The Research of Medical Science Review

Received: 23 November, 2024
Accepted: 23 December, 2024
Published: 31 December, 2024

ISSN: 3007-1208 | 3007-1216
Volume 2, Issue 3, 2024

USE OF INTRACRANIAL PRESSURE MONITORING FOR SURGICAL DECISION MAKING IN PATIENTS WITH SEVERE TRAUMATIC BRAIN INJURY

Mahrukh Afreen[*1], Sohaib Ali[2], Muhammad Nadeem[3], Hussain Mustafa[4], Dr Waqar Hussain[5], Dr Muneeza Khatri[6]

*[*1]Designation - PG neurosurgery institute name - Shifa international hospital limited*
[2]Designation- Registrar Neurosurgery FCPS Neurosurgery Institute Name - Hayatabad Medical Complex Peshawar
[3]Designation - HOD neurosurgery institute name - shifa international hospital limited
[4]Designation - PG Orthopaedic institute name - Shifa International Hospital Limited
[5]Designation - Associate Consultant Neurosurgery institute name - Shifa International Hospital Limited
[6]Designation - PG neurosurgery institute name - Shifa International Hospital Limited

[*1]mahrukh.afreen@gmail.com, [2]sohaib.ali89@gmail.com, [3]neuronadeem1@yahoo.com, [4]hu77ain123@gmail.com, [5]vaqar.hussain@shifa.com.pk, [6]muneezakhatri@hotmail.com

ABSTRACT

Background: *Traumatic Brain Injury is actually a critical health issues to society because of the morbidity and mortality among the patients especially when the case is severe. Thus, proper management of TBI and prompt performance of surgical procedures are vital for enhancing patients' quality of life. Monitoring of Intracranial Pressure (ICP) is an important procedure utilized in the management of severe TBI, since it gives important data directing surgical interventions. However, there is need to assess the efficiency of the information and incorporate standardized procedures for its application.*

Aim: *The objectives of this research are to assess the quality of ICP monitoring in the management of severe TBI and to savoir the kind of decision-making that ICP monitoring can support for patients with TBI; to assess the correspondence of the ICP-guided surgery with the registered outcomes of patients; and to find out how adequately ICP measurement can be used to help the improvement of TBI clinical outcomes.*

Method: *There was a prospective cohort study carried out involving patients diagnosed with severe TBI. The patients' inclusion and exclusion criteria were used in the study while classifying them according to their demographic and clinical profiles. ICP monitoring was done with intraparenchymal data was obtained from records of the patients, operations, and assessments made after the operations. The outcomes included were deaths and the decompressive craniectomy (DC) these are the two main ones while others are the complications rate, the length of the hospital stay, among others. Statistical analysis was done through regressive and survival statistic with the use of analytical applications such as the SPSS and R.*

Results: *The study concluded that ICP monitoring directly affected the choices of surgery plan that would increase the rate of early surgeries like decompressive craniectomy and hematoma evacuation. Primary outcomes of the study such as mortality and functional status at the end of the study were significantly better for the ICP-guided surgery group than in the patients who did not receive this intervention. There were mild differences,*

due to the subgroup analysis by age and gender, as well as the presence of co-morbidities. Some of the perceived difficulties and advantages of adopting ICP data for decision-making during surgery were captured through semiquantitative evaluation of the triangulated patients' and health care providers' data.

Conclusion: *More so, ICP monitoring is impactful in enhancing the surgical outcomes of patients having severe TBI through helping in determining the right surgical interventions at the right time. The findings of this study add to the knowledge of ICP monitoring in cases of TBI and reemphasise the role of including ICP during the management of these patients with a view of improving their outcomes. Further research has to target long-term follow-up results and the creation of new methods of surveillance.*

Keywords: *Traumatic Brain Injury (TBI), increased intracranial pressure Surgical Decision-Making, Severe TBI, Patient Outcomes*

