



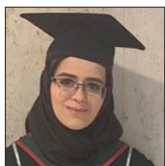
Editorial

# A customized checklist for microsurgical clipping of intracranial aneurysms

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“To Err is Human” is the core principle behind the introduction of checklists in critical procedures.<sup>[10]</sup> Checklists are designed to break down complex tasks into a number of essential steps to surpass the need for human memory. The use of checklists in orchestrating procedural steps is well established in several high-risk industries, including aviation, manufacturing, military operations, and nuclear power production.<sup>[4,13]</sup> Behind the obvious benefits derived from instituting their individual items, checklists have been praised for promoting a safety culture and enhancing team communication.<sup>[5,11,12,14]</sup> The checklist is, however, a double-edged sword; while a well-designed and concise checklist has a promising potential to ensure an error-free procedure, an overly expansive one can result in the opposite, partially, by posing a significant burden to the users. Nevertheless, the optimal checklist length remains unclear. Importantly, a checklist is not intended as a panacea for all errors, rather, it is aimed at mitigating the effects of the inherent human fallibility on task completion.

The release of the report, “To Err Is Human: Building A Safer Health System” by the institute of health in the fall of 1999, has established the cornerstone for the incorporation of checklists in the medical field.<sup>[10]</sup> In that same year, an editorial series titled that “The Business of Surgery” was published by the editor of surgical neurology, by Prof. James Ausman who argued for the incorporation of business principles in neurosurgery to improve patient outcomes. Specifically, Prof. Ausman highlighted the importance of meticulous planning during even the most routine tasks in neurosurgery. He referred to operations analysis used in business settings to analyze in detail the processes of manufacturing to eliminate errors. Even though no checklist was proposed by Prof. Ausman, his series has laid the foundation steps for modern surgical checklists.<sup>[1-3]</sup>

Surgical adverse events constitute 50–67% of all medical errors and it is estimated that 50% of these events are preventable.<sup>[5]</sup> In an attempt to remediate medical errors, the World Health Organization (WHO) has compiled a 19-item checklist as part of its “Safe Surgery Saves Lives” project. The checklist was designed for noncardiac surgery and included three specific pause points; the “sign-in,” before anesthetic induction, the “time-out,” before skin incision, and the “sign-out” before patient transfer outside the operating room. The authors of

the checklist consulted lessons from the aviation industry where an experience of 70 years has been gained in the design and application of checklists.<sup>[6,17]</sup> A pilot study was carried out to test the efficacy of this checklist at eight hospitals in different parts of the world and the checklist was, consequently, implemented in 3955 consecutive surgical cases resulting in a total of 4% reduction in the perioperative morbidity rates (11.0–7.0%;  $P < 0.001$ ) and 0.7% reduction in the in-hospital mortality within 30 days of the surgery (1.5–0.8%;  $P = 0.003$ ).<sup>[9]</sup> The implementation of the WHO checklist has also proven effective in reducing surgical mortality and morbidity in a wide variety of surgical subspecialties;<sup>[8]</sup> however, their use in neurosurgery is less well documented.<sup>[9,11,15,16]</sup> However, the problems with the present checklists are that they are used to guarantee the hospitals side of patient surgery and its liability. No such checklists have been utilized by surgeons to guide their conduct of a surgical procedure.

Vascular neurosurgery has unique demands given its unforgiving nature, the complexity of the procedural tasks, the numerous instrumental sets required, the diversity of the personnel involved in a single surgery, the inherent vulnerability of its patients, and the dire nature of its potential complications. Furthermore, it involves many additional key steps that are not routinely required in other surgeries calling for special focus [Figure 1]. Therefore, a custom-made surgical checklist that addresses the uniqueness of vascular neurosurgical procedures may offer a significant benefit to neurovascular surgeons. In Iraq, the fact that vascular neurosurgery is still a relatively young specialty and is practiced under sub-optimal conditions, beyond international standards, further necessitates the use of such checklists.

In this paper, we present a role-based checklist tailored specifically for the unique demands of cerebral aneurysm surgery [Figure 1]. This checklist was derived from the personal experience of our local surgeons and guided by the WHO checklist principles. As communication has been identified as a key factor in adverse and near-miss events in health-care settings,<sup>[7]</sup> this checklist was designed with the main purpose of buttressing interprofessional communication and promoting a safety culture within the operating room.

The success of a surgical procedure is related to the performance of all personnel who participate in this patient procedure that includes those preparing the instruments for surgery, preparing the operating room for a procedure, nursing, scrub nurses, anesthesiologists, residents, and the surgeon his/herself. To make a procedure, a success requires that all understand the goals of the surgery and the steps during that procedure. This success requires constant communication among all of the staffs involved in this

operation. It requires an understanding of the personalities involve with each staff member to achieve that success. Most often these principles are ignored by the attending surgeon as if they are not part of the operation.

