar *et al.* found that the use of a pre-operative checklist with various stop points, where key features (e.g. patient identity, site for incision) were checked and signed off, halved major errors over the three-year implementation period.[37]

The WHO SSC was published in 2008; it highlights three key time points for perioperative patient safety. First, before induction of anaesthesia; secondly, before incision; and finally, before the patient leaves the theatre.[38] The checklist was based on the WHO's 'Ten Essential Objectives for Safe Surgery' (as laid out in their Safe Surgery Saves Lives report of 2008) and aspects of the checklist reflect these objectives.[2] For example, the requirements for sponge and instrument counts in the checklist reflect objective 7 (to prevent inadvertent retention of foreign objects in surgical wounds).[2] In their multi-national implementation study of 2009, Haynes *et al.* found that using the WHO SSC was associated with a decrease in complications from 11% to 7%. Similar decreases were seen in all-cause mortality, from 1.5% to 0.8%.[4] They also found that appropriate antibiotic use increased from 56% to 83%, which could potentially result in a drop in associated infections by 33%.[4,39]

Some have questioned the sufficiency of a generic checklist and suggest that specific checklists, with common problems for particular surgical specialities, may be more appropriate.[40] The WHO itself states that the checklist is not a final format or perfect. However, it believes that the SSC should be the basis for some form of intervention at the specific moments in the patient journey outlined.[4] Indeed, a number of specialties have made modifications. In obstetric theatres, specific checks on maternal haemoglobin levels, properly functioning neonatal resuscitation equipment, and neonatology input have all be included prior to commencing a caesarean section.[41] The use of checklists has now been expanded to include the whole of the patient journey – not just the perioperative period. Use of one these demonstrated a significant improvement of adherence to widely accepted clinical practices for childbirth practices. Use of a 'whole journey', from admission to discharge, checklists would certainly seem to be the future evolution of the WHO SSC.[42]

Communication

Communication is an important part of modern medical practice, both with patients and between fellow healthcare professionals. Makary *et al.* found that communication errors are key factors in medical errors. Given the highly complex inter-professional environment seen in theatres, it should come as no surprise that The Joint Commission found that communication impacts on roughly 65% of sentinel (i.e. reportable) events.[43,44] This is especially important in the perioperative environment, where up to half of all complications are potentially avoidable.[45] Given the prominent role communication plays in errors, methods for improving communication between team members should reduce the number and frequency of such errors.[46] Perhaps the most interesting of such methods was the work carried out by Catchpole *et al.* in 2010 investigating how Formula One® racing teams work during pit stops. They used this to improve paediatric handovers – specifically implementing protocols and procedural training to make handover as smooth and as accurate as possible.[47]

Lingard *et al.* demonstrated that 36% of communication errors in theatres caused wasted resources, inefficiency, list delays, patient inconvenience, and an increased rate of procedural errors. As many as 30% of these communication errors occurred during the pre-list briefing, and of these, 46% were due to poor timing, 36% to incomplete information, 24% to issues left unresolved, and 21% to failure of including key personnel. Increase in tension, work-load, and interruption of workload occurred in 33% of these failures.[48]

Until recently, the improvement of team communication has been slow.[49] Only 32% of non-physician caregivers felt the primary surgeon's perioperative communication was effective in cardiovascular surgery.[50] One of the crucial steps in the development of teamwork improvement was an adoption of CRM principles into the practice of high-risk medical areas. This is a highly relevant concept within anaesthesia, where understanding of team behaviour during crisis periods can influence dynamic decision making.[31] Deeper understanding of human factors that contribute to mistakes has allowed critical appraisal of errors and implementation of measures to prevent future events. One such example is that of Elaine Bromiley, a patient admitted for a 'routine Operation' that led to loss of her airway and her eventual death; her husband, an airline pilot, has started a scheme looking into the human factors that surround such situations. Her story is portrayed in the video 'Just a Routine Operation' and shows how important it is that everyone is comfortable communicating if they feel something is wrong.[50,51] Anaesthetics Crisis Resource Management now comprises a large component of an anaesthetist's non-technical skills, where decision making and teamwork are thought to be as important as having the skills required to enact management decisions.[52] The adoption of simple, formulaic systems of communication and problem solving are central to this methodology. Examples include the use of 'SBAR' (Situation, Background, Assessment and Recommendation) when discussing acutely ill patients.[53]

The concept of 'surgical flow' was a key factor in the development of the WHO SSC; these are deviations from the normal progression of an operation, potentially compromising patient safety. An increase in small, but problematic, events is correlated with a decreased chance of coping with a major event.[54] Furthermore it has been observed that 52% of surgical flow disruptions are caused by impaired communication.[55] Wiegmann *et al.* also reported that delayed capture events (where a problem is not noticed or resolved immediately, but is before ending the operation) were often not detected by the primary surgeon. It is thus not surprising that this study also indicated that communication and teamwork were the only significantly contributing factors to adverse event outcome, further upholding the importance of communication improvements.[30]

Conclusion

The last 50 years have seen vast steps forward for anaesthetic practice. Including pulse oximetry, end tidal carbon dioxide monitoring, ERAS, Goal Directed Therapy, and recent developments that look to change the future landscape of anaesthetic practice (such as depth monitoring).[5–7,10–13,15,16,17] The implementation of checklists has given a proven benefit for patient safety perioperatively. As training, in both technical and non-technical skills, continues to improve, patient benefit should increase further. Anaesthetists have a long history of a patient safety orientated practice, and while a 0.7% decrease in mortality may seem small, when one considers the sheer volume of operations performed worldwide its importance becomes clear. Early implementation of such measures into developing healthcare systems is crucial to reduce the mortality burden currently associated with surgery.[2]

The concept of 'First; do no harm' is pertinent to all areas of medicine, but especially in the operating theatre where risk of mistakes, and impact of such mistakes, are so high.[19] Some may feel the checklist is wasting waste of time, and that these checks should be performed as part of normal practice; evidently this is not the case and studies have shown the average time-out takes between one and four minutes.[55]

The combination incident reporting and clinician training should lead to improved guideline formation, and further outcome benefit for patients. Especially since the Bristol babies enquiry of 2001 – the summary issued by the Department of Health asserted that "We are determined that some good can come from the tragedy that took place there." This is at the very heart of incident reporting – getting as much information out of a bad situation and trying to adapt practice to ensure it never happens again.[56] This is perhaps best highlighted by the fact that Bridgewater *et al.* found publication of outcomes in cardiac surgery was associated with reduced mortality.[57] Greater provision of non-technical skills training, and use of simulation for practice of drills in anaesthetic CRM settings, would allow for optimisation of such non-technical skills.

As with all things, practice makes perfect – the use of non-technical skills is no exception. With time, communication, drills, checklists, and people's skills utilising them will be refined, and, with them, patient safety improved. Ultimately, all patients are put at risk during an operation, the whole basis of modern anaesthetic practice is to minimise this risk while optimising patient outcome. Use of the WHO SSC, improved communication, further understanding of human factors, and non-technical skills development have all been crucial steps in this on-going battle. The EUSOS study stated that 75% of the 4% of patients who died as surgical inpatients had not been admitted to a critical care setting. This very worrying figure indicates that the whole patient journey must be considered and carefully mapped if patients are to have their surgery and recover in as safe a way as possible.[3]

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