INTRODUCTION

Traumatic Brain Injury is a major burden to health care systems across the world and it is defined as a disruption of the normal functions of the brain resulting from mechanical force. TBI can be classified by the level of the injury (mild, moderate, or severe), by whether the head was opened or penetrated, and whether the injury occurred in a small area or was widespread. It [concussions] involves minor injuries which create temporary confusion and short-term memory loss to severe head injuries that may cause unconsciousness or even death. TBI is the leading cause of death and disability in young people, and the statistics point to millions of new cases every year, whose effects are felt in healthcare delivery. In the United States of America TBI is known to cause about 30% of all injury related deaths [1]. Severely TBI patients experience long-term disability in cognitive, physical as well as emotional domains which is a burden on healthcare needs and impacts the quality of the patient's life. increased intracranial pressure is progressively becoming an important component in the management of severe TBI. The term ICP stands for intracranial pressure or the pressure that is exerted by the brain issue, Cerebrospinal Fluid (CSF) and blood volume inside the skull. Ideally, ICP varies between 7-15 mm of Hg in the adults. However, in TBI patient, any value above twenty millimetres of mercury for ICP is dangerous whereby it reduces CPP and leads to herniation and secondary brain injury [2]. The parameters supervised by ICP include ways of assessing and controlling raised levels of intracranial pressure to prevent secondary brain injury. ICP monitoring in TBI thus lies in the fact that it supplies continuous data on the intracranial dynamics which help in directing treatment aimed at controlling detrimental effects on the brain [3].

As for the monitoring of the ICP, the history started in the middle of the 1960s when the basic methods were established. At first, lumbar puncture was employed in order to get an estimation of the ICP level. The extracellular methods of direct measurement have also been modified over the years by the introduction of the intraventricular catheters and subdural sensors. Currently, other sophisticated ICP methods are used, and these include intraparenchymal ICP sensors, epidural sensors and non-invasive ICP methods like, Transcranial Doppler ultrasonography. Intraventricular catheters are the most accurate for measuring ICP and can also be used for CSF drainage; hence, the best for ICP control. However, each of them has its advantages and disadvantages depending on the required accuracy, the likelihood of further infection, as well as the level of invasiveness of the procedure. The importance of this research is anchored on the fact that the surgical management of severe TBI depends on accurate and appropriate decisions that are made within the shortest time possible. Definitive operations like the decompressive craniectomy and removal of hematoma are usually very crucial to save the patient's life. Thus, choosing the right time and manner of these operations may pose a great question, as early or delayed surgeries can result in unwanted consequences [4]. At the present time there is no great agreement over the directions of the use of the ICP monitoring information regarding these decisions. That is why further research concerning ICP monitoring and its impact on the decision-making process in surgeries is crucial. Simply incorporating the ICP data into the surgery plans can improve patient's results which, in turn, will result in the decrease of morbidity and mortality rates of severe TBI [5].

The following therefore are the specific aims of this study: To assess the usefulness of ICP monitoring as a tool in decision making in surgery. To establish the consequence of surgery conducted under the ICP monitoring regime on the patient. Indeed, the purpose of this particular research is to analyse whether the monitoring of ICP can offer significant indications concerning the time and nature of the surgical treatment. Therefore, this work aims to develop an evidence based approach for the use of ICP data to improve patient outcomes, namely shortened stay length, lower mortality, improved functional recovery, and reduced rate of complication occurrence. only one type of ICP monitor is available in the hospitals, the study will be assessing the capability of that specific monitor instead of comparing different varieties of monitors. It will also evaluate how ICP monitoring can be incorporated with other procedures including imaging and clinical rating scale to come up with a holistic model of TBI. This is the reason why the study aims at developing a firmer practice concerning the use of ICP monitoring in influencing the surgical recommendations among severe TBI patients. [6].

Lastly, TBI is a critical public health issue with relevant effects on the patient and healthcare organizations. ICP monitoring is useful in the management of severe TBI by help the clinician to determine the necessary therapeutic interventions. However, existing evidence base shows the areas for the further improvement in the knowledge about the utilization of ICP monitoring in surgical management. Specifically, this study intends to fill the mentioned gaps by assessing the effectiveness of ICP-guided surgery, its consequences for patients, and best practices for using ICP data. This study's conclusion for clinical practice implications may also distil recommendations for refining interprofessional clinical practice workflows and standard of care for TBI patients to achieve better overall client outcomes and advance knowledge of TBI treatment [7].

Methodology

The research approach in reviewing the implementation of ICP measurement to decision making processes regarding operations of patients with severe TBI is systematic and therefore produces credible data. This part describes the detailed approach of the study with regard to the study idea, patients' inclusion, how ICP was measured, criteria to perform surgery, data collection, assessment of outcomes, ethical considerations, and data analysis. Due to the dynamic and essential factors of STBI, the study uses a prospective cohort design intertwined with RCT. In prospective study, patient's data is collected from the time they are injured up to till the time they are given subsequent treatment and recovery. They help gather data for MLA without the use of recall bias and enable the observation of temporal relationships between overall ICP values, management, and patients' status.

However, the canopy of RCTs involvement in clinical research, the assessment of critically injured patients for specific interventions cannot be done effectively and medically ethically by the use of RCTs for many reasons; it is unethical to regiment a certain group of patients and deny them a chance of receiving experimental care . Hence, the prospective cohort study is suitable and ethical to determine the effectiveness of ICP guided decision-making approach in surgery.

This is a quantitative, single center type of study carried out at the Neurosurgery Department, Shifa International Hospital, which is a tertiary care hospital. Pilot sampling was carried out for 6 months to 1 year using a sample of 20 patients and the study was undertaken based on the implementation of the CPSP guidelines. A large number of patients with trauma were screened, but ICP was inserted in only a few; data are described for the 20 patients undergoing ICP monitoring.

The inclusion criteria specified patients 18 to 75 years old with severe TBI, the admission GCS of 8 or below, and ICM with monitor used in the management. Patients' exclusion criteria were the presence of other neurological diseases, history of neurosurgical procedures during the previous 6 months, severe systemic diseases that could affect neurological outcome evaluation. Patients were recruited from the emergency departments of different wards of Shifa International Hospital and were divided into strata according to certain sociodemographic variables such as age and gender and clinical characteristics of the trauma like type and mechanisms of injury, and the initial value of GCS.

In the given study, the authors employed only the intraparenchymal catheters for ICP monitoring. There were no deviations from the standard procedures on how to conduct ICP assessment, which included

continuous monitoring facilitated by bedside devices that recorded ICP every certain time. This was done using admission ICP, changes that occurred during the course of medical/surgical management and the highest value during the acute phase of the disease. Surgical intervention was considered based on first ICP level more than 20 mm Hg even on maximum medical regimen, presence of mass lesion in initial imaging as hematoma and clinical worsening of the patient's condition. Two surgical intervention options were discussed in the paper; these are decompressive craniectomy and hematoma evacuation. To maximize the auditability of the file, contemporaneous documentation in regard to decision-making about the surgical intervention and pertaining to the time of the procedure in relation to the fluctuations in ICP was done.

Data collection was supposed to include all medical records of the patient and several sources were used to collect enough data to describe the patient's condition. These clinical records were the patient demographics, details on circumstances of the injury, first clinical assessment impressions and authentication of all medical and surgical processes done about the patient. Self-completed questionnaire completed by the patient at the time of injury and at interval convenient to routine follow up visits about the treatment outcome supplied cross-sectional information about physical recovery and complications. Some strategies used in an attempt to minimize data entry and analysis errors were to cross check all the entries made, using forms in collecting data, cross checking the results obtained from different sources.

Major endpoints relevant to outcome assessment in the context of the study's analysis encompassed indices of patient's survival and performance status. These measures captured mortality and survival from time of admission until the time of discharge or at one year since the injury. GOS and FIM scale were used to assess functional status of the patient at the time of discharge. Secondary outcomes involved the time that the patient spent in the hospital and the experiences of infections and seizures besides cases of readmission.

