

SEMINARS IN MEDICINE SEMINARI IZ MEDICINE

WHEN SECONDS COUNT – ETHICAL AND EVIDENCE-BASED MANAGEMENT OF NEUROSURGICAL EMERGENCIES IN PREGNANCY

KADA SEKUNDE ODLUČUJU – ETIČKO I NA DOKAZIMA ZASNOVANO ZBRINJAVANJE NEUROHIRURŠKIH HITNIH STANJA U TRUDNOĆI

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Abstract

Introduction. Neurosurgical emergencies during pregnancy are associated with maternal and fetal risk and require rapid, coordinated, and ethically sound decision-making. Conditions such as traumatic brain injury, intracranial hemorrhage, rapidly expanding intracranial tumors, acute hydrocephalus, and spinal cord compression often necessitate urgent intervention despite the physiological adaptations of pregnancy, altered pharmacokinetics, anesthetic constraints, and limitations in diagnostic imaging. Owing to the predominance of case reports and small series in the literature, management strategies are frequently individualized. **Material and Methods.** This narrative review synthesizes the available literature on urgent neurosurgical care in pregnant patients, with particular emphasis on maternal and fetal outcomes, pregnancy-specific modifications of neurocritical and surgical management, and ethical considerations. A structured search of PubMed and Scopus was conducted to identify relevant studies addressing surgical timing, perioperative strategies, multidisciplinary coordination, and reported ethical dilemmas. **Conclusion.** The reviewed evidence underscores the importance of early diagnosis, prioritization of maternal stabilization, and close collaboration among neurosurgery, obstetrics, anesthesia, and neonatology teams. When indicated, neurosurgical procedures should generally not be delayed solely due to pregnancy, and individualized anesthetic strategies may help minimize fetal exposure. Ethical issues – including informed consent, maternal autonomy, and consideration of fetal interests – require clear communication and shared decision-making. Despite improvements in care, standardized management guidelines remain limited, highlighting the need for higher-quality evidence and structured interdisciplinary treatment pathways.

Key words: Pregnancy; Brain Injuries, Traumatic; Intracranial Hemorrhages; Neurosurgical Procedures; Patient Care Team; Ethical Dilemmas

Sažetak

Uvod. Neurohirurška hitna stanja tokom trudnoće nose visok rizik za majku i fetus i zahtevaju brzo, koordinisano i etički utemeljeno donošenje odluka. Stanja poput traumatske povrede mozga, intrakranijalnog krvarenja, brzorastućih tumora, akutnog hidrocefalusa i kompresije kičmene moždine zahtevaju pravovremenu intervenciju, uprkos izazovima koje nameću fiziološke promene trudnoće, izmenjena farmakokinetika, ograničenja u primeni anestetika i smanjene dijagnostičke mogućnosti. Pošto se većina dostupnih dokaza zasniva na prikazima slučajeva i manjim serijama slučajeva, postupanje se često prilagođava svakoj pojedinačnoj pacijentkinji. **Materijal i metode.** Ovaj rad obuhvata postojeću literaturu o urgentnoj neurohirurškoj nezi kod trudnica, sa fokusom na ishode za majku i fetus, specifične modifikacije neurokritične i hirurške nege, kao i etičke aspekte. Strukturisano pretraživanje naučnih baza *PubMed* i *Scopus* identifikovala je studije o hirurškom tajmingu, perioperativnim strategijama, multidisciplinarnoj koordinaciji i zabeleženim etičkim dilemama. **Zaključak.** Ključni rezultati ističu značaj rane dijagnostike, stabilizacije majke i bliske saradnje neurohirurga, ginekologa-akušera, anesteziologa i neonatologa. Neophodne hirurške intervencije, po pravilu, ne treba odlagati zbog trudnoće, a prilagođene anestezičke strategije mogu smanjiti fetalnu izloženost lekovima. Etička pitanja – uključujući informativni pristanak, autonomiju majke i interese fetusa – zahtevaju jasnu komunikaciju. Uprkos napretku, standardizovane smernice ostaju ograničene, što naglašava potrebu za jačim dokazima i strukturisanim interdisciplinarnim pristupom.

