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CHECKLISTS IN NEUROSURGERY – AN UPDATED REVIEW

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Abstract: *Introduction.* Checklists represent questionnaires aimed to reduce and prevent medical errors, a reliable and cost-efficient way to increase patients' safety and quality of healthcare services. They were first implemented in Intensive Care Units (ICU) and later adopted by several surgical specialties. Neurosurgery, not being immune to medical errors because of the complex procedures and large interdisciplinary teams, is a specialty which may highly benefit from adoption of safety checklists.

Materials and Methods. Data from the international literature has been gathered through online libraries - PubMed and Google Scholar. We focused on the most relevant and up to date studies, reviews and meta-analysis which point to a direct connection between the implementation of checklists and reduction of error, complication and mortality rates.

Discussion. Checklists are widely adopted in the ICU department as well as other medical specialties. Surgical specialties lay behind the latter, neurosurgery being in its early days of checklist implementation. Until now, the available data shows promising results on reducing complications and mortality.

Conclusion. These results should be tested in larger studies, on multiple centers, all over the world. Starting from the ones already using these procedures it can lead to a global shift in both perception and health care procedures.

Key words: checklist, neurosurgery, complication, error, mortality.

INTRODUCTION

There are approximately 310 million surgical procedures carried out every year [1], having different mortality and morbidity rates reported, ranging from 0.5% up to 4%[2, 3]. A recent study conducted in 2016 established that out of the total number of procedures, 75 million patients (approximately one in three patients) will experience a postoperative complication which eventually leads to 2 million deaths/year [4].

Surgical specialties, neurosurgery in particular, has developed exponentially in the last decades, mainly because the use of special devices and techniques, among them stereotactic surgery and neuronavigation playing a crucial role. Neurosurgery is not at all immune to medical errors. Neurosurgical patients' complexity as well as the interdisciplinary teams required to manage their conditions expose these patients to the both common errors shared among other surgical specialties as well as unique faults. Thus, new algorithms that ensure smooth procedures and a positive outcome needed to be implemented; surgical safety checklist are one of them.

Medical errors have been defined in various ways, but their essence is represented by acts of omission or commission that cause harm or have the potential to cause harm to patients. This definition was elaborated in the neurosurgical literature by Stone and Bernstein as any act of omission or commission resulting in deviation from a perfect course for the patient. A perfect course was defined as one in which nothing went wrong, from the smallest detail (such as dropping a sponge) to the most obvious example – wrong side neurosurgery [5, 6].

The report conducted by The Institute of Medicine - "To Err is Human: Building a Safer Health

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System", may be categorised as a milestone in the development of surgical checklist as it argued the safety in the American Healthcare industry - it revealed between 44,000 and 98,000 patients who died each year in the United States because of preventable medical errors, with an estimated cost between $17 billion and $29 billion each year. Although the study showed that prospects were not good, a positive outcome emerged - medical errors were most often the manifestation of universal human fallibility and not unique to the world of healthcare. The report cited ICUs (Intensive Care Unit), EDs (Emergency Department) and surgical operating rooms (OR) as having the highest error rates [7, 8].

Checklists in neurosurgery – actual data

Checklists represent a simple and standardized option meant to increase the healthcare quality, acting as a cognitive aid for standard protocols and mental reminders as well – they are questionnaires divided into subsections, each section being addressed to a health care provider, from the ward nurse and the attending doctor to the OR nurse, surgical and anaesthesia teams. They enhance the already existing knowledge of the physician which may display fatigue, burden or simply being overwhelmed by the number of required actions [9, 10]. Checklist originate from the ICU department where they were first implemented [7]. However, the burden and stress generated by surgical specialties required the adoption of safety surgical checklist.

The WHO (World Health Organisation) developed a 19 items checklist (Fig. 1) as part of the "Safe Surgery Saves Lives" Project [11] designed to reduce complications during surgery. The trial of the WHO Safety Checklist represents one of the most comprehensive trials conducted on this matter [12]. The WHO Checklist requires 19 items to be filled in, grouped in 3 categories according to three time points:

- "sign - in" - before anaesthesia = patient's identity altogether with surgical site and procedure of choice are verified. Airway patency, allergies, pulse oximetry as well as the probability of needing blood and fluids are also taken into account.

- "time-out" - prior to skin incision = every professional is being introduced, procedure and complications are reviewed while preoperative imaging

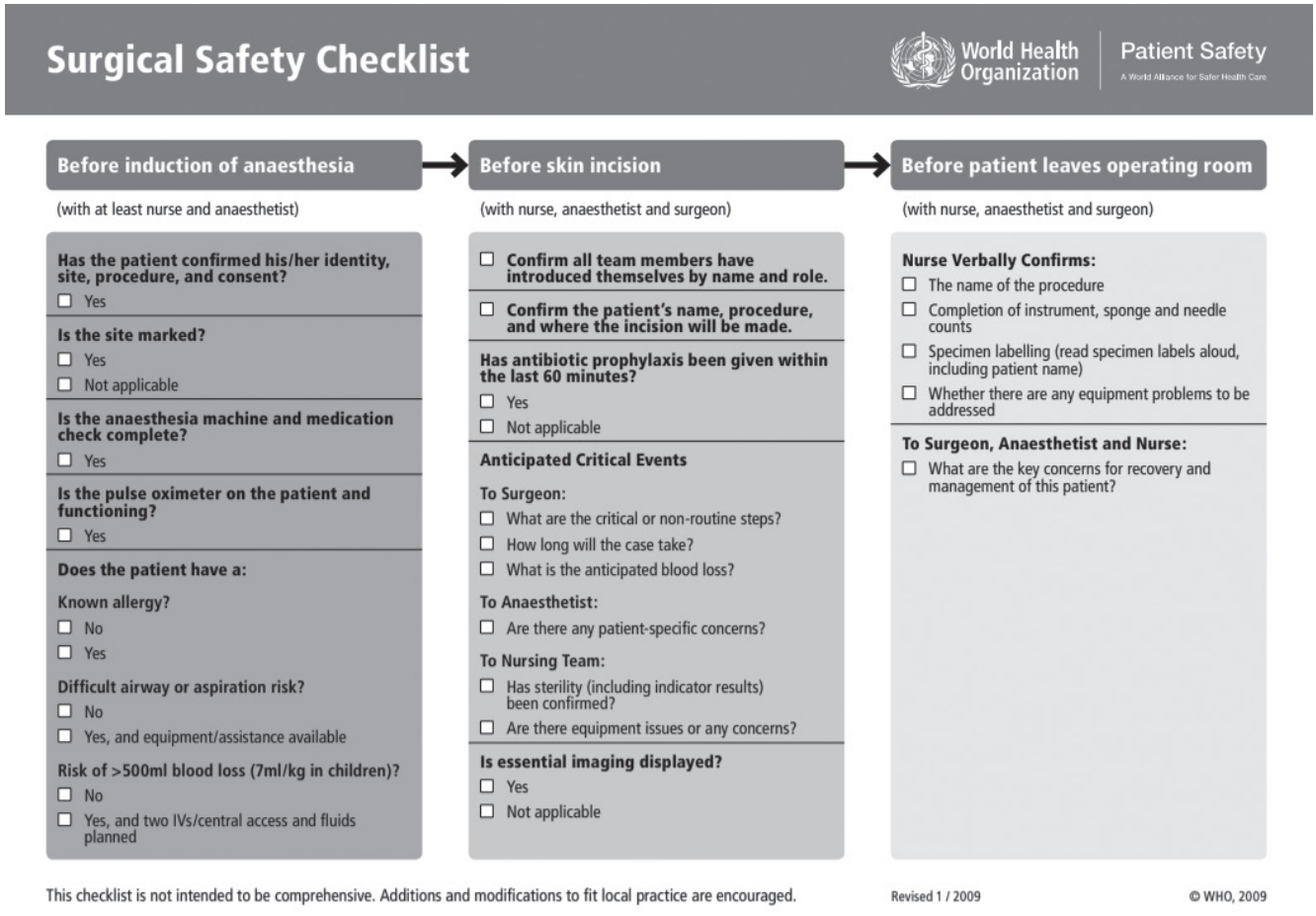


Figure 1. WHO Safety Checklist https://www.who.int/patientsafety/safesurgery/checklist/en/

and antibiotic prophylaxis are also checked. The operation is carried out by surgical and anaesthesia team as well as the nursing staff.

- "sign-out" = surgical materials are rechecked after the procedure ended. A full staff review is also performed.

This checklist was firstly applied in 8 centres across the world in order to test its efficacy. A number of 3995 cases have been documented, the results showing an overall decrease of 4% in surgery related complications as well as a 0.7% drop in total-hospital deaths. Complication rates in high-income sites dropped from 10.3% - before introduction of the checklist to 7.1% after its implementation, while in low-income sites the rated fell from 11.7% to 6.8% after checklist adoption. Death rates dropped as well, from 0.9% to 0.6% in high-income sites and in low-income sites from 2.1% to 1%. Another publication [13] evaluated the outcome of performing the WHO Checklist in other 3 centres, this time focusing on emergency surgeries. From a total of 1750 consecutive emergency surgeries, in 908 (51.88%) the checklist was performed, while in the remaining 842 (48.12%) it was not. The results showed a 6.7% decrease in major complication and a 2.3% decrease in overall mortality.

A prospective observational study analysis[14] based on the International Surgical Outcomes Study (ISOS) focused on two main outcomes in relation with performing a surgical checklist: in hospital mortality and postoperative in hospital complication, assessed according to a pre-defined criteria. The inclusion criteria consisted of patients aged more than 18 undergoing elective surgery and with only one planned overnight stay in hospital. Overall, 40 245 (89.8%) patients were exposed to the surgical safety checklist, 7508 (16.8%) presented at least one postoperative complication and 207 (0.5%) died before hospital discharge. Checklist exposure have been associated with a drop in mortality rate – from 1% to 0.4%. However, a decrease in the postoperative complication incidence has not been reported at all [14].

A systematic review and meta-analysis screened 3554 abstracts, 41 full-texts and 11 studies (including the aforementioned ISOS) gathering a total of 419 799 patients. From the whole number of patients, 230 929 (55%) were exposed to the checklists while 188 870 (45%) were not. The results of meta-analysis showed that checklist exposure was associated with reduced mortality. Patients exposed to the checklist had a 1.1% mortality rate (2624/230 929) compared to a mortality rate of 1.3% reported by patients on which the checklist was not performed (2466/188 870)[14].

In a 2015 extensive review [15], 15 checklists were analysed through various criteria. The first checklist was published in 2001. It was elaborated by the North American Spine Society and aimed to prevent wrong site neurosurgery (wrong site, wrong level and wrong patient surgery). Overall, checklists specifically compiled for general neurosurgery were 7 out of 15 [16-22], while 3 were aimed for vascular neurosurgery [23-25], 2 for stereotactic and functional neurosurgery [26, 27] and another 2 for spinal neurosurgery [28, 29] as well as 1 elaborated for external ventricular drainage[30].

More than half of the studies include checklists for both elective and emergency procedures (8/15)[16, 17, 19-21, 25, 28, 29]. Moreover, three studies included exclusively checklists for elective procedures [11, 26, 27] while other three were designed just for emergency procedures [23, 24, 30]. In terms of preventing incorrect site surgery, almost all the checklist studied aimed to prevent it (11/15)[16-22, 25-28] while three out of fifteen checklists [23, 24, 29] did not include this aspect and one did not make this item clear[30]. In contrast with prevention of the wrong site surgery, incorrect positioning complications were included only in two out of fifteen analysed checklists. [17,21] - they were designed mostly for intraoperative MRI (Magnetic Resonance Imaging) potential complications. In terms of device operation and performance complications, one third of all checklists analysed contained items targeting this issue [17, 20, 21, 26, 27].

