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Review article: Current literature on surgical checklists and handoff tools and application for orthopaedic surgery

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ABSTRACT

Despite the adaptation of checklists for specific surgeries being developed, there remains a lack of an available standard for an orthopaedic-specific checklist. Benefits of implementing checklists include cost-effectiveness as well as the ability to significantly reduce both mortality and complication rates in a variety of healthcare settings. The aim of this review is to analyze the evidence surrounding the effectiveness of checklists as well as recommend for the development of a standard checklist for specific orthopaedic surgeries such as total joint arthroplasty (TJA).

1. Introduction

Orthopaedics is a specialization that encompasses a wide assortment of operations known to be invasive and complex.[1–4] When compared to other industries such as aviation and nuclear power, orthopaedic surgery has a higher risk for complications.[5] The recorded mortality rate from complications associated with surgery is 1 per 10,000. With roughly 234 million operations performed annually, it is vital that the mortality rate be reduced.[1] For comparison, commercial aviation runs the risk of 2 deaths per million passengers, whereas the healthcare industry has a recorded 6000 deaths per million per patient.[6] Although both industries differ in service type, it must be acknowledged that both occupations place a strong emphasis on the well-being of their consumers. As such, it is vital to find more effective ways to improve surgical safety.

The usage of checklists was first established by the aviation industry to assist in ensuring their passengers' safety. American surgeon and writer, Atul Gawande, explores the origins and benefits of this checklist in his book titled the 'Checklist Manifesto'. The checklist not only made the practice of aviation simpler, but also created a safer environment.[7] Aviators used such checklists to simplify tasks and ensure complex functions had been carried out. Application of these checklists would break routine and allow for focused attention towards vital steps, increasing safety, as well as effectiveness.

On June 25th, 2008 The World Health Organization (WHO) implemented the Safe Surgery Saves Lives campaign with the creation of the Surgical Safety Checklist (SSC).[8] The intent of the SSC is to reduce complication and mortality during surgery. With the benefits of checklists becoming more evident, the SSC is now utilized in many types of procedures worldwide. This 19-item checklist can be separated into three distinct phases: before induction of anesthesia, before skin incision, and before the patient leaves the operating room. While other checklists are being created and implemented, the SSC is now the standard for surgery in North America as well as Europe. In February 2010, Panesar et al. reported all hospitals across the United Kingdom have employed use of the SSC to assist in surgical care.[9] Fig. 1 contains the SSC as issued by the WHO.[10]

2. Improving patient outcomes via checklist

Panesar et al. advocated for the development of tools to assist in the prevention of patient safety incidents (PSI).[9] An observational study

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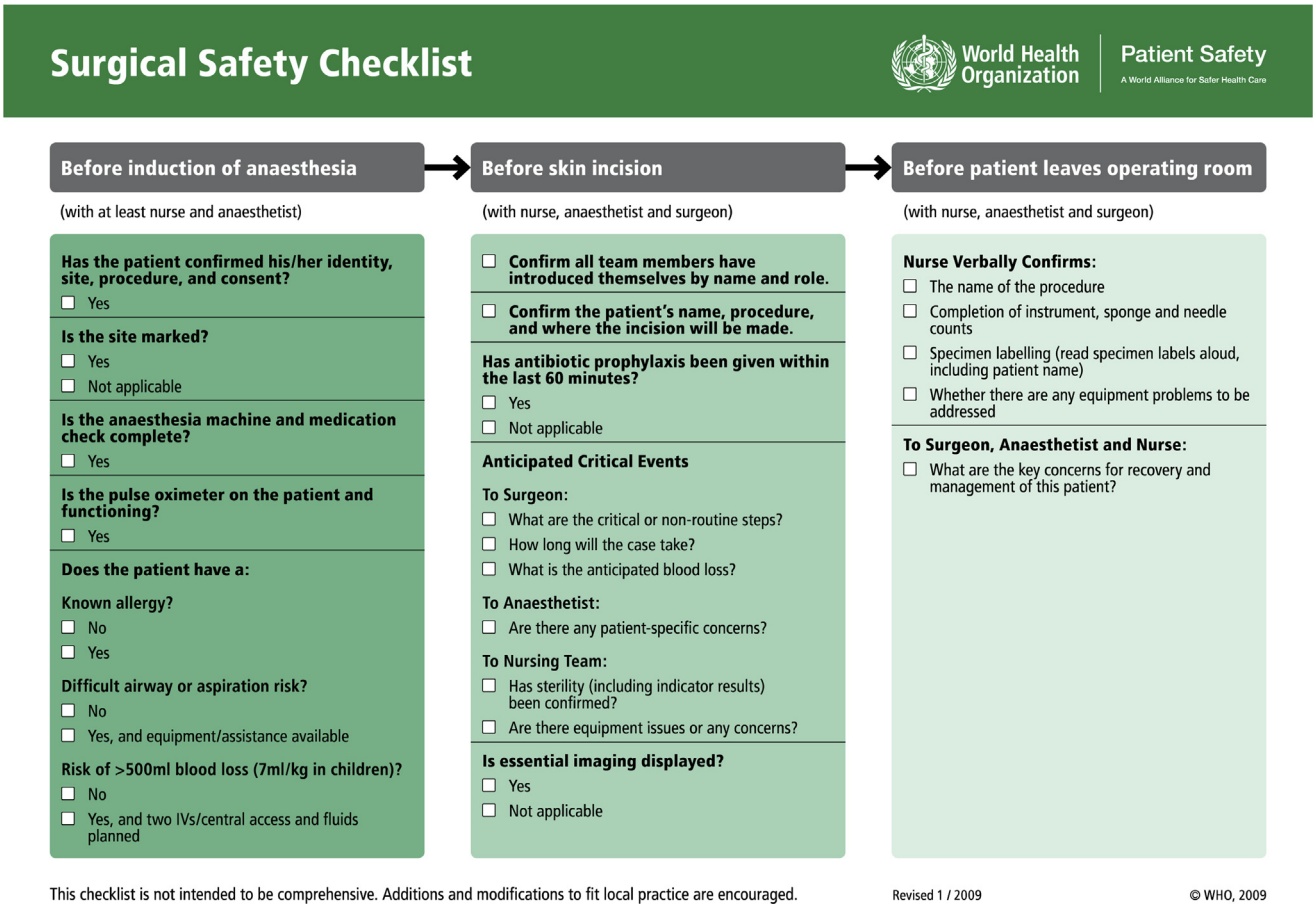

Fig. 1. Surgical Safety Checklist. This figure depicts a 19-item, 3-phase, checklist as depicted by the World Health Organization (WHO).

with use of the National Patient Safety Agency Database concluded that 21.1% of PSIs may have been prevented in cases supplemented by the SSC.[9] In a 2009 study carried out by Haynes et al., results provided evidence as to how use of the SSC decreased morbidity and mortality worldwide. Most hospitals used in the study indicated that the practice of oral confirmation and preoperative site marking was a new method utilized to confirm patient identity.[1] The prospective review was performed at hospitals in eight separate countries. Reports at all study sites indicated major decreases in postoperative complication rates with substantial decreases in both high-income and low-income sites. Reported results included that average complication rate decreased from 11% to 7%.[9] Additionally, a significant reduction in the mortality rate of all patients was observed (1.5%–0.8%).[9] Though an average reduction in complications of 36% was observed, in one hospital there was a substantial 80% decrease in mortality and complication.[9] The SSC is also correlated with an increase in compliance to proper antibiotic use. Significant decrease in surgical site infection rates were also apparent under application of the SSC (33%–88% decrease).[9] Similar results were reported by de Vries et al. in a different prospective study to examine the effects of SSC on patient outcomes. The observations took place across two academic centers and four teaching hospitals. Following checklist intervention, there was a general reduction in complication rate from 27.3 complications per 100 patients, to 16.7 complications per 100 patients.[4] The in-hospital mortality also dropped from 1.5 to 0.8%.[4] These complication rates remained constant during the 3-month post-implementation phase. Within the same post-implementation phase, control hospitals demonstrated no change in patient outcomes. The results indicate that there was an association with the reduction in complication rate following SSC implementation.[4] Additionally, reduced complication rates were reported in patients for whom 80% or more of the checklist items were completed.[4]