Ključne reči: trudnoća; traumatske povrede mozga; intrakranijalno krvarenje; neurohirurške procedure; multidisciplinarni tim; etičke dileme

Abbreviations

TBI	– traumatic brain injury
MRI	– magnetic resonance imaging
CT	– computed tomography

Introduction

Neurosurgical emergencies in pregnancy represent a high-risk clinical domain in the intersection of acute neurocritical care and maternal–fetal medicine. These conditions are associated with disproportionate maternal and perinatal morbidity and mortality due to the concurrence of rapidly progressive neurological compromise and the complex physiological adaptations of gestation. Clinical management is further complicated by diagnostic and therapeutic limitations, variability in institutional expertise, and a scarcity of high-quality evidence. As a result, optimal outcomes depend on early recognition, prompt intervention, and coordinated multidisciplinary care, with treatment strategies carefully individualized to balance maternal stabilization with fetal safety. The continued reliance on case reports and expert consensus highlights the lack of structured, evidence-informed frameworks applicable to these uniquely challenging scenarios [1–12]. The clinical spectrum encompasses a heterogeneous group of acute, potentially life-threatening conditions, including intracranial and subarachnoid hemorrhage, traumatic brain injury (TBI), rapidly expanding intra-axial and extra-axial mass lesions, acute hydrocephalus, spinal cord compression syndromes, and other cases of sudden neurological deterioration. Although relatively uncommon, these entities are associated with substantial maternal morbidity and increased perinatal vulnerability, often exacerbated by diagnostic delays, concerns regarding fetal exposure to imaging modalities, and hesitancy to pursue timely invasive interventions [2,3,7,10].

Pregnancy-related physiological changes – such as altered cerebrovascular reactivity, increased intravascular volume, gestation-specific modifications in coagulation and hemostasis, reduced functional residual capacity, and significant alterations in pharmacokinetics and anesthetic sensitivity – further complicate the application of standard neurocritical and neurosurgical algorithms. These adaptations necessitate recalibration of monitoring strategies, neuroprotective measures, surgical timing, and anesthetic management to mitigate risks to both maternal neurological function and fetal viability [4,12]. Beyond clinical and physiological complexity, neurosurgical emergencies in pregnancy raise profound ethical challenges. Decision-making may be influenced by maternal-fetal risk asymmetry, particularly when urgent intervention carries uncertain fetal con-

sequences or when gestational age affects neonatal viability, the feasibility of perimortem delivery, or therapeutic aggressiveness. In the absence of comprehensive guidelines and robust prospective data, clinicians must rely on multidisciplinary deliberation, structured ethical analysis, and transparent patient counseling to guide management [1,5,8,9]. The convergence of neurological urgency, physiological vulnerability, and ethical uncertainty underscores the need for comprehensive, evidence-informed approaches integrating emergent neurosurgical priorities with maternal-fetal considerations.

Material and Methods

This review aims to synthesize current evidence and expert consensus regarding neurosurgical emergencies during pregnancy, identifying gestation-specific physiological, diagnostic, anesthetic, and therapeutic factors requiring modification of standard neurosurgical practice, and examine prevailing ethical challenges and multidisciplinary decision-making frameworks.

A structured literature review was conducted using the PubMed and Scopus databases, identifying relevant publications available up to the time of writing. Search terms included combinations of “neurosurgical emergencies”, “pregnancy”, “intracranial hemorrhage”, “traumatic brain injury”, “spinal lesions”, “neurocritical care”, “maternal outcomes”, and “ethical considerations”. Original research articles, systematic reviews, narrative reviews and case series were included.

Eligibility criteria encompassed studies addressing urgent neurosurgical interventions in pregnant patients, reporting maternal or fetal outcomes, or discussing ethical and clinical decision-making processes. Exclusion criteria included non-acute neurosurgical conditions, non-human studies, and reports lacking sufficient clinical or methodological detail. Studies from both low- and high-resource settings were included to reflect variability in institutional capabilities and practice patterns.

Data extraction focused on maternal and fetal morbidity and mortality, timing and type of neurosurgical intervention, anesthetic strategies, multidisciplinary coordination, and documented ethical dilemmas. The extracted evidence was synthesized to identify core principles guiding clinical practice, emphasizing pregnant-specific physiologic considerations, perioperative risk mitigation, and evidence-informed, ethically grounded decision-making. Where available, consensus statements and institutional protocols were incorporated to provide a structured framework applicable across diverse clinical environments.

Discussion

Neurosurgical emergencies during pregnancy constitute rare but high-stakes clinical situations in which acute neurological deterioration threatens both maternal and fetal survival. Conditions such as traumatic brain injury (TBI), intracranial hemorrhage, rapidly expanding intracranial tumors, and other fulminant neurosurgical pathologies require urgent intervention to prevent maternal morbidity and mortality, while simultaneously accounting for fetal well-being [1,2]. The complexity of management arises from pregnancy-related physiological adaptations, altered pharmacodynamics, anesthetic constraints, and the necessity for rapid multidisciplinary coordination [3,4].

Although uncommon, these emergencies carry profound consequences. Esmailzadeh et al. [1] reported that prompt diagnosis and timely neurosurgical intervention are essential for optimizing maternal outcomes without necessarily compromising fetal viability. Severe TBI during pregnancy exemplifies the dual-

patient challenge, wherein life-saving maternal interventions may entail unavoidable fetal risk [2,3]. Ethical dilemmas frequently arise when maternal and fetal interests appear discordant, necessitating careful application of ethical principles such as autonomy, beneficence, and non-maleficence. Physiological adaptations of pregnancy complicate both diagnostic evaluation and therapeutic planning [4]. Magnetic resonance imaging (MRI) is generally preferred for neuroimaging due to the absence of ionizing radiation, while computed tomography (CT) remains justified in emergent situations requiring rapid assessment [3,5]. Importantly, the literature consistently indicates that necessary neurosurgical procedures, including craniotomy and tumor resection, should not be delayed solely because of pregnancy, as postponement is associated with worse maternal outcomes [5,6]. Anesthetic management must be carefully tailored, following neuroanesthetic principles adapted to pregnancy-specific physiological constraints [4]. Multidisciplinary collaboration is repeatedly emphasized as a determinant of favorable

Table 1. Key neurosurgical emergencies during pregnancy

Condition	Clinical presentation	Diagnostic limitations in pregnancy	Therapeutic priorities	Perioperative considerations	Expected outcomes
Traumatic brain injury (TBI)	Altered consciousness, focal neurological deficit, raised intracranial pressure; often associated with polytrauma	Limited use of CT due to radiation concerns; MRI preferred when feasible; fetal monitoring may interfere with acute imaging	Rapid maternal stabilization, airway protection, control of intracranial pressure; neurosurgical intervention when indicated	Multidisciplinary trauma management; left lateral positioning to avoid aortocaval compression; cautious use of sedatives and osmotherapy	Maternal outcome depends on injury severity; fetal outcome closely linked to maternal hemodynamic stability
Intracranial hemorrhage (ICH)	Sudden headache, focal deficit, decreased level of consciousness; may be associated with hypertension or coagulopathy	CT often required in emergencies despite radiation exposure; MRI useful for etiological assessment	Immediate blood pressure control, reversal of coagulopathy, urgent neurosurgical evacuation when indicated	Tight hemodynamic control; avoidance of hypotension and hypoxia; fetal monitoring in viable gestation	Favorable outcomes possible with timely intervention; delays increase maternal and fetal mortality
Intracranial tumors	Progressive neurological deficits, seizures, signs of raised intracranial pressure; symptom progression may accelerate during pregnancy	MRI without contrast preferred; gadolinium generally avoided; limited role of CT	Symptom control; surgical resection if neurological deterioration occurs; elective surgery deferred when stable	Timing of surgery individualized by gestational age and tumor behavior; anesthetic strategies minimizing fetal exposure	Generally good maternal outcomes with appropriate timing; fetal outcomes favorable when maternal stability maintained
Acute hydrocephalus	Headache, nausea, vomiting, altered mental status, papilledema	MRI preferred; rapid imaging essential despite pregnancy	Urgent cerebrospinal fluid diversion (EVD or shunt)	Careful fluid and electrolyte balance; infection prevention; coordination with obstetric team	Good maternal and fetal outcomes when treated promptly
Spinal stenosis/cord compression	Progressive motor weakness, sensory loss, sphincter dysfunction	MRI is modality of choice; diagnostic delay may occur due to nonspecific symptoms	Urgent decompression in cases of neurological deterioration	Prone positioning challenges; gestational age-specific anesthetic planning	Neurological recovery depends on timing of intervention; fetal outcomes generally favorable

outcomes. Cohen-Gadol et al. [5] demonstrated improved results when neurosurgeons, obstetricians, anesthesiologists, and neonatologists jointly determined the timing and extent of intervention. Maternal stabilization remains the primary priority, with fetal considerations informing perioperative planning than delaying essential treatment [3,7]. Established guidelines for management of pregnant trauma patients emphasize structured protocols that integrate ethical deliberation with clinical urgency. In the absence of an immediate threat to maternal life or evidence of a rapidly progressive neurological deterioration, deferring surgery until the postpartum period is generally appropriate. Conversely, when operative intervention is clearly indicated, it should not be delayed because of pregnancy, as maternal safety remains the overