



Optimizing Comfort and Efficiency: The Crucial Role of Ergonomics for Neuroanesthesiologists in the Operating Room

Sapna Suresh¹ Ashitha Arumadi² Sreeja Ravindranath² Ajay P. Hrishi²
Ranganatha Praveen² Manikandan Sethuraman²

¹ Department of Neuroanesthesia and Critical Care, Aster Medicity, Kochi, Kerala, India

² Division of Neuroanesthesia & Critical Care, Department of Anesthesiology, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum, Kerala, India

Address for correspondence Ajay Prasad Hrishi, MD, DM, EDAIC, Division of Neuroanesthesia, Department of Anesthesiology, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum 695011, Kerala, India (e-mail: drajay@sctimst.ac.in).

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Abstract

Ergonomic principles, when applied effectively, reduce the risk of musculoskeletal injuries, fatigue, and discomfort among neuroanesthesiologists who spend extended hours in the operating room. Properly designed workstations and equipment can enhance accessibility and allow for better positioning during procedures, minimizing the potential for errors and complications. Furthermore, an ergonomic approach fosters a culture of safety and well-being, supporting neuroanesthesiologists' physical and mental health. It promotes teamwork and communication among the surgical team, leading to smoother and more efficient surgeries. Neuroanesthesiologists who work in ergonomically optimized environments are more likely to remain focused, make critical decisions with clarity, and provide the highest standard of patient care. In the evolving landscape of neurosurgery, where advancements in technology and techniques continue to push the boundaries of what is possible, ergonomics is a fundamental pillar that ensures neuroanesthesiologists can adapt, learn, and perform at their best. As we recognize the significance of ergonomics, it becomes essential to invest in ongoing education, research, and implementation of ergonomic solutions to support the dedicated professionals who play a crucial role in neurosurgical care. In summary, prioritizing ergonomics in neurosurgical operating rooms is not just a matter of comfort, it is an investment in the well-being and effectiveness of neuroanesthesiologists and, ultimately, in the quality of care provided to patients undergoing neurosurgical procedures. By integrating ergonomic principles into our practice, we can create safer, more efficient, and more sustainable environments for neuroanesthesiologists, ensuring the continued success of neurosurgery in the years to come.

Keywords

- ▶ ergonomics
- ▶ neuroanesthesia
- ▶ neurosurgery
- ▶ operating room

Introduction

In the high-stakes environment of the operating room (OR), where precision and focus are paramount, the role of neuroanesthesiologists is both critical and demanding as they are

entrusted with ensuring patients' comfort, safety, and anesthesia management throughout neurosurgical procedures. However, the relentless nature of their responsibilities often means long hours spent standing or sitting in the same position, which can lead to physical strain and discomfort.

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Hence, optimal ergonomics in the OR is not merely a matter of convenience, it is a fundamental component of patient care and the well-being of health care providers.¹ This article highlights the interconnection between ergonomics, the quality of patient care, and the physical and mental health of these dedicated medical professionals. In the subsequent sections, we will delve deeper into the key aspects of ergonomic considerations for neuroanesthesiologists and how they can contribute to enhanced patient outcomes and improved job satisfaction within the OR.

Optimal Workplace Posture

Embracing and consistently maintaining correct posture in the workplace is fundamental in preventing discomfort or pain during work. Anesthesiologists must assume a neutral and natural posture to reduce the incidence of posture-related injuries. Neutral position implies maintaining a straight or slightly reclined back posture, ideally between 95 and 110 degrees with the shoulders abducted at an angle of <20 degrees and elbows flexed at an angle of 90 to 100 degrees. The forearm is to be kept pronated, ensuring the wrist, hand, and forearm align in a straight line with the work item.¹ Care must be taken to avoid excessive wrist extension or deviation, limiting it to within 15 degrees from the neutral position. The lower leg is kept perpendicular and the thighs are to be kept parallel to the floor. Ensure that the position hip joint is slightly higher than the knee joint. To provide additional support, feet could be rested flat on the floor or footrest. Furthermore, anesthesiologists should organize their workspace to minimize the need for stretching or reaching behind patients, equipment, or monitoring devices.¹

Operating table heights at the level of xiphoid process height were found appropriate for endotracheal intubation as it avoids crouching and causes lesser strain on the cervical and lumbar spine. Novice anesthetist should be taught to intubate with their back straight and to adjust their line of sight accordingly to avoid stooping. Compensation for height should occur with the lower body when the trolley height is fixed.²

Workspace Layout in the Operating Room

Organizing the anesthesia workspace and equipment is essential to reduce the need for stretching or uncomfortable movements. The patient monitor screen is typically mounted on adjustable arms, facilitating positioning as needed. Having the monitor at eye level and directly in front of the anesthetist is essential.