In a study conducted by Haugen et al., patient outcomes were assessed after application of the SSC. The study was conducted in two hospitals across five separate specialties. Care processes and patient outcomes were evaluated.[11] Respiratory complications, cardiac complications, surgical infections, wound rupture, and blood loss were significantly reduced during introduction of the intervention. Postoperative bleeding was decreased from 2.6 to 1.0%. Intraoperative blood loss decreased from 6 to 4.5% with a significant decrease in need for blood transfusion in procedures where SSC was used.[11] Haugen et al. endorsed usage of SSC to obtain improved patient outcomes.[11]

Boaz et al. conducted a study to assess the efficacy of SSC implementation in an orthopaedic department. One aspect of the study was to analyze the effects of implementing surgical safety strategies on postoperative fever.[3] Boaz et al. compared the frequency of complications between patients that received treatment accompanied by checklist against patients that did not.[3] A significant reduction in rates of postoperative fever (10.3%–5.3%) was correlated with patients who received treatment accompanied by the SSC.[3] Sewell et al. conducted a study assessing the effectiveness of the SSC. Objective observational variables included complication and mortality rate, whereas subjective outcomes were reported by survey analysis of staff perception.[12] Surgical staff were trained on how to implement the SSC. In the pre-training audit, 1.9% of the patients died compared to the post-training audit, where 1.6% of patients died. These results concluded that the use of the SSC was not associated with significant decreases in early complications and mortality of orthopaedic trauma patients.[12] Sewell and colleagues reported 55% of surgical staff was opposed to early implementation of checklist, believing it to be time consuming and unproductive. However, after educating staff on potential benefits of

checklist use, use of SSC practice increased from 7.9% to 96.9%.[12] Russ et al. performed a systematic review observing the effect of the SSC on the quality of teamwork and communication in the operating room.[13] After the screening process, 20 studies were used in the final review. The quality of teamwork and communication was measured through self-report questionnaires, observations, and 360-degree ratings. It was concluded that the application of the checklist improved communication between the operating room staff while also enhancing efficiency and teamwork.[13] Russ et al. further emphasized instances in which cultural or team barriers may potentially hinder the success of checklist implementation. Examples of such obstacles include reluctance of staff to change habitual work ethic and perceived threats to the practice of healthcare professionals.[13]

Ko et al. sought to determine whether the use of paper based safety checklists improved the safety of patients in an acute setting.[14] There were 9 studies evaluated across four clinical settings including the intensive care unit (ICU), emergency department (ED), surgical department, and multi-departmental acute care.[14] In the ICU reduction in length of stay (LOS) and improvements to compliance were observed, however results were not consistent across all studies.[14] In the ED there was a significant decrease in LOS.[14] In the analysis of surgical checklist usage, there was reduction in complication, surgical site infection, re-operations, and mortality.[14] With regards to the acute care setting, checklists were associated with improved antibiotic stewardship for patients with pneumonia.[14] Papaconstantinou et al. performed a study to observe the effects of SSC effectiveness at an institutional and surgical subspecialty level.[15] More specifically researchers sought to evaluate what impact the SSC had on time utilization. The time data analyzed was operating room time (patient in to patient out), operation time (incision to close), and patient preparation time (patient in to incision). There was no difference in the length of operating room time, or operation time when compared within their groups. However, upon analysis of operations specific to general surgery a significant reduction of 5 min in both operating room time and operative time was observed.[15] The study concludes that the implementation of the SSC does not significantly impact overall efficiency, however there was an overall decrease in cost per procedure.[15]