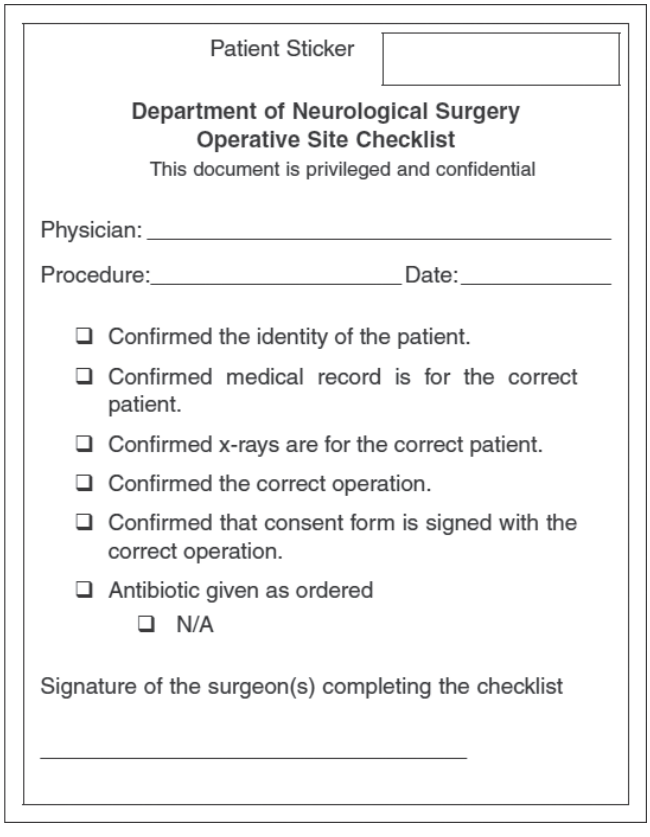
Another aspect worth mentioning is time needed for checklist completion, which in fact, is one of the most important successful predictors of implementation. In 3 of the studies [17, 19, 26], the time ranged between 1 to 8 minutes, with no average time of completion being specified in neither of them. Educational preparation and training plays also an important role in checklist adoption, as several studies states [17, 19, 21, 22, 28]. The measures taken in this regard included displaying the checklist in the OR in the most visible area, educational training consisting of videos, lectures and mock emergency procedures and lastly reading the checklist as well as safety instructions prior to the operative MRI.. However, there is insufficient data regarding barriers and efforts to checklist implementation. Part of the barriers such as not having a unanimous participation, lack of attention given to some items, skipping items or not completing the checklist at all were reported by a singular study [19].

Safety and quality being two of the most important criteria that any checklist should met, the results on each neurosurgical area showed various outcomes. Da Silva-Freitas *et al.* [18] reported 51 events in 44 performed surgeries (general neurosurgery) and managed to obtain prevention of approximately 88% of the errors before the procedures began. Lepanluoma *et al.* [22] reported a drop in wound complications as well as unplanned readmissions, while studies of Matsumae *et al.* [17] and Rahmathulla *et al.* [21] reported no safety incidents or accidents in their analysis on the checklists designed for intraoperative MRI procedures.

Stereotactic and functional neurosurgery – the two studies in the review showed different results, Connolly *et al.* [26] reporting no significant change in terms of the number of errors per case after the checklist administration while Kramer *et al.* [27] reported a decrease from 3.2 to 0.8 total errors per case.

Fargen *et al.* [25] reported a significant drop of complications, by 35% after the introduction of their checklist in the field of vascular neurosurgery while 95% of staff expressed their willingness to apply the checklist for future interventions. Ziewacz *et al.* [29] showed the effectiveness of checklist regarding intraoperative neuromonitoring alerts in spinal neurosurgery and McConnell *et al.* [30] showed a substantial reduction in ventriculostomy infection rate – from 9.2% to 2.7% in only two months after checklist implementation. Based on the number of cases the checklist has been applied on, two distinct studies show significant results. In order to gather data to improve patient safety and quality in the OR as well as reduce any potential errors in care.

Lyons *et al.* [16] have conducted an 8-year study comprising a total of 6313 operative checklists for 6345 patients. Its uniqueness stands in the fact that it was conducted in a single institution and department over a frame of several years. The study focussed on general neurosurgery – both elective and emergency procedures with the specific aim of guaranteeing accurate image studies and antibiotic administration. The key elements of the checklist were: patient's identity, correct medical record, correct imaging studies, correct operation planned, correct and signed informed consent and correct antibiotic as well as timing of infusion (if applicable) - (Fig. 2). The surgical checklist is performed in the operating room by the attending neurosurgeon which also ensures that the patient is



Patient Sticker

Department of Neurological Surgery
Operative Site Checklist
This document is privileged and confidential

Physician: _____

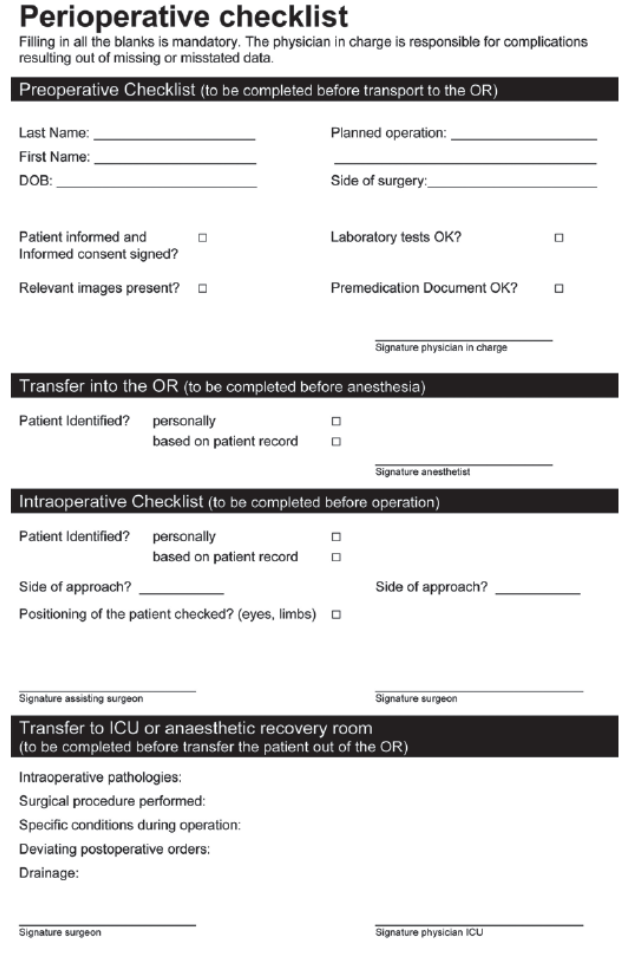
Procedure: _____ Date: _____

- ❑ Confirmed the identity of the patient.
- ❑ Confirmed medical record is for the correct patient.
- ❑ Confirmed x-rays are for the correct patient.
- ❑ Confirmed the correct operation.
- ❑ Confirmed that consent form is signed with the correct operation.
- ❑ Antibiotic given as ordered
  - ❑ N/A

Signature of the surgeon(s) completing the checklist

_____

Figure 2. Neurosurgical Checklist [16].



Perioperative checklist

Filling in all the blanks is mandatory. The physician in charge is responsible for complications resulting out of missing or misstated data.

Preoperative Checklist (to be completed before transport to the OR)

Last Name: _____ Planned operation: _____
First Name: _____ _____
DOB: _____ Side of surgery: _____

Patient informed and Informed consent signed? ☐ Laboratory tests OK? ☐
Relevant images present? ☐ Premedication Document OK? ☐

_____
Signature physician in charge

Transfer into the OR (to be completed before anesthesia)

Patient Identified? personally ☐
based on patient record ☐

_____
Signature anesthetist

Intraoperative Checklist (to be completed before operation)

Patient Identified? personally ☐
based on patient record ☐

Side of approach? _____ Side of approach? _____
Positioning of the patient checked? (eyes, limbs) ☐

_____ _____
Signature assisting surgeon Signature surgeon

Transfer to ICU or anaesthetic recovery room
(to be completed before transfer the patient out of the OR)

Intraoperative pathologies:
Surgical procedure performed:
Specific conditions during operation:
Deviating postoperative orders:
Drainage:

_____ _____
Signature surgeon Signature physician ICU

Figure 3. Perioperative Neurosurgical Checklist [20].

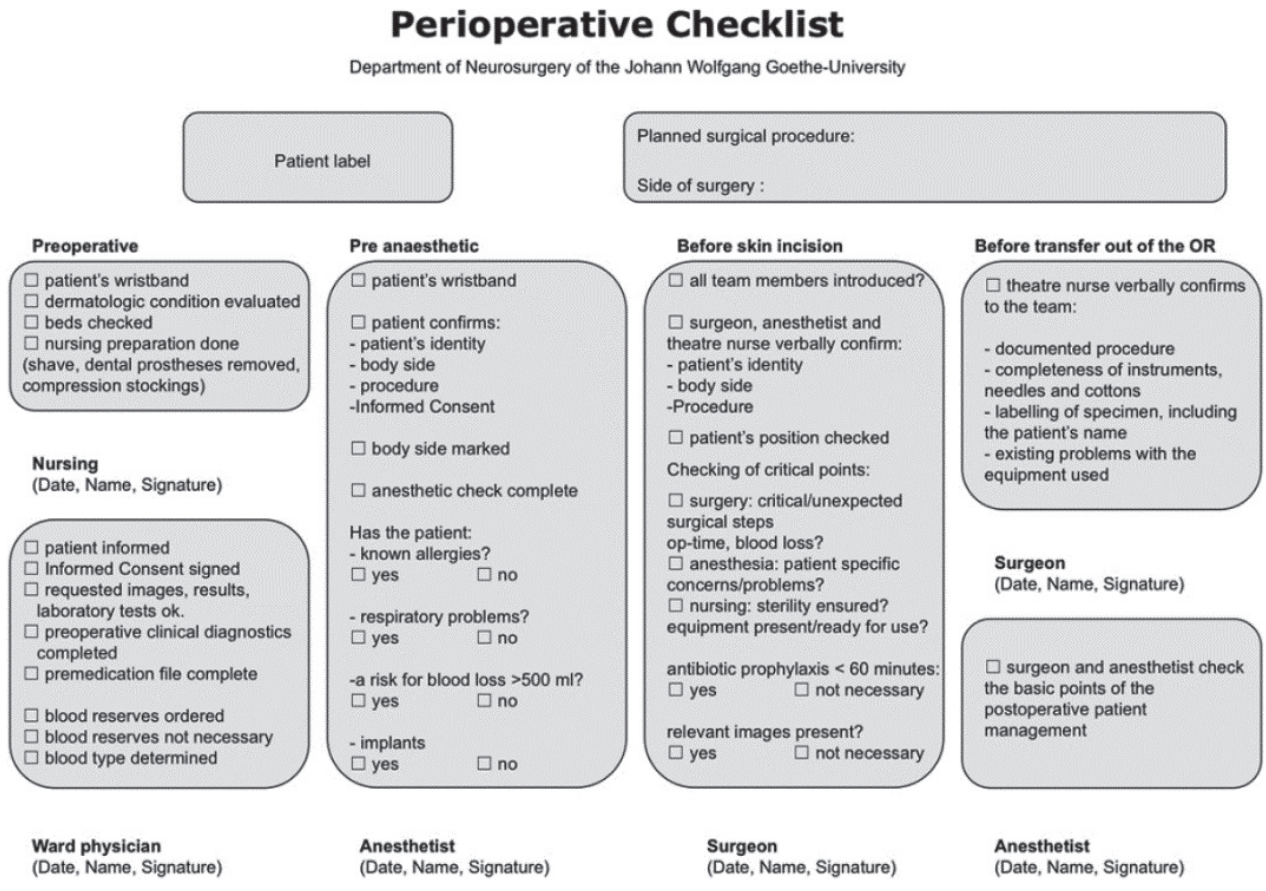


Figure 4. Advanced Perioperative Neurosurgical Checklist [20].

in the correct OR. Results are promising, showing no complications due to wrong side neurosurgery and a 99.5% compliance with checklist implementation.

Oszvald *et al.* [20] conducted in Germany a 5-year study on general neurosurgery between 2007 and 2012, split in two phases: phase 1 =2007–2010 and phase 2 = 2011–2012. Phase 1 addressed only to elective procedures – 6332 out of 8795 while the 2nd phase comprised both elective and emergency procedures – 3595 in total.

During the first 4 years of the study (phase 1) the perioperative checklist was performed in 6322 elective surgical procedures (out of 8795 surgeries performed in total). The checklist included the perioperative work-up (checked and signed by the physician in charge), the planned procedure, surgical side, informed consent, absence of major pathological findings in the blood test and anaesthesiologist's approval. Before anaesthesia and skin incision patient's identification details were verified again. In the first phase there were only 2 complications reported (0.03%) – one wrong side burr hole and one wrong side lumbar approach.