Anesthesia workstations should prioritize features such as being lightweight, compact, and easy to maneuver. Though unknown to many, these machines come in two primary configurations based on the placement of the reservoir bag, often referred to as “left-handed” and “right-handed,” depending on whether they are intended to be positioned to the left or right of the anesthetist. In the case of a left-handed machine, it is typically positioned on the left side of the anesthetist. In this setup, the anesthetist would use their right hand to hold the facemask while controlling the reservoir bag with their left hand. Conversely, a right-handed

machine is meant to be placed on the right side of the anesthetist, allowing them to use their right hand to control the reservoir bag and their left hand to hold the facemask. It is, therefore, crucial to correctly identify the machine's configuration and position it appropriately to the right or left of the anesthetist to ensure optimal working conditions. For instance, if a left-handed machine is placed on the right side of the anesthetist, it would necessitate the anesthetist to lean forward or move the machine to reach the reservoir bag, often causing discomfort. This could also result in the monitor being placed behind the anesthetist, requiring them to turn their head repeatedly. A similar issue arises when a right-handed machine is incorrectly placed on the left side.³ During the anesthesia induction phase, the anesthetic workstation controls should be within the arm's reach of the anesthetist. Thus, with one hand holding the facemask, the other can efficiently operate the adjustable pressure-limiting valve, adjust gas flows, activate the vaporizer if necessary, and manage the reservoir bag.

It is worth noting that most anesthesia equipment is biased toward right-handed individuals. Studies have revealed that right-handed and ambidextrous individuals preferred to use their right hands for tasks requiring precision.³ In contrast, left-handed individuals typically used their left hand for tasks involving force, regardless of the dominant hand's usage in all participants. Moreover, relying on the nondominant hand can harm the anesthetists' critical task performance.³ In light of these findings, anesthetists should make workplace adjustments to optimize their performance using their dominant hands. Ideally, equipment design should aim for neutrality, allowing both left-handed and right-handed individuals to operate the machinery effectively. This could be achieved by placing critical components, such as the reservoir bag and common gas outlets, at the center of the machine.

Tracheal intubation presents ergonomic challenges, whether performed with a traditional laryngoscope, a video laryngoscope, or a fiberoptic bronchoscope (whether the patient is asleep or awake).⁴ The anesthetist should have an unobstructed line of sight to the patient, the monitor, and the video screen. Immediate access should be available to infusion pumps, the anesthetic machine, oxygen delivery equipment, and suction. The anesthetic assistants should primarily position themselves with easy access to the airway trolley and close to the anesthetist.

In neurosurgical procedures, the anesthetist will have limited access to the patient's head, so the endotracheal tube should be safely secured before draping. The breathing circuit, monitor cables, and intravenous and intra-arterial lines with suitable extension lines are secured at accessible locations and should be organized to avoid bulky tangling.⁵

Special Situations

In awake craniotomy anesthetist needs to maintain constant communication with the patient and needs to have a vigilant watch on any intraoperative complications like loss of airway, new-onset neurological deficits, adequacy of analgesia, and seizures, and hence will have to occupy a

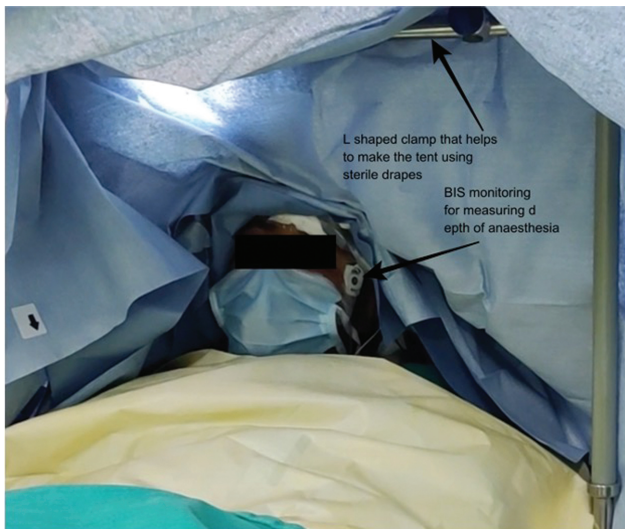


Fig. 1 Arrangement of the draping with L-bar when a patient is undergoing an awake craniotomy.

space next to the patient preferably on the side where the tests are being performed and there is clear visibility of patient's face with an L-bar and transparent drapings (► **Fig. 1**).

