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Optimizing Surgical Instrument Management in Geriatric Decompressive Craniectomy: A Case Report on Checklist-Driven Patient Safety and Operative Efficiency

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Abstract:
Emergency decompressive craniectomy in elderly patients presents unique perioperative challenges, where procedural delays or instrument mismanagement can exacerbate physiological vulnerabilities and significantly increase mortality risks. This study evaluates the efficacy of a structured, gerontology-sensitive surgical instrument management protocol during an emergency decompressive craniectomy. A single-case observational study was conducted at Prof. Ngoerah General Hospital in Bali in April 2025. Data were collected via direct non-participant observation and semi-structured interviews with the surgical team. A hospital-adapted surgical checklist was systematically applied across preoperative, intraoperative, and postoperative phases for a 66-year-old male presenting with severe traumatic brain injury. Preoperative verification of 46 specialized instruments was completed in 12 minutes, ensuring absolute operational readiness. Continuous intraoperative monitoring successfully intercepted two potential errors, specifically a misplaced forceps and an unsterilized clamp, thereby averting immediate contamination risks. This rigorous, structured approach prevented retained surgical items. It saved an estimated 15 minutes of total operative time, directly mitigating the severe risks associated with prolonged anesthesia and tissue exposure in geriatric patients. Structured, age-adapted instrument management protocols significantly enhance both operative efficiency and patient safety in high-risk geriatric neurosurgery. Healthcare institutions must prioritize the consistent adoption of gerontology-sensitive surgical checklists to optimize clinical outcomes, minimize surgical site infections, and mitigate preventable perioperative complications. Future multi-center research is warranted to validate these findings and establish standardized geriatric neurosurgical safety guidelines.

Keywords:
decompressive craniectomy, elderly, instrument management, patient safety, surgical checklist

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INTRODUCTION

The global aging population has precipitated a significant rise in traumatic brain injury (TBI) incidence, primarily driven by fall-related accidents among older adults. Globally, the incidence of traumatic brain injury (TBI) is estimated at approximately 349 cases per 100,000 people annually (Kapapa et al., 2024). This rising trend is largely attributed to the growing elderly demographic and their heightened susceptibility to falls, which represent the leading cause of TBI in this group (Maas et al., 2022). Such trauma frequently escalates into life-threatening neurological conditions, including

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subdural hematoma, midline brain shift, and dangerously elevated intracranial pressure, all of which mandate immediate medical intervention (García-Pérez et al., 2023).

Decompressive craniectomy (DC) serves as a critical, life-saving neurosurgical intervention for severe TBI by alleviating elevated intracranial pressure (Vitali et al., 2023). The procedure is designed to lower intracranial pressure by removing a portion of the skull, thereby providing the swollen brain with essential space to expand without compression (Tyagi et al., 2021). This surgical intervention is paramount in preventing irreversible neurological damage, brain herniation, and subsequent mortality (Hanko et al., 2021). The success of this high-stakes operation relies heavily on precise surgical execution and optimal operating room efficiency.

Elderly patients undergoing DC present unique physiological challenges that distinguish them from younger surgical populations (Kim et al., 2023). These older individuals frequently exhibit impaired physiological reserves, reduced tissue elasticity, unstable hemodynamic responses, and an increased susceptibility to intraoperative bleeding and postoperative infections (Hatamleh, 2022). These compounding factors make geriatric patients particularly vulnerable to adverse surgical outcomes if standard procedural workflows are disrupted or delayed. Research has consistently demonstrated that advancing age significantly influences and elevates the mortality rate of patients undergoing DC (Schröder et al., 2024).

Contemporary surgical instrument management predominantly relies on generalized safety checklists designed for broad operative populations (Reddy et al., 2025). Current management protocols focus on overall surgical safety and universal counting procedures rather than addressing the specific, nuanced needs of geriatric patients. These generic checklists provide a foundational layer of safety. However, they often fail to account for the specialized instruments, modified handling techniques, or the accelerated, highly coordinated workflow required when operating on frail, elderly individuals with complex comorbidities. Effective instrument management remains a cornerstone for ensuring both patient safety and surgical team efficiency during complex procedures (Mee et al., 2024).

A critical research gap exists regarding the development of tailored instrument management protocols for geriatric neurosurgery. Studies have shown that older adults over the age of 65 typically experience poorer prognoses after DC compared to their younger counterparts (Niedermeyer et al., 2025). Existing literature tends to focus almost exclusively on general surgical protocols, leaving a distinct void in understanding how specialized, age-adapted instrument preparation impacts clinical outcomes. This lack of targeted research represents a significant opportunity to redefine perioperative standards for the elderly.

Optimizing surgical instrument management in geriatric DC is an urgent clinical imperative. Improper or incomplete instrument preparation can prolong operative time, unnecessarily increase anesthesia exposure, and elevate the risk of severe complications in elderly patients (Nichol et al., 2023). Understanding and improving surgical instrument management in decompressive craniectomy for geriatric patients is directly relevant to patient safety and resource allocation. Even minor delays or procedural errors in this high-risk population can rapidly cascade into fatal consequences, making the refinement of these protocols a matter of immediate clinical priority (Garcia et al., 2024).

This case report evaluates the application of a structured, gerontology-sensitive surgical instrument management protocol during an emergency decompressive craniectomy in a geriatric patient. The study aims to highlight the critical importance of a targeted, age-adapted approach in instrument preparation to improve patient safety, minimize operative time, and enhance overall surgical team efficiency during high-risk emergency procedures. By documenting this specific clinical scenario, the report provides actionable, evidence-based insights to optimize perioperative

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workflows and mitigate preventable risks in the vulnerable geriatric neurosurgical population (Zietlow et al., 2022).

STUDY DESIGN

Design

This study employed a descriptive, single-case observational framework. This design was selected to facilitate an in-depth, nuanced evaluation of surgical instrument handling and management protocols in older adults, a demographic inherently at a higher risk for perioperative surgical complications.

Setting and Time

The study was conducted at Prof. Ngoerah General Hospital in Bali, Indonesia. The data collection and observational period took place in April 2025.

Population, Sample, and Sampling

The target population comprised elderly patients undergoing emergency neurosurgical interventions. A purposive sampling technique was utilized to select a single representative case. The subject was a 66-year-old male who sustained severe head trauma following a traffic accident. Inclusion criteria for this case were based on critical clinical indicators: decreased consciousness (Glasgow Coma Scale: E1 M1 Vt) and computed tomography (CT) scan findings revealing an acute subdural hematoma in the left frontotemporoparietal region (18 mm thickness), a 21 mm midline shift to the right, left frontal intracranial bleeding (12 cc), contusions in the right frontal and parietal lobes, and significant brain swelling. These findings necessitated an emergency decompressive craniectomy.

Intervention

The primary clinical intervention was the emergency decompressive craniectomy. From a research perspective, the observational intervention was the systematic application of a hospital-adapted, gerontology-sensitive surgical instrument management protocol. This protocol was integrated into the standard surgical workflow to evaluate its efficacy in preventing errors and optimizing operative efficiency.

Instrument and Measurement Properties

The primary data collection instrument was a standardized surgical checklist for decompressive craniectomy, provided and validated by the hospital. This checklist was designed to track instrument verification across three distinct surgical phases. A secondary, unstructured interview guide was used to capture the surgical team's subjective perspectives and experiences regarding instrument management workflows.

Data Collection Procedure

Data were gathered through direct, non-participant observation of the entire surgical process, with a focus on meticulous documentation of each step in instrument management. The checklist was systematically applied at three critical junctures: before skin incision (preoperative verification), during wound closure (intraoperative monitoring), and after wound dressing (postoperative confirmation). The scrub nurses held primary responsibility for checklist execution, with circulating nurses supporting, and final verification conducted by the surgical resident and the anesthesiologist.

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Concurrently, informal interviews were conducted with the scrub nurses and other surgical team members to gather qualitative insights into the practical challenges and benefits of the instrument management process.

Data Analysis

A mixed-methods descriptive approach was utilized for data analysis. Qualitative data from direct observations and informal interviews were synthesized and triangulated to identify recurring themes regarding workflow efficiency and adherence to safety protocols. Descriptive statistical analysis was applied to measurable quantitative outcomes, specifically operative duration, the total number of instruments prepared and verified, and the quantification of potential complications (e.g., retained items or missing tools) prevented through strict protocol adherence.

Ethical Declaration

This study was conducted as part of a professional nursing practicum and received formal approval from the clinical preceptor, the ward supervisor, and the Ethics Committee of the Faculty of Medicine, Udayana University. All procedures strictly adhered to established ethical research principles. Informed consent was obtained from the patient's family prior to the procedure. The research team ensured absolute patient confidentiality, data anonymization, and strict adherence to the ethical principles of beneficence and non-maleficence throughout the study duration.

PATIENT INFORMATION

A 66-year-old male patient presented to the Emergency Department (ED) following a traffic accident in which he struck his head on the ground. Upon arrival, the patient exhibited a significantly decreased level of consciousness, with a Glasgow Coma Scale (Eye, Verbal, Motor) score of 1-1-1. His medical history revealed previously controlled hypertension. A head CT scan revealed an acute subdural hematoma (SDH) in the left front temporoparietal region with a thickness of 18 mm and a midline shift (MLS) of 21 mm to the right.

CLINICAL FINDINGS

The patient struggled with traumatic intracerebral hemorrhage (tiCH) in the left frontal region (volume approximately 12 cc), cerebral contusions in the right frontal and parietal lobes, and evidence of cerebral edema, further deteriorating the patient's neurological condition. Based on these findings, the patient was diagnosed with severe traumatic brain injury (TBI), necessitating emergency decompressive craniectomy to reduce intracranial pressure and prevent brain herniation and irreversible brain damage.

THERAPEUTIC INTERVENTION

During the preoperative phase, a decompressive craniectomy set consisting of 46 instruments was prepared and verified using a surgical checklist, a process that required 12 minutes and ensured all instruments were sterile, functional, and complete. Intraoperatively, continuous checklist monitoring allowed the surgical team to identify and correct two potential errors (a misplaced forceps and an unsterilized clamp), preventing contamination and saving approximately 15 minutes of operative time. Postoperatively, the final instrument count confirmed that all 46 instruments were intact and accounted for, thereby eliminating the risk of retained foreign bodies and reducing the

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likelihood of postoperative infection. As a result, the patient tolerated the procedure without any instrument-related complications and was transferred to the ICU in stable hemodynamic condition.

As an elderly patient, the decompressive craniectomy procedure required special consideration, particularly in the management of surgical instruments and the readiness of the surgical team. Older adults exhibit different physiological characteristics compared to younger patients, including decreased tissue elasticity, less stable hemodynamic responses, and an increased risk of bleeding. Instrument preparation involved selecting a decompressive craniectomy surgical set, including surgical scissors (e.g., Metzenbaum and dissecting scissors), anatomical and surgical forceps, various clamps such as Mayo mosquito and sponge-holding forceps, elevators, raspatories, and craniotomy tools, including handpiece perforators and trephine drill bits. All instruments were meticulously prepared and inspected by the operating room nurse in accordance with a hospital-adapted surgical safety checklist. This checklist covered verification of instrument quantity and type, sterilization status, and documentation of use throughout the procedure to ensure no instruments were left behind and to minimize infection or other complications.

An initial nursing assessment was conducted thoroughly before the procedure began, including patient identity verification, review of comorbid conditions such as hypertension, and close coordination with the surgical and anesthesiology teams regarding appropriate adjustments to general anesthesia in elderly patients. The nurse was also responsible for matching the prepared instrument set with the checklist designated for decompressive craniectomy and completing detailed documentation on the preoperative observation form. All procedures were conducted in the operating room under the supervision of a clinical preceptor, as part of the author's professional nursing practicum. This case report adhered to ethical research principles, including the confidentiality of patient medical data and obtaining informed consent from the patient's family for all medical interventions.

DISCUSSION

This case report demonstrates that implementing a structured, gerontology-sensitive surgical instrument management protocol significantly enhances both operative efficiency and patient safety during emergency decompressive craniectomy in elderly patients. The clinical scenario involving a 66-year-old male with severe traumatic brain injury highlighted the tangible benefits of this approach. Preoperative verification of 46 instruments was completed in 12 minutes, ensuring absolute readiness. Intraoperative checklist adherence successfully intercepted two distinct errors, specifically a misplaced forceps and an unsterilized clamp, thereby preventing contamination and saving an estimated 15 minutes of operative time. The flawless postoperative count confirmed that all instruments were fully accounted for, eliminating the risk of retained foreign bodies (Badiee et al., 2025). These measurable outcomes underscore the direct clinical value of adherence to systematic checklists in high-stakes neurosurgical environments.

Preoperative instrument verification is a foundational pillar for mitigating medical errors, particularly in geriatric populations, where physiological reserves are inherently diminished. Elderly patients are more prone to postoperative complications, thus requiring meticulous verification to reduce the risk of medical errors that could worsen their condition (Harlanu et al., 2023). During decompressive craniectomy, all cutting and suction devices are thoroughly checked to ensure optimal performance and prevent intraoperative disruptions caused by equipment mismatch (Berra et al., 2023). The current case aligns perfectly with these principles, as the checklist-based verification not only prevented potential mismatches but also saved approximately 12 minutes of operative time. This observed efficiency gain directly supports previous findings by Gomes et al.

(2021), who established that standardized preoperative checklists streamline surgical workflows and reduce preventable delays in complex procedures.

Efficient intraoperative instrument handling is paramount to maintaining surgical momentum and preventing iatrogenic harm in vulnerable older adults. Poor instrument management can lead to procedural delays or errors that may worsen the patient's condition, especially in elderly individuals, who are more vulnerable to tissue injury and other complications (Yan et al., 2024). A well-organized and systematic approach during surgery not only accelerates the operation but also enhances patient safety (Jia et al., 2025). In the present case, continuous intraoperative checklist use successfully intercepted two distinct instrument errors. Preventing the use of the unsterilized clamp directly averted a potential surgical site infection, while resolving the misplaced forceps avoided unnecessary surgical pauses. These results corroborate existing evidence that structured instrument protocols minimize complications and enhance team coordination in elderly surgical care.

Rigorous intraoperative monitoring and documentation are especially critical in geriatric neurosurgery due to the profound physiological vulnerabilities associated with advanced age. Elderly patients require special attention due to physiological differences compared to younger adults, including thinner, more fragile skin; brittle tissues and bones; a higher risk of bleeding; and slower wound healing. Prolonged operative time is particularly hazardous, increasing the risks of hemorrhage, hypothermia, and organ dysfunction. Age-related physiological changes, including reduced vascular elasticity, mild coagulopathy, and limited organ reserves, can result in intraoperative hypotension, massive blood loss, poor tissue perfusion, and hypothermia. Surgeries lasting more than 3 hours significantly increase postoperative complications such as infection and bleeding. The meticulous documentation process used in this study facilitated early identification of instrument issues, thereby mitigating these age-related risks and aligning with global recommendations for elderly surgical safety (Gomes et al., 2021). The 15-minute intraoperative time savings achieved in this case directly mitigated these specific age-related risks, as shorter anesthesia duration correlates with reduced blood loss and better thermal regulation.

Postoperative instrument counting and inspection represent the final, indispensable barrier against retained surgical items and subsequent infectious complications. In elderly patients, who have decreased immunity and wound healing capacity, thorough postoperative instrument checks are vital to prevent infections and other devastating complications. Early detection of damaged or malfunctioning tools also ensures they are repaired before future use (Ferreira et al., 2024). In this specific case, the final postoperative count confirmed that all 46 instruments were intact and fully accounted for. This absolute accountability directly reduced the risk of retained foreign bodies and associated infections, a finding highly consistent with the international literature on checklist safety. The successful execution of this final verification phase underscores the need to maintain vigilance until the very end of the surgical procedure.

The findings of this case report carry significant clinical implications for the standardization of perioperative protocols in geriatric neurosurgery. Current surgical safety checklists are often generic and fail to address the unique temporal and physiological demands of elderly patients undergoing emergency craniectomies. The demonstrated success of a tailored, gerontology-sensitive instrument protocol suggests that hospitals should adopt specialized checklists for high-risk demographics. Implementing such targeted protocols can optimize operating room efficiency, reduce anesthesia exposure time, and ultimately improve survival rates in frail patients. Nursing leadership must champion and integrate these specialized protocols into institutional policies, ensuring that geriatric safety is not an afterthought but a core component of surgical planning. The case also highlights the indispensable role of circulating and scrub nursing teams in orchestrating these safety measures

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and advocating for enhanced training programs focused on geriatric surgical instrument management (Guo et al., 2025).

Despite the valuable insights provided, this study is subject to several inherent limitations that must be acknowledged. The primary limitation is the single-case observational design, which inherently restricts the statistical generalizability of the findings to the broader geriatric neurosurgical population. The reliance on informal interviews and direct observation introduces the potential for recall bias and the Hawthorne effect, wherein surgical teams may alter their behavior simply because they are being observed. The study also lacks robust quantitative outcome measures, such as precise time-motion analysis or comparative data from a control group, and relies solely on the specialized checklist. The estimated time savings of 12 and 15 minutes, while clinically relevant, remain subjective approximations rather than rigorously measured variables. Future research should involve larger, multi-center cohorts and standardized metrics to validate these observations and formally develop evidence-based, gerontology-specific surgical protocols.

CONCLUSION

Effective surgical instrument management is a critical determinant of procedural success and patient safety during decompressive craniectomy in geriatric populations. Rigorous preoperative verification, systematic intraoperative handling, and meticulous postoperative counting collectively mitigate the risks of surgical delays, retained foreign bodies, and postoperative infections in physiologically vulnerable older adults. Operating room nurses must consistently enforce standardized checklists to optimize instrument flow. At the same time, surgical teams should actively develop and integrate gerontology-specific protocols that account for age-related vulnerabilities such as tissue fragility and hemodynamic instability. Subsequent investigations must transcend single-case observational designs by employing larger, multi-center cohorts and objective measurement metrics to validate these findings and establish robust, evidence-based safety guidelines for elderly neurosurgical care.

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