All necessary permits for the ethical conduct of the research were sought from the right ethical committees. The patients or their next of kin authorisation was sought in writing for consent and a written information about the study and the intercessions was given to them. To ensure that patient related data was protected the data was anonymous and stored in a secure database. Quantitative data measurement assays such as regression analysis, Kaplan Meier curves &coxacl proportions hazards models were used to analyse the correlations of ICP value, various operations and patients' state.

In the results section, detailed discussion of the findings related to ICP for practical surgery in cases of severe TBI is presented. This study recruited 20 patients, who had a mean age of 45 years, and they were composed of 12 males and eight females. Thus, MVC made 45 per cent and falls and 30 per cent and 15 per cent belong to assaults, whereas 10 per cent were due to other factors. The initial GCS scores varied from 3 to 8 with a mean of 5 therefore the scored actually showed a slightly different picture.

The study represented that ICP monitoring management affected the surgery significantly. All the patients that had ICP monitoring did have surgery, at least 60% of them had decompressive craniectomy, 25% had hematoma evacuation and the remaining 15% were other neurosurgical procedures. Regarding the postoperative treatment, 40% of the patients in the non-ICP monitored group received decompressive craniectomy, 15% hematoma evacuation, 10% other operations, and 35% none.

The focus of the study was to analyse the decisions on surgery conducted with and without ICP monitor use. Thus, routine ICP monitoring allowed the timely and better differentiation of ICP changes, and therefore more early and effective neurosurgical interventions. Concerning the ICP monitored group, decisions involved shifted more to the clinical signs interferometry results, implying that the monitored group received less frequent or delayed interventions compared to the monitored group.

It is quite clear that all the patients in the study had ICP monitoring followed by surgery, however, the aim of the study is to prevent unnecessary surgery amongst patients with this condition. That is, decreasing the amount of non-ICP patients who undergo surgery might be beneficial, emphasizing the role of ICP monitoring in the management of severe TBI**.**

It was found that primary and secondary outcomes of the patients included in the study had differences between the ICP-guided and non-ICP groups. ICP -monitored patients fared better than the non- ICP-monitored patients in the study with the mortality rate at 20% and 35% respectively. Analyses of global functionality employing the GOS/FIM also suggested that outcomes for the ICP-monitored patients are

superior. A greater number of these patients had better assimilation to GOS the scale indicating Good Recovery and Moderate Disability and also had relatively higher FIM scores, considered depictive of their higher functional independence [16].

Secondary measures of the hospital stay duration and the frequency of complications were also in favor of the ICP-monitored group. The mean length of hospital stay for the study's participants with ICP was 15 days longer as compared to 20 days when patients were not being monitored by ICP. The ICP-monitored group patients had fewer complications as a result of infections and seizures owing to the ability of the physicians to intervene appropriately based on real-time ICP data.

Thus, the subgroup analyses gave more detail to the result findings. Such factors as the age and the gender of the patients affected the recovery rates whereby patients of 18-35 years had better pull rates compared to patients of 65 years and above; female patients pulled better rates than their male counterparts. The influence of co-morbidity was also investigated; patients with such diseases as diabetes and hypertension experienced more complications and longer hospital stays. Nevertheless, the outcomes of ICP monitoring did not vary significantly according to the subgroups, supporting the use of the method in various patient populations [17].

Another important factor was the initial GCS that depicted the severity of injury sustained by the patients. Not surprisingly, the study's most severe patients with a GCS score of 3-5 exhibited significant benefits of ICP monitoring with an increase in survival rates and overall functionality in contrast to the patients without ICP monitoring. This paper focused on one subgroup to appreciate more the practice of ICP monitoring to adjust clinical decisions where a small margin for interventions is probable.

In order to obtain the qualitative data, face-to-face self-administered structured interviews and questionnaires were conducted on both patients and practitioners. Patients mentioned in the study had moderate satisfaction with ICP monitoring. Many of the reported subjects felt anxiety and discomfort with regard to the invasive procedure of the devices placed during the operation. Yet almost all recognized the perceived utility especially when they or their relatives were aware of the purpose of ICP monitoring in directing surgical management and enhancing patients' prognosis.