In neurosurgical procedures involving a sitting position, an L-bar is kept to provide access to the patient's airway. Transesophageal echo probe is used intraoperatively to detect venous air embolism in sitting craniotomies and with the operator positioned facing the patient to facilitate probe manipulation as shown in ► **Fig. 2**.

In O-arm-guided procedures, the anesthesia workstation, intravenous pole, and anesthesiologist occupy the head end of the table. The stimulation and recording boxes can be held

at the patient's head or leg end during spine surgeries. The neuromonitoring boxes can be located at the patient's leg end during cranial surgery. Intravenous tubing, invasive pressure monitoring lines, breathing circuits, gas sampling lines, neuromonitoring cables, stimulation and recording boxes, electrocardiogram cables, urinary catheters, and temperature probes should all be well tucked under the operating table sheet and secured with plasters without entanglement.⁶

Procedures that involve depth of anesthesia monitoring like bispectral index or intraoperative neuromonitoring involve multiple cables and recording boxes which need to be properly labeled and care must be taken to ensure that the cables are properly secured to avoid entanglement and the monitoring device must be placed in appropriate position where it does not hinder the anesthesiologists' access to multipara monitor, ventilator, and patient's airway in case of an emergency.

Optimal Patient Positioning for Procedure Ergonomics

The positioning of the anesthetist in relation to the patient is an important consideration. The patient's placement on the trolley, bed, or operating table imposes ergonomic challenges on the anesthetist.¹ Anesthetists come in various heights, and best practice dictates that the patient should be positioned at a height where the anesthetist can comfortably hold a facemask above the patient without bending their knees or back. This typically corresponds to the level of the umbilicus, T10 dermatome, or the waist of the anesthetist, as the spine naturally curves at this point. For optimal results, it is advisable to position the patient to enable the anesthetist to hold the facemask above them with a slightly flexed elbow and no shoulder strain.¹ The other shoulder should allow the hand to move quickly toward the reservoir bag at an angle of



Fig. 2 Arrangement of the operating room in a patient undergoing craniotomy in the sitting position. This depicts the position of the anesthesiologist, the monitors, the workstation, and the echo machine.

approximately 45 degrees from the sagittal plane. In this position, the arm should be slightly flexed at the elbow with the forearm in a three-quarter pronated orientation. This setup allows for the most effective utilization of both shoulder joints and arms for bag/valve/mask ventilation while minimizing strain on the involved joints. During intubation, if the patient is lying on an operating table or trolley for tracheal intubation, the table's height should be adjusted so that the patient's forehead aligns with the anesthetist's xiphoid process.¹ Some evidence suggests that video laryngoscopes lead to body postures that are less likely to cause musculoskeletal injuries than traditional laryngoscopy.⁷⁻⁹ Additionally, the chosen position should facilitate drug administration by the anesthetist without requiring them to lean or stoop. This can be accomplished by bringing the injection port closer to the anesthetist, either by gently flexing the patient's arm or attaching an infusion line with a three-way tap or injection port positioned near the anesthetist.

Positioning the patient for central line insertion in a neurosurgical setting does not encourage head down position and the height of the table should be adjusted to minimize flexion of the anesthetist's neck, lower back, and knees. If done under ultrasound guidance, the machine is placed to the side opposite to the operator's side with the screen at his eye level and the equipment trolley with sterile instruments and central venous catheter is to be placed in the operator's dominant side.¹⁰

Patient Positioning for Surgery

Musculoskeletal issues, such as back pain, account for many sickness absences among anesthetists.¹ Manual handling of patients during positioning is a common feature of the activities performed by anesthetists. They must assess the risk of injury associated with any manual handling that cannot be avoided and take measures to reduce this risk as far as reasonably practicable.