The checklist consists of three parts and an additional [X] section addressing the steps to be followed during temporary clipping, should the surgeon opt for it, and intraoperative aneurysm rupture, should this complication occur.

## STUDY DESIGN

The checklist was applied for 14 months with a compliance rate of 97% for a total of 60 cases involving three neurosurgeons. The 3% noncompliance rate was attributed to the initial hesitancy with the acceptance of the checklist by the various team members and the time of significant staff shifts. At the conclusion of the study period, the postimplementation adverse incident rates were contrasted with those of another 46 patients who had been operated on before the implementation of the checklist. Overall, 106 aneurysms were included in the study, of which 92.6% were ruptured. Besides, the effect of the checklist on team communication was assessed by double-blinded staff surveys.

## CHECKLIST IMPLEMENTATION

The introduction of the checklist into neurosurgical practice was facilitated by a series of institutional amendments mandating the use of the checklist in all upcoming aneurysm clipping surgeries to test its practical validity. Furthermore, all prospective users were trained to use the checklist 1 month in advance through the Hospital's Continuous Medical Education program.

## SAFETY OUTCOMES

Overall mortality and morbidity rates have decreased by 2.2% and 6.8%, respectively ( $P < 0.00001$  for both).

### Surgery-related complications

Given the multifactorial nature of intraoperative rupture (IOR) and its related complications, estimation of the precise impact of the checklist in such cases was challenged by a set of confounding variables. However, the average time from onset to control of the IOR was significantly reduced following the introduction of the checklist; with ranges of 13 and 7 min, for pre- and postimplementation cases, respectively.

The impact of the checklist was noted during the following surgical steps: intraoperative administration and correct dosing of papaverine, hematoma evacuation, intended lamina

	<b>SURGEON</b>	<b>NURSE</b>	<b>ANESTHESIA</b>	
<b>STAGE ONE</b>	<ul style="list-style-type: none"> <li>• Confirm:                             <ul style="list-style-type: none"> <li>o Patient ID</li> <li>o Team members ID &amp; roles*</li> <li>o Site</li> <li>o Procedure</li> <li>o consent</li> </ul> </li> <li>• Positioning (+ head-holder devices)</li> <li>• Hair removal</li> <li>• Marker</li> <li>• Radiology films displayed</li> <li>• Document pre-operative. neurological status</li> <li>• Document urgency of the surgery</li> <li>• Anticipated surgery time</li> <li>• Declare non-routine steps</li> </ul>	<ul style="list-style-type: none"> <li>• Equipment check:                             <ul style="list-style-type: none"> <li>o Craniotomy set</li> <li>o Drills</li> <li>o Microsurgery set</li> <li>o Microscope draping</li> <li>o Aneurysm clipping set</li> <li>o Suction device</li> <li>o Suction control device</li> <li>o Second suction device</li> <li>o Layla retractor set</li> <li>o VTE prophylaxis</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• ASA status</li> <li>• Difficult airway/ risk of aspiration</li> <li>• Machine &amp; medications</li> <li>• Known allergy</li> <li>• Anticipated blood loss</li> <li>• BP target</li> <li>• ICP control &amp; brain relaxation measures:                             <ul style="list-style-type: none"> <li>o LP drain</li> <li>o Steroids</li> <li>o Hyperosmolar agents</li> </ul> </li> <li>• IV access (Arterial line, CV line)</li> <li>• Antibiotic prophylaxis</li> <li>• AEDs prophylaxis</li> <li>• Pain killers</li> <li>• Any specific concerns</li> </ul>	
<b>READY TO LAUNCH THE SCALPEL</b>				
<b>STAGE TWO</b>	<ul style="list-style-type: none"> <li>• Address the aneurysm</li> <li>• Apply the clip(s)</li> <li>• Confirm sufficient clipping:                             <ul style="list-style-type: none"> <li>• Direct visual assessment</li> <li>• Doppler u/s</li> <li>• +/- DSA**</li> </ul> </li> <li>• +/- Aneurysmorrhaphy</li> <li>• +/- muscle wrapping</li> <li>• EVD</li> <li>• Hematoma evacuation</li> </ul>	<ul style="list-style-type: none"> <li>• IOM***</li> </ul>	<ul style="list-style-type: none"> <li>• Consider refraining muscle relaxants</li> <li>• Vitals &amp; UOP</li> <li>• BP changes</li> </ul>	
<b>HOPEFULLY, YOU'RE READY TO GO INTO STEP THREE, UNLESS SOMETHING WRONG HAS JUST HAPPENED THEN GO TO STAGE X</b>				
<b>IS HERE FOR YOU:</b>				
<b>STAGE X</b>	<b>TEMPORARY CLIP</b>	<ul style="list-style-type: none"> <li>• Alert for temporary clipping</li> </ul>	<ul style="list-style-type: none"> <li>• Timing</li> </ul>	<ul style="list-style-type: none"> <li>• Burst suppression</li> </ul>
	<b>• IOR</b>	<ul style="list-style-type: none"> <li>• Alert for the intraoperative rupture</li> <li>• Two suction catheters in the field</li> <li>• Apply temporary clip</li> <li>• +/- Repair (neck tear/parent vessel injury)</li> <li>• Huntarian ligation</li> </ul>	<ul style="list-style-type: none"> <li>• Facilitate communication</li> </ul>	<ul style="list-style-type: none"> <li>• Blood transfusion standby</li> <li>• Assess blood loss</li> <li>• +/- CP resuscitation</li> </ul>
<b>STAGE THREE</b>	<ul style="list-style-type: none"> <li>• Intracisternal papaverine .....</li> <li>• Liliquist membrane/Lamina terminalis fenestration ****</li> <li>• Key concerns for recovery</li> <li>• Alert for iatrogenic consequences</li> </ul>	<ul style="list-style-type: none"> <li>• Dilution .....</li> <li>• Count matching for consumables</li> </ul>	<ul style="list-style-type: none"> <li>• Pre &amp; post-installation assessment of pupil size &amp; vitals</li> <li>• Target closure BP</li> <li>• Inform ICU</li> <li>• Key concerns for recovery</li> </ul>	
<p>* VERBALIZATION OF NAMES &amp; ROLES (surgeons, nurses, &amp; anesthesia)                      ** FEASIBLE IN HYBRID OR ONLY                      *** PERFORMED BY NURSES and/or NEUROPHYSIOLOGIST (according to the institution)                      **** routinely done for all ruptured aneurysms at our institution</p>				