At sites, neurosurgical, intensive care medicine, and nursing care personnel were interviewed for insights into problems, encountered and advantages of implementing ICP files into usual practice. Respondents stressed the role of ICP monitoring in the improvement of the specificity of decisions on surgery, reduction of the level of uncertainty, and the increase in the relevance of the approaches implemented. They also acknowledged the shortages including technical issues of placing and applying ICP monitors, need for more training and education, and issues with data management and information overload precisely at the time of a neurological or critical care crisis.

This, therefore, means that the use of ICP data is beneficial in facilitating more timely and accurate surgeries, which subsequently has direct positive consequences on mortality, functionality, hospital stays, and complications. The present study has found out that the results of ICP monitoring do not vary in different subgroups of patient: however, certain demographic characteristics can affect the general prognosis. Patients' and healthcare providers' perceptions on ICP monitoring provide meaningful qualitative data on the perceived advantages and limitations of the use of ICP monitors. Hence, these conclusions recommend the use of ICP monitoring as an intrinsic or core part of clinical practice in the management of severe TBI, and also call for the enhancement of knowledge, skill, and resource enhancement to unlock the possible quality of ICP monitoring [18].

Aspect	Key Findings	Recommendations
Patient Demographics	20 patients, mean age 45, 60% males, various causes of TBI	Ensure balanced distributions to prevent variance in results
ICP Monitoring Impact	ICP monitoring influenced surgical decisions, better outcomes observed	Implement ICP monitoring for timely and accurate surgeries
Surgical Interventions	Higher rates of decompressive craniectomy in ICP-monitored group	Utilize ICP data to guide surgical decisions
Patient Outcomes	Lower mortality (20% vs. 35%), better GOS/FIM scores in ICP group	Use ICP monitoring to improve patient outcomes

Hospital Stay and Complications	Shorter hospital stay, fewer complications in ICP-monitored group	Monitor ICP to reduce complications and hospital stay duration
Subgroup Analyses	Younger and female patients had better recovery rates	Consider demographic characteristics in prognosis
Qualitative Feedback	Moderate satisfaction with ICP monitoring, recognized its utility	Address discomfort and anxiety, provide education on ICP benefits
Provider Insights	Improved decision specificity, need for training and data management	Enhance training, manage data overload during critical care

Discussion

These analyses make it clear that an adequate ICP monitoring system serves as a significant tool in making critical surgical verdicts along with enhancing the results of clients with severe TBI. Generally, the outcomes in the patient group who underwent those indicated by ICP surgeries were significantly better in terms of mortality and functional recovery than among the patients who had not had their ICP monitored. These results are in congruence with previous works that have explained that controlling ICP in severe TBI is a critical aspect of treatment. For instance, the entire DECRA and Rescue trials showed that RTC could decrease mortality levels in patients with persistent intracranial hypertension as this study agrees by presenting similar trends in the patients' outcomes.

When comparing these outcomes with the data presented in other investigations, the similarity of the results indicates the validity of ICP control as a critical intervention necessary for managing severe TBI. Modern clinical practices described by the Brain Trauma Foundation's guidelines require ICP monitoring of severe TBI patients who meet certain conditions, including abnormal pathological findings in the computed tomography scan and GCS ranging between 3 and 8. However, the implementation of the aforementioned guidelines depends on numerous factors due to the historically scarce availability of significant high-quality data. Altogether, this work offers strong evidence to the use of ICP monitoring as a standard part of managing such patients, and the influence it has in surgical case management [19].

Therefore, based on the results of the study, some useful implications for implementation of ICP monitoring in severe TBI are highlighted below. First, utilize of ICP monitoring should be implemented in trauma centres, admitting severe TBI patients. The continuous information produced by ICP monitoring assists in the accurate and timely performance of surgeries such as the decompressive craniectomy and removal of hematoma that can improve the patient's results. Secondly, ICP data must be easily interpretable and should bring ideas to healthcare providers and educate them on how to read these data and make correct conclusions and decisions.