In the 2nd phase the checklist has been refined according to the WHO Checklist [11] and "time-out" point was included. This meant that the main focus was shifted prior to the skin incision, the surgeon having to introduce all the team members and review the procedure and detail foreseen complications, confirming both the availability of required imaging and that prophylactic antibiotics had been given less than 60 minutes before incision. During this phase the checklist was applied to a total of 3595 procedures – 2746 elective and 849 emergency, reporting no error whatsoever. In both time periods the checklist has been applied to 9917 procedures. Overall, an incomplete checklist was found in 290 patients (3%), 215 found in the first time period and 75 in the second one. Out of the total number, 238 (2%) were found before the patients was transferred to the OR – preventing a useless transport, while 52 reached the OR. 10 out of the 52 had to be transferred back to the ward because of incomplete data.

DISCUSSION

Safety Neurosurgical Checklists represents a newly aimed tool acting both as memory aid as well as reminder for physicians and nurses, with the sole

purpose of ensuring the implementation of critical steps in surgical procedures. Furthermore, the studies published so far observed an enhanced team work and communication, all leading to a higher healthcare quality, patient satisfaction and improved OR efficiency. However, there are several drawback and limitations checklists currently face, among them the insufficient data on which the results are based on. Although a decrease in error rate and mortality was indeed reported by several authors, there are others arguing that no improvement has been observed whatsoever.

A key role in safety surgical checklists adoption is played by the inability to have a consensus regarding the items to be included, the proper duration of completion or whether it should be presented on paper rather than electronic. In order to address these issues, we can propose 2 ways for further work:

- A universal surgical safety checklist dedicated to neurosurgery should be compiled in order to target the most frequent surgical errors and then adopted and tested by as many centres/departments as possible;

- Guidelines for successfully compiling such checklist should be elaborated in order to ensure common errors coverage, allowing in the same time any surgical department/centre to personalize it by adding items which address specific matters.

In conclusion, in order to ensure a checklist implementation an active engagement from both physicians and administrative personnel is mandatory, dedicating time to training, simulations and other required practices. Early adopters may represent a good starting point, exerting the ability to demonstrate the advantages of checklist integration and lead by example[29].

Conflict of interest

The authors declare that they have no conflict of interest.

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