**Figure 1:** Modified intracranial aneurysm clipping safety checklist. ID: Identification, VTE: Venous thromboembolism, ASA: American Society of Anesthesiologists, ICP: Intracranial Pressure, LP: Lumbar puncture, IV: Intravenous, CV: Central venous, AEDs: Antiepileptic drugs, U/S: Ultrasound, DSA: Digital subtraction angiography, EVD: External ventricular drain, IOM: Intraoperative monitoring, UOP: Urine output, BP: Blood pressure, CP: Cardiopulmonary, ICU: Intensive care unit, IOR: Intraoperative rupture.

terminalis, and Lilliquist membrane fenestration – performed in all cases with ruptured aneurysms at our institution – aneurysm muscle wrapping and accurate timing of temporary clipping. The respective reduction rates of the time required to administer these steps were as follows: 15.2%, 4.3%, 4.3%, 8.6%, 10.9%, and 6.5% ( $P < 0.05$ ), respectively.

### Anesthetic complications

Key anesthetic complications that were significantly ( $P < 0.05$ ) reduced following the administration of the checklist include cessation of muscle relaxant to enable intraoperative monitoring (15.2%), intraoperative antibiotic and anti-epileptic prophylaxis administration, 4.3% and 8.3%, accordingly, and allergic and transfusion reactions, 4.3%, and 2.1%, respectively.

### Equipment-related complications

Delays are commonplace in everyday neurosurgical practice here due to several factors, including personnel shortages, unreliable task assignments, and hardware failure, and failure of the surgeon to prepare adequately for the multiple alternative outcomes and abnormalities in the conduct of the surgery. Our checklist was designed to reflect the following “typical” time consuming and often missed steps: proper surgical set and aneurysmal clip preparation, availability of a second suction system, timely preparation, draping, and “white balance” check of the microscope. On average, with the exclusion of the disparity in surgical experience, the estimated range of surgical delay due to these mundane steps is approximately 60–90 min in up to 70% of cases. Postimplementation, the sequence of these steps has been guaranteed, eliminating interruptions, and ensuring intraoperative flow at an untraceable rate.

### Team satisfaction

A total of 34 staff members were surveyed, including two neurosurgeons, 13 neurosurgery residents, 10 nurses, two anesthesiologists and five anesthesia assistants, and two intraoperative monitoring personnel, with the main objective of determining the impact of the checklist on the level of interdisciplinary team communication within the operating room. In addition, the postimplementation survey asked the staff to indicate if they would recommend the continuous application of the checklist and to rate its ease of use.

The questionnaires were circulated before and after the launch of the checklist and, to reduce observer and reporting bias, responders were informed that the survey was part of a quality improvement project. Overall, the team graded the checklist favorably, with 96% encouraging its continued

application. Specifically, 94% “agreed” or “strongly agreed” that the safety culture in the operating room had been enforced by the checklist. A significant improvement in communication was also seen, with a 50% increase in participants who scored communication as “excellent” ( $P < 0.05$ ).

### CONCLUSION

A checklist devised specifically for intracranial aneurysm clipping surgery has the potential to improve team communication and maximize surgical outcomes, specifically in low-volume centers.

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