Bergs et al. performed a meta-analysis to assess the impact of the SSC on postoperative complications for orthopaedic surgeries. Five studies reported significant decreases in complication rates (11%–7.0%, 18.4%–11.7%, 22.9%–10%, 23.6%–8.0%, and 21.5%–8.8%).[2] Significant reduction in mortality rate was observed in two of the studies (1.5%–0.8%, and 3.7%–1.4%).[2] The report also established a reduction in surgical site infections in three of the studies (6.2%–3.4%, 11.2%–6.6% and 14.9%–4.7%).[2] Proportion of operation blood loss greater than 500 ml significantly declined from 20.3% to 13.3% in one of the studies.[2] In evaluating unexpected returns to the operating room, rates dropped significantly in two of the studies (2.4%–1.8% and 1.9%–1.5%).[2] Pneumonia rates were significant in one study as a recorded decrease from 4.7% to 2.6% was observed.[2] Moreover, Bergs and colleagues emphasized the importance of adequate adherence to the SSC. Compliance regarding checklists has also been examined in literature.

In 2011, Maziero et al. conducted a study to evaluate the adherence to the checklist usage on numerous hip and knee replacement surgeries.[16] The results indicated that even though the SSC was used in all surgeries, there was no significant adherence to the tool or verbal verification to the items on the checklist. Stricter adherence to checklists is necessary to improve the quality of surgical procedures while reducing the amount of complications that occur due to negligence.

While there exists a large amount of evidence that suggest checklists decrease complication, some studies report conflicting results. Reames et al. conducted a study observing surgical outcomes and healthcare costs of Medicare patients following implementation of a checklist-based intervention.[17] The “Keystone Surgery” program was evaluated by gathering data from the Center for Medicare and Medicaid Services. The analysis of this checklist was based upon six clinical outcomes; mortality, any complication, serious complication, reoperation, readmission, and LOS.[17] When comparing hospitals participating in the keystone surgery program to control hospitals, any complication rate (18.4% vs 20.3%), serious complication rate (8.8% vs 9.1%), reoperation rate (0.6% vs 0.5%), and readmission rate (13.1% vs 13.3%) revealed no significant decrease following implementation.[17] There was a slight increase in risk of serious complications. However, there was a slight associated decrease in LOS (7.2 vs 6.6 days) following Keystone Surgery application.[17]

3. Cost-effectiveness of safety checklists

As checklist utilization has been associated with decreased complication rates, acceptance for further implementation of such protocols is growing. However, a common criticism of checklists is that they may not be cost effective due to time required for administration. Semel et al. performed a decision analysis to determine if implementation of the SSC in the United States reduces costs within the hospital level.[18] Usage of the checklist was expected to cost the hospital roughly $40,859 USD. However, the net savings of the SSC was substantial. The costs associated with the checklist were separated into one-time usage costs and recurrent usage costs. In the base-case analysis, the implementation of the checklist was projected to save $103,829 USD in a hospital that performed 4000 non-cardiac surgeries annually (~$25.96 USD per operation performed).[18] For every complication prevented, there was a recorded net saving of $8652 USD. As implementation costs for SSC comprise the majority of the expenses, savings could potentially be greater if analyzed for a prolonged study interval.[18]

In a prospective study conducted by Haugen et al., a 40% cost reduction in blood transfusions was demonstrated following SSC implementation.[11] In a study conducted by Tarrago et al., they assessed the use of their pediatric intensive care unit (PICU) checklist and the effect on patient safety and cost.[19] Initially the checklist used in the study was paper-based with subsequent versions integrated within their electronic medical records (EMR). As daily compliance with checklist rose, a reduction in percent IV dose (77%–46%) was noted.[19] The number of laboratory studies drawn decreased by six per patient per day which equated to $595 USD of daily savings to the patient. With regards to Medicare cost charge ratios, daily cost reductions averaged $173 USD.[19] Tarrago et al. concluded that by using the PICU checklist, safety and quality were improved, accompanied by an associated cost reduction to patients and the hospital.

Papaconstantinou et al. demonstrated that urology and orthopaedic departments utilizing SSCs had significant reduction in operative costs per procedure ($39 USD and $46 USD less, respectively).[15] However, there was a major increase to cost per procedure in pediatric, gynecologic, and plastic surgeries ($69 USD, $140 USD, and $315 USD increase, respectively).[15] In the study conducted by Reames et al. in which the surgical outcomes and healthcare costs of Medicare patients were measured, researchers reported lack of association between checklist-intervention and readmission rates. Researchers also conveyed lack of correlation between checklist use and decrease in Medicare payments.[17] Contrarily, in control hospitals there was a $516 USD average increase in Medicare payments, $439 USD increase in index admission payments, and $564 USD increase in readmission payments 17.