Lateral Transfer of Patients

The fact that a patient must be transferred between trolleys and beds, or their head needs to be supported as a pillow is removed, results in manual handling issues for all members of the team dealing with a patient. The increase in bariatric patients presents additional challenges that must be met. One of the most significant issues for the anesthetist is the weight of the patient. However, many other factors can increase the risk of injury, such as the frequency with which something is moved, how far it is carried or pushed, the height at which it is picked up or put down, and whether it is handled at a distance from the body.^{11,12} Added to these considerations must be a review of whether any twisting, bending, or stretching of the body of the handler occurs simultaneously. The number of staff required to position the patient safely will depend on the patient's size. For a patient who weighs 70 kg, the anesthetist and three staff members use a lateral transfer device. There is a range of each of the different types of lateral transfer devices on the market, and staff should be familiar with the equipment used in their

place of work. It is vital to ensure the bed is at a suitable height for the transferring team with a pull point (i.e., the starting position of the staff member's hands) between their waist and nipple line.

Supine to Prone Positioning

The patient is likely to be anesthetized when positioning the patient in the prone position. Therefore, the anesthetist controls the head, neck, and airway. An additional four members of staff are required to facilitate the transfer. If a mechanical assist device like Allen's advanced spine table is available, this should be utilized.¹¹

Lateral Positioning of the Patient

To safely position the patient in this position, a minimum of three members of staff plus the anesthetist is required for patients weighing > 50 kg.¹¹

Transfer Devices

Manual handling of patients is cumbersome and dangerous for both OR personnel and the patient. Transfer devices can be broadly divided into mobile and fixed patient transfer devices. Mobile patient transfer devices, like roller boards and air transfer systems, transfer patients between two different surfaces. The roller board is a more economical solution but it is more difficult to disinfect and is found to be an unpleasant experience for the transferred patient and is not suitable for transferring patients who weigh more than 160 kg. The air transfer system though expensive can be used for heavy patients with weights up to 500 kg.¹³

Fixed patient transfer unit has many advantages: no lifting of the patient is needed while transferring between different surfaces, a more "humane" handling, increased patient safety, and theater personnel work more effectively without using excessive energy and without hyperextending muscles and joints. However, a fixed patient transfer solution needs special infrastructure and space and is more time-consuming.¹³

Operating Room Temperature and Humidity

The typical temperature in the neurosurgical OR tends to be cooler, typically within the range of 18 to 22°C. To prevent discomfort for the personnel working in the OR, it is recommended that the ambient temperature be maintained at 21°C.¹⁴ It is essential to keep the vertical air temperature difference between head and ankle levels below 3°C. The relative humidity levels in the 40 to 70% range are recommended for the ORs.¹⁵ The stability of temperature and humidity within the operating theater may be disrupted by factors like the opening of doors and the movement of individuals and equipment. Therefore, it is essential to minimize the same.

Ergonomic Clothing

Comfortable clothing, particularly attire that provides warmth without compromising mobility, is crucial for anesthetists. It allows them to focus on their critical tasks without being distracted by the discomfort of being too cold.

Additionally, comfortable clothing can contribute to a more pleasant and efficient working experience, which is vital in a high-pressure and time-sensitive setting like the OR. Many anesthesiologists opt for warm but breathable layers that can be easily adjusted. These layers may include thermal undergarments, cozy scrubs or laboratory coats, and footwear that offers support and comfort. The choice of clothing should align with the specific climate control measures in the operating theater to strike the right balance between warmth and breathability.

Noise Control, Music, and Communication in Operating Rooms

Noise within the OR can originate from various sources, encompassing staff activities, conversations, ventilation systems, surgical equipment, alarms, and background music.¹⁶ The recommended noise level in operating theaters typically ranges between 40 and 50 dB. Music is commonly introduced into the operating theater environment to alleviate stress and enhance the performance of certain staff members. However, it is important to note that music can also hinder effective communication.^{17,18} What may be pleasing and beneficial to one practitioner might prove distracting to other members of the operating theater team.¹⁶

To reduce OR noise, incorporating acoustic materials whether by using wall or ceiling panels or other sound-absorbing elements can be considered. Care must be taken to minimize traffic going into and out of the room.¹⁹

Nonessential conversations and communications can similarly be distracting, potentially leading to errors in patient care. Drawing inspiration from aviation practices, the “sterile cockpit” concept was introduced to reduce distractions during critical phases of a flight, especially during takeoff and landing, typically occurring below 10,000 feet.²⁰ The induction and emergence phases can be likened to these critical flight phases in anesthesia. Consequently, it has been proposed that the “sterile cockpit” principle should apply during these periods in anesthesia practice.²⁰

However, it is essential to recognize that each team within the operating theater may experience varying cognitive workloads at different stages of a surgical procedure.²¹ This variability can result in casual conversations at the moment when another team member requires absolute quiet. To mitigate this potential issue, anesthetists should assertively communicate their intention not to engage in nonemergency discussions during drug preparation. This approach aims to enhance medication safety by reducing the likelihood of errors.²²

Alarm systems hold a critical role in patient safety; however, they can become problematic if they impose potential hazards or impede the operator's performance.²³ A high rate of false alarms can lead to desensitization and complacency.²⁴ This, in turn, may result in the inappropriate muting of audible alarms and could cause anesthesiologists to disregard alarms that require immediate attention. Hence, the precise configuration of alarm trigger levels is paramount to ensure optimal patient safety. To avoid false alarms steps to improve signal extraction (prevention or detection of artifacts), algorithms for alarm generation, and alarm

validation must be taken. Although statistical approaches are predominantly used for the reduction of artifacts, artificial intelligence like rule-based expert systems, neural networks, fuzzy logic, and Bayesian networks offers the possibility of integrating more complex contexts.²⁵

In awake craniotomy, the alarm tone is preferably kept at a lower range without compromising patient safety to avoid the patient getting unnecessarily anxious with the alarms.

Ambient Lighting in Operating Rooms

Lighting is critical in ensuring a suitable work environment without causing eyestrain. The recommended minimum illumination levels for tasks requiring attention to detail are set at 200 lux.²⁶ However, specific health care settings, such as the anesthesia room, necessitate higher illumination levels, requiring 1,000 lux at the head of the trolley located 1 m from the light source. To ensure optimal visibility and usability, it is essential to adjust the brightness and contrast controls on the screen of the anesthetic workstation to match the lighting conditions within the operating theater. Factors like brightness, light direction, and quality must be carefully considered when selecting laryngoscopes. Laryngoscopes should offer an illumination level of at least 500 lux which should be maintained even when applying a force of 65 N to the laryngoscope blade.²⁷ For reusable laryngoscopes, this specified illumination level should be upheld even after the maximum recommended number of uses, including cleaning, disinfection, and sterilization cycles.

Regular Breaks

Regular breaks for anesthesiologists in the OR are not merely a luxury, they are a necessity that can profoundly impact the quality of patient care and the well-being of these medical professionals.^{28–30} Anesthesiologists are tasked with ensuring patients remain sedated, comfortable, and safe throughout surgical procedures, often lasting several hours. This demanding role demands unwavering focus and attention, which can affect their physical and mental health over time. Prolonged periods of standing or sitting in the confined space of the OR can lead to significant fatigue and discomfort for anesthesiologists. This fatigue affects their performance and poses risks to patient safety. A break schedule can be incorporated into the OR routine without compromising patient care. Adequate staffing and planning are crucial to ensure that qualified personnel are always available to monitor the patient during an anesthesiologist's break. Additionally, health care institutions must foster a culture that values the well-being of their medical professionals and recognizes the importance of these short breaks in sustaining the high standards of care they provide. Here is why allowing regular breaks for these health care providers is essential^{28–30}:

- *Physical relief:* Anesthesiologists often find themselves in static positions during surgeries, resulting in muscle stiffness, joint pain, and reduced circulation. Short breaks allow them to stretch their legs, move their bodies, and alleviate physical discomfort.

- **Mental refreshment:** The OR is a high-pressure environment where the slightest lapse in concentration can have severe consequences. Brief breaks offer mental respite, helping anesthesiologists return to their duties with enhanced focus and clarity.
- **Error reduction:** Fatigue is a known contributor to medical errors. The likelihood of mistakes decreases by providing anesthesiologists with opportunities to rest and recharge, ultimately improving patient safety.
- **Team communication:** Breaks offer a natural opportunity for anesthesiologists to communicate with the surgical team, share updates on the patient's condition, and address any concerns or changes in the surgical plan. This collaboration fosters a more coordinated and practical approach to patient care.

Training

Provide training and education on ergonomic principles to anesthesia staff. This includes proper body mechanics, posture, and ergonomic techniques for minimizing strain and injury.

Feedback and Adaptation

Encourage anesthesia staff to provide input on ergonomic issues and continually make necessary adjustments to improve the workspace and workflow.

Conclusion

In conclusion, the importance of ergonomics for neuroanesthesiologists in neurosurgical ORs cannot be overstated. Neurosurgery is a highly specialized field that demands precision, focus, and endurance from its practitioners. By optimizing the ergonomic design of the OR and anesthesia workspace, we can significantly enhance the well-being, comfort, and performance of neuroanesthesiologists, ultimately leading to improved patient outcomes and operational efficiency.

Conflict of Interest

None declared.

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