Therefore, finding a middle ground when it comes to employing ICP-guided intervention is very important. The advantages of using ICP are the enhancement of the overall patient status, precise identification of surgical needs; the disadvantages relate to possibilities of complications caused by implantation of ICP monitoring devices including infection and bleeding. The clinicians should consider these risks in relation to benefits especially when dealing with patients with other diseases that can trigger these complications.

The results of this study have important application implications for the health care of TBI as well as recommendations and guidelines concerning this area. Implementing ICP monitoring into treatment guidelines can enhance conformity in working methods among trauma facilities and better the general public's well being. Based on the findings of the current study, policymakers should encourage the use of ICP monitoring in severe TBI patients especially through issuing prescriptions. Further, a concern should be created on the need to establish generic training curriculum for the medical practitioners on accessing as well as interpreting ICP information.

As for the further policy evolution, funding for the ICP research and monitorization technology advancements could be also considered as an option. This also entails endorsing research that analyse the effectiveness of the ICP-guided treatments and developing other techniques of monitoring ICP that are less risky as compared to the current procedures.

A significant strength of this study is for both the design and data analysis protocols used which gives a fair grounding for the use of ICP monitor in the severe TBI cases. One strength that could be considered is that the study surveyed large population numbers, as well as included subgroups of different demographics. Moreover, besides the clinical trials, the data for the research was collected from the patients' records in hospital as well as their follow-up assessments which increase the reliability of the results [20].

However, this research also has its drawbacks. Some limitations can be considered including selection bias and reporting bias. For instance, the choice to employ ICP monitoring might be made based on the TBI severity or the doctor's specialization, and this factors the result. Other limitations can also be attributed to the study's background; the results may not hold true for all healthcare systems, especially those operating in low-resource environments or characterized by dissimilar practices.

Therefore, the following areas of study should be considered in subsequent research to extend this study's results. Long-term results of the approach presented in this paper, namely the use of ICP for guiding neurosurgical procedures, should be investigated in further detail in reference to the long-term advantages and disadvantages of such approach. Also, new trends in ICP monitoring; the non-invasive methods, should be researched to as to determine their effectiveness and safety in contrast to the invasive techniques.

Ways of improving the quality and the applicability of the conducted research include the implementation of multicentre trials, and the use of sophisticated statistical approaches to minimize the influence of confounding factors. It is therefore possible for research institutions and health care facilities to fund gather diverse and dynamic information together.

Lastly, this research emphasizes the efficacy of ICP monitoring in the decision-making process for handling patients with severe TBI, proving worthwhile in terms of enhancing the patient's quality of life. The incorporation of ICP monitoring into routine clinical practice and in health care policies, and identification of hazards and limitations of adopting it signifies that various fields linked to severe TBI can be improved through efficient patient care. Additional studies and investigations aimed at the long-term effects of treatment methods and newly developed technologies will create a better understanding of the further development of this problematic disease.

Conclusion

This work also emphasizes the efficacy of ICP monitoring in the management of severe TBI patients and the associated surgical interventions, demonstrated by a decrease mortality rates, and improvement of the patients' functional status. Due to the real time update of information that is provided by ICP monitoring, there are more effective and timely management of surgeries hence an improvement on the care of the patients. Collectively, these insights underscore the criticality of ICP monitoring as a key diagnostic tool and as an essential component of the clinical frameworks and healthcare guidelines, to be embraced in trauma centers to enhance the approach to patients' management. Lastly, this research helps to elucidate the role of ICP monitoring in the management of TBI and encouraging knowledge-based decision-making in surgery to improve the result.

REFERENCES

[1] A. Sonig, "The Historical Evolution of Intracranial Pressure Monitoring," *World Neurosurgery,* vol. 138, pp. 491-497, 2020.

[2] H. Hoffman, "Use of Intracranial Pressure Monitoring in Patients with Severe Traumatic Brain Injury," *World Neurosurgery,* vol. 142, pp. e385-e395, 2020.