4. Variation and adaptations

An extensive variety of innovative and specific checklists are being developed with the intention of furthering patient safety. The adaptation of checklists is accompanied by the idea that further specialization is a necessity to decrease mortality and complication. Specialized checklists are being created not only in the operative setting, but also as concepts for patient handoffs as well as other procedures. Leblanc et al.

Table 1
Types of orthopaedic equipment failure.

(1) surgery delayed due to missing equipment
(2) lack of sterility of equipment
(3) equipment not available
(4) equipment malfunction
(5) equipment sets incomplete
(6) additional equipment brought into the room necessary for completion of case

developed one of the foremost checklists concerning handover of orthopaedic trauma patients.[20] Gagnier et al. studied one such handoff tool for orthopaedic trauma residents.[21] The observations that were reported assessed how the tool affected complication rates and the LOS in the hospital. The group of patients that was supplemented by the handoff tool reported a decreased risk of adverse events (51.7% of patients versus 59.7% of patients in the control group), as well as a significant reduction in LOS for the duration of the test period (2.85 versus 3.33 days).[21] Hill et al. improved the current SSC by merging it with the pre- and postoperative debriefings used to establish the 5 Steps for Safer Surgery (5SSS).[21] Researchers reported the change in safety culture correlated with the implementation of the 5SSS.[22] Evidence supports that working to improve safety culture by modifying surgical checklists may be beneficial.[21] Due to the increasing number of intricate medical procedures outside of the operating theatre, it is essential to develop checklists for these areas as well. The British Society of Echocardiography and Association of Cardiothoracic Anesthetists postulate that transesophageal echocardiogram (TOE) is one such operation that can gain benefit through the creation of a specialized checklist.[23] The specialized TOE checklist is held within comparable structure to the WHO SSC, being devised into three stages: patient checks, pre-procedure, and post-procedure.[24] It is believed that adoption of this intervention will assist in maintaining a reliable process when performing TOE to diminish risk of avoidable complication. Procedure specialized checklists have also been developed for operations such as endoscopies. Matharoo et al. describes how it is necessary for a checklist to be succinct and easy to use in order to better prevent complication and mistakes during operations.[25] Matharoo et al. applies this notion in the development of an endoscopic safety checklist. The endoscopic checklist is a two-phase checklist with stages such as: timeout prior to scope insertion, and the sign out at the end of the procedure.[25] While researchers believe there is no guidance on how to best implement safety checklists for endoscopy, it can be argued that innovation of such tools is an important step in furthering the safety of patients.

5. Conclusion

Orthopaedic surgery is a specialty in which specific checklists are needed for various procedures. Although the specialty has benefitted by use of the SSC in reducing complications and mortality, elective operations including TJA do not have specified communication tools. In a study conducted by Thomasson et al., the SSC was evaluated in its ability to prevent orthopaedic error.[26] The results indicated that the institution's SSC had failed in preventing orthopaedic equipment failures (Table 1). Researchers concluded that even though the SSC is a useful safety tool, it cannot be the only tool used in preparation for an orthopaedic case.[26] Errors in orthopaedic surgeries have potential for some of the highest complication costs. In developing a specific checklist, the economic benefits to both patient and healthcare system by decreasing complication cannot be overlooked. Now is the time to critically assess safety precautions in the orthopaedic care continuum. The errors in pre-, intra-, and post-operative settings may be reduced with implementation of safety tools tailored for orthopaedic specific procedures. Opportunities for hip and knee replacement protocols are especially needed as the volume of such procedures continues to be challenged by growing pressures of a value-based healthcare environment. More evidence on quality-based interventions are needed to provide examples to our community on how to enhance the safety of our patients.

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Appendix A. Supplementary data

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