A Novel Approach to Improving the Safety of Patients Undergoing Lumbar Laminectomy

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The anesthesiology field has recently embraced the use of checklists to obviate the need for long-term memory, improve safety, and achieve goals and tasks. These checklists serve to increase safety, improve consumer satisfaction, and reduce mortality and morbidity.

Spinal surgery with the patient lying prone is associated with complex morbidities when there is inattention to proper positioning technique. Problems arising from malpositioning of the patient undergoing spinal surgery are attributed to body habitus and the body's contact with specialized and complex operating room table frames. Common problems associated with the prone position are brachial plexus injury, cervical spine nerve injuries, and postoperative visual loss.

The purpose of this research project was to examine the use of a checklist for nurse anesthetists who provide care for patients undergoing spinal surgery. The checklist addressed specific positioning needs as a means of decreasing mortality and morbidity. It is theorized that the use of a checklist will serve as a systematic aid to memory and enable the anesthetist to adhere to proper positioning techniques in this patient population and thereby improve outcomes.

Keywords: Checklist, ischemic optic neuropathy, malpositioning, postoperative vision loss, Trendelenburg position.

Mortality and morbidity related to anesthesia has decreased dramatically during the past 2 decades.[1(p260)] This trend has been influenced by factors such as consumer awareness, a rise in insurance rates, and malpractice judgments.[1(p260),2] Consumer demand has fostered regulation of practice through professional boards and government agencies to promote safety. State and local boards discipline errant members. The American Hospital Association and the Joint Commission regularly inspect hospitals, operating rooms (ORs), staff, and procedures to ensure compliance with safety regulations. Noncompliance may result in the revocation of privileges to continue operation. The pressure generated on hospital boards creates a demand for a culture of safety from the top down.[2-4(p313)]

The anesthesiology community's decision to identify key causative factors that have contributed to the death and injury of nearly 10,000 patients annually has made its practitioners leaders in healthcare safety innovation.[2,3] Standards of practice must be skillfully combined with the use of technology and improvements in education, training supervision, audit, and vigilance.[3] Quantifying studies and the discussion of errors leading to mortality and morbidity are the first steps to creating new technologies and instituting practice to eliminate error and injury.[5(p1402)]

One such area that still exists as vulnerable in anesthesia practice and is entirely preventable is injury due to improper patient positioning during surgical procedures. Faulty positioning can cause injuries, especially when specialized OR table frames come into contact with various body types. In a case documented by Dr Jonathan Roth,[6] a patient having a retropubic prostatectomy suffered bilateral sciatic and femoral neuropathies, rhabdomyolysis, and acute renal failure. This was caused by faulty positioning where the OR table's kidney lift was elevated excessively and later changed without regard to the effect it had on the patient.[6] In other instances, patients have suffered paresthesias, including upper brachial plexus injuries when positioned improperly in the decubitus position. The brachial plexus can also be stretched, causing neurapraxia (damage to the nerve by overstretching) when the shoulder and arm are pulled toward the lower extremity and fixed to maximize the view for fluoroscopy. Peroneal nerve injury can be caused by compressing the nerve in lithotomy stirrups. This has been known to cause foot drop. These are a few examples of perioperative injuries of nonprone patients caused by hyperabducted or overstretched nerves coming in contact with nonpadded OR table surfaces in the anesthetized patient. These anesthetized patients cannot vocalize pain or the feeling of numbness in a limb.[7,8]

There is a class of injuries peculiar to morbidly obese patients undergoing laminectomy surgery in the prone position on a Jackson table with a Wilson frame.[9] The author used reports of table failure from the US Food and Drug Administration to find the coexisting link with this specific table and frame.[9] Common problems associated with patients in the prone position include postoperative vision loss (POVL), brachial plexus injuries, and cervical spine injuries.[3,10-16]

On the basis of a retrospective study, a reasonable

solution includes use of a number of specific items for the prone patient undergoing spinal laminectomy such as padding, safe positioning, and the use of colloids. The development of a checklist tool was used to ensure the consistent and evidence-based method of application.

The author hypothesizes that the use of a checklist tool will prevent or reduce morbidity during laminectomy with the patient in the prone position and will improve outcomes. This method could be used to guide the anesthesia provider through the intricate process of proper positioning of these vulnerable patients. The checklist was developed by incorporating combined documented experiences proved to be effective and evidence based with the tenets of Informational Processing Theory.[17,18]

Methods

The purpose of the project was to develop a checklist tool to be used by anesthesia providers in the OR to reduce morbidity in the prone patient undergoing spinal laminectomy. In the process of developing a checklist tool for anesthesia providers, a key list was identified. This list included the following: (1) identify problems of malpositioning that may cause injuries in the prone patient during laminectomy (anecdotal reports suggest brachial plexus injuries, cervical spine injuries, and POVL as common injuries), (2) conduct a literature review to discover evidence of a relationship between improper prone positioning and injury, and (3) examine the literature with respect to creating an effective checklist.

• ***Patient Injuries Related to Improper Intraoperative Positioning.*** In addition to the previously mentioned injuries such as sciatic and femoral nerve injuries, peroneal nerve injury, and brachial plexus praxis,[6] faulty positioning has been implicated as a contributor to cervical spine injuries. This may be due to overflexion or extension of the neck.[15] Reverse Trendelenburg position, together with the use of colloids, has been suggested by the ASA to prevent POVL.[12(p3)]

Prone positioning poses unique opportunities for injury. Spinal surgery in the prone position has surpassed cardiac surgery as a leading cause of POVL. Postoperative visual loss may result from corneal trauma, hemianopsia, and vascular insults to the visual tracts associated with hypotension, hypoperfusion, thromboembolic events, or retinal artery occlusion caused by direct pressure to the globe.[10] Central retinal artery occlusion and ischemic optic neuropathy have been investigated as direct causation of POVL. Ischemic optic neuropathy has occurred in prone patients in Mayfield tongs without globe compression.[12(p3)] The ASA's task force on POVL recommends the use of colloids for volume replacement, arterial catheters to monitor blood pressure, central venous pressure monitoring to evaluate fluid volume status, and positioning of the head above the heart to avoid this catastrophic injury.[19(p5)]

Brachial plexus injuries have been investigated as a major complication of the prone position during laminectomy because of increased stretching of the upper extremities. Neurapraxia and nerve compression have been implicated in this particular nerve injury. Various authors have identified peripheral nerve injuries during general anesthesia.[3,15] Welch et al[16] described a statistically significant number of peripheral nerve injuries in one retrospective study.

• ***Creating an Effective Checklist.*** In high-reliability organizations, checklists have served as cognitive aids for operators to improve performance. As part of this project, a literature search was conducted to discover information with respect to creating an effective checklist for use by nurse anesthetists caring for patients undergoing spine surgery in the prone position. Checklists designed for use in complex environments should (1) address a population's needs,[20] (2) be appropriate to the demands of the situation and environment,[21] (3) be simple enough to understand and detailed enough to accomplish its goal,[22] (4) not be cumbersome, and (5) be written in an easily digestible form.[21]

Checklists are developed from a practitioner's personal frame of reference. Checklists evolve because results dictate whether they are efficient or must be changed.[23] Good human engineering requires testing in the target environment.

Characteristics of online checklists should include adaptability, usability, flexibility, consistency, efficiency, reduced redundancy, and accessibility.[24] A process should measure enhanced usability attributes of the checklist and should locate specific usability problems. Problems include those factors that confuse the user and prevent instantaneous understanding of what is expected. The checklist itself must be clearly understandable and efficient, without conflicting elements. Ideas must be simple and bold.

Checklists augment task accomplishment if they are simple and focus on accomplishing specific goals. Similarly, checklists should be based on scientifically grounded theory and evidence. Bosk et al[25] state that scientific principles need to be simplified so that the public can put them into use. It is also necessary to be able to measure outcomes and provide feedback on the results. The distribution and use of checklists without understanding their principles, may pose a threat to the patient population.[25]

Checklists do not replace constant vigilance in the complex environment.[26] Vigilance is especially important while positioning prone patients to avoid nerve injuries, cervical spinal injuries, and POVL. Attention to detail in this instance is paramount to avoid patient injury. A checklist-based preoperative anesthesia equipment check has been associated with a decrease in intraoperative morbidity and mortality.[27]

1. Preoperative evaluation
2. Passive range of motion of cervical spine preoperatively—to check for arthritic changes, cerebrovascular disease, and thoracic outlet syndrome
3. Blood pressure monitoring
4. Plasma replacement (use of colloids under discussion)
5. Position head properly; head tongs prevent abrasions to forehead and chin
6. Pad head, shoulders, arms, breasts, and genitals with proper padding
7. Assess eyes for excessive or undue pressure every 15 min
8. Palpate radial artery pulse
9. Position patient in reverse Trendelenburg approximately 10 degrees anti-Trendelenburg (eyes above heart)
10. Complete postoperative questionnaire

Table 1. Preliminary Checklist Tool [10-16,33]

A theoretical basis for the support of a checklist tool was researched. Informational Processing Theory was identified as a supporting framework of the value of a checklist tool to teach and improve clinical skills without dependence on long-term memory. This theory incorporates general skills and knowledge.[18] Vocalizing protocols, as well as eye movements, are linked to the Informational Processing Theory and are limited to short-term memory. This vocalizing has been proved to be a genuine problem-solving behavior of short-term memory.[26]

A person's informational gathering strategies and perceptions in problem solving uses changes in short-term memory and storage or retrieval in the long-term memory. Poorly structured data are processed in the short-term memory as "chunks." Rote memory of data chunks is required to inset data in long-term memory for retrieval and use at a later date.

The "problem space" of a person's short-term memory is similar to the desktop space of a computer. This is different from the task environment and each piece of data (node) is a possible state of attainable knowledge. Differences in characteristics of nodes are evaluated as attainable or unattainable goals. Information can be stored in long-term memory as symbols, designating a pattern. The instance of a memory of a generated theorem is held in long-term memory and used for comparison.[18] Similar patterns are recognized and projected as a possible solution in games of strategy.[25] Problem-solving pattern recognition is stored in semantic memory.

Checklists serve as cognitive aids to accomplish tasks and goals in an effective manner.[28,29] Use of cognitive aids to learn protocols culminates in the learning and physical management of tasks. Cognitive aids assist with the performance of tasks without the dependence on long-term memory, and they improve the knowledge and technical skills of anesthetists.[28] Checklists are a growing trend to enhance learning in a surgical environment. This use will increase efficiency and reduce errors and stress on the practitioner.[17,18,28-32] Checklists may also enhance postoperative screening for possible complications.[33]

- ***Checklist Development.*** The author developed a checklist (Table 1) specific to proper positioning of the patient undergoing spine surgery in the prone position. The checklist was developed on the basis of a survey of literature regarding the needs of patients undergoing spinal surgery. An evaluation attached to the checklist tool queried relevance, utility, and the attainment of written cues to identify proper positioning needed to reduce injury. The section concerning written cues was subject to the interpretation and the opinions of the responding neurosurgeons, Certified Registered Nurse Anesthetists (CRNAs), and anesthesiologists who were experienced in this activity. The last question asked if there were any changes or additions that needed to be made to the checklist tool. The checklist tool was presented during spinal surgery to a neurosurgeon and CRNA caring for a patient in the prone position. Twenty-three respondents were queried overall. These included 2 neurosurgeons (chief and associate), 3 CRNAs and 4 anesthesiologists from hospital A and 1 neurosurgeon (department chief), 8 CRNAs, and 5 anesthesiologists from hospital B. Each was asked to score the items on a scale of 1 to 5 with 1 indicating strongly disagree and 5 representing strongly agree. The only qualification was that these individuals regularly participated in neurosurgical anesthesia. Items comprising the checklist include important elements of caring for the prone patient undergoing spinal surgery (see Table 1).

The final checklist was derived from a poll of 2 neurosurgeons and 3 anesthesiologists, which was taken to explore weakness of the original checklist. The personnel involved were in the original study at both hospitals. Feedback from the poll was used in the development of the final checklist, which is shown in Table 2.

Results

The respondents scored the checklist on a scale of 1 to 5, with 1 being strongly disagree and 5 being strongly agree. One respondent scored 3 for ease of use, and one respondent scored 4. The rest scored a 5. For value to patient safety, one respondent scored 4; the rest, 5.

One respondent specified that this 10-point checklist

1.	Preoperative evaluation
2.	Passive range of motion of cervical spine preoperatively—to check for arthritic changes, cerebrovascular disease, and thoracic outlet syndrome
3.	Blood pressure monitoring with indwelling arterial catheter (for longer cases or high-acuity patients)
4.	Plasma replacement with colloid
5.	Position head properly; head tongs prevent abrasions to forehead and chin. Alignment of C5 and the occiput when parallel to the floor prevent overflexion or extension of the cervical spine.
6.	Pad head, shoulders, arms, breasts and genitals with proper padding
7.	Assess eyes for excessive or undue pressure every 15 min
8.	Palpate radial artery pulse
9.	Position patient in reverse Trendelenburg approximately 10 degrees anti-Trendelenburg (eyes above heart)
10.	Complete postoperative questionnaire

Table 2. Final Checklist Tool

should be extended where applicable to many complex procedures. Another respondent stated that in prone patients undergoing laminectomy, C5 (cervical vertebra 5) should be in line with the occiput.

The results of the evaluation found that the checklist itself was easy to use in its intended environment and accomplished the set goal of including the many facets of proper positioning needed to help prevent morbidity. Additional comments such as the correct positioning of C5 in relation to the occiput would later be added to the final product.

Discussion

The checklist was the result of surveying articles spanning a complex array of injuries in the prone patient undergoing laminectomy. The primary task was to find an evidence-based link between malpositioning of prone patients during laminectomy and morbidity. Secondarily, a survey of evidence-based literature was used to develop a checklist that would reduce the incidence of morbidity.

During the final phase, anesthesiologists from hospital B were as a whole not in favor of administering colloids as a standardized precaution to help prevent blindness a result of decreased choroidal blood flow studies.[13] Anesthesiologists from hospital A promoted the use of colloids and cited literature supporting the subsequent safety vs expense/risk ratio involved.

The final phase of the investigation compared preliminary perceptions held by neurosurgeons and anesthesiologists to determine if there were any omissions in the initial investigation. This study is based on retrospective research of the literature and supplemented by an investigation into the expert opinions of practitioners in the field of neurosurgery and anesthesia.

Validation of checklists is another aspect of the verification of their utility and usability. In a forum called "PPRuNe"[34] run by and for professional pilots, a user nicknamed "Willit Run" echoes the concern of many professional pilots. He states that most pilots are concerned with how fast they can read through the checklist and not whether they are accomplishing the necessary tasks. The literature has stated that not understanding the underlying principles has been the cause of many accidents.[25] Checklists are valuable cognitive aids that can reduce the possibility of forgetting important items or that one highly overvalued item will overshadow another. This is the halo effect. They reduce the possibility of double weighting one of the items and the tendency of the Rorschach effect: seeing expected results. Checklists need to be complete, clear, and concise and not overlap. Furthermore, the items must be measurable.[35]

Conclusion

There is a national trend in modern medicine to adopt the use of checklists to promote safety and efficiency.[36-39] Checklists have been demonstrated to be effective in accomplishing tasks that reduce dependence on long-term memory and human error.[17,18,29-32] The investigation in this area is a result of study into the Informational Processing Theory and how it relates to protocols used in the training of medical personnel and their ability to accomplish new tasks.

The *New England Journal of Medicine*'s 19-point checklist[39] has already been highlighted in international news journals.[21,26,36,40] The time-out in surgery, to identify the right person, right site, right procedure, is a good example. This new trend in supplementing the education of students in the field of anesthesia by using checklists has also been done in the field of aviation.[41,42] This will dramatically enhance the accomplishment of new goals and tasks[17,18,28-32] in complicated surgical procedures such as laminectomy procedures with prone patient positioning and reduce the occurrence of morbidity and mortality.[36,37]

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