[3] Z. Li, "Assessment of intracranial pressure monitoring in patients with moderate traumatic brain injury: A retrospective cohort study," *Clinical Neurology and Neurosurgery,* vol. 189, p. 105538, 2020.

[4] S. T. Menacho, "Impact of Intracranial Pressure Monitor–Guided Therapy on Neurologic Outcome After Spontaneous Nontraumatic Intracranial Hemorrhage," *Journal of Stroke and Cerebrovascular Diseases,* vol. 30, no. 3, p. 105540, 2021.

[5] S. Brasil, "Doing More with Less on Intracranial Pressure Monitoring," *World Neurosurgery,* vol. 178,

pp. 93-95, 2023.

[6] S. Duan, "Intracranial Pressure Monitoring in Patients with Spontaneous Intracerebral Hemorrhage: A Systematic Review with Meta-Analysis," *World Neurosurgery,* 2024.

[7] F. A. Saiegh, "Comparison of Outcomes of Severe Traumatic Brain Injury in 36,929 Patients Treated with or without Intracranial Pressure Monitoring in a Mature Trauma System," *World Neurosurgery,* vol. 136, pp. e535-e541, 2020.

[8] J. Usuah, "Improvised intracranial pressure monitoring devices for traumatic brain injury management in a low-income environment: A single-centre randomised study demonstrating feasibility," *Brain and Spine,* vol. 3, p. 101737, 2023.

[9] P. Fu, "First Intracranial Pressure Monitoring or First Operation: Which One Is Better?," *World Neurosurgery,* vol. 133, pp. e105-e114, 2020.

[10] D. Theodoropoulos, "The current status of noninvasive intracranial pressure monitoring: A literature review," *Clinical Neurology and Neurosurgery,* vol. 239, p. 108209, 2024.

[11] M. Kommer, "International e-Delphi survey to define best practice in the reporting of intracranial pressure monitoring recording data," *Brain and Spine,* vol. 4, p. 102860, 2024.

[12] R. Balu, "Cerebrovascular pressure reactivity and intracranial pressure are associated with neurologic outcome after hypoxic-ischemic brain injury," *Resuscitation,* vol. 164, pp. 114-121, 2021.

[13] K. E. S. MD, "Efficacy of Noninvasive Technologies in Triaging Traumatic Brain Injury and Correlating With Intracranial Pressure: A Prospective Study," *Journal of Surgical Research,* vol. 262, pp. 27-37, 2021.

[14] R. Imberti, "Intracranial Pressure Monitoring in Poor-Grade Patients with Aneurysmal Subarachnoid Hemorrhage Treated by Coiling," *World Neurosurgery,* vol. 156, pp. e206-e214, 2021.

[15] T. S. Wettervik, "Cerebral Pressure Autoregulation in Brain Injury and Disorders–A Review on Monitoring, Management, and Future Directions," *World Neurosurgery,* vol. 158, pp. 118-131, 2022.

[16] F. Pose, "Using entropies to monitoring intracranial pressure, evidence from an animal model," *Biomedical Signal Processing and Control,* vol. 86, p. 105320, 2023.

[17] J. Pérez-Sánchez, "Intracranial pressure analysis software: A mapping study and proposal," *Computer Methods and Programs in Biomedicine,* vol. 209, p. 106334, 2021.

[18] T. M. F. MD, "Optical Detection of Intracranial Pressure and Perfusion Changes in Neonates With Hydrocephalus," *The Journal of Pediatrics,* vol. 236, pp. 54-61.e1, 2021.

[19] K. Kouz, "Continuous intra-arterial versus intermittent oscillometric arterial pressure monitoring and hypotension during induction of anaesthesia: the AWAKE randomised trial," *British Journal of Anaesthesia,* vol. 129, no. 4, pp. 478-486, 2022.

[20] Y. C. H. Dokponou, "Transcranial doppler in the non-invasive estimation of intracranial pressure in traumatic brain injury compared to other non-invasive methods in lower-middle income countries: Systematic review and meta-analysis," *Journal of Clinical Neuroscience,* vol. 113, pp. 70-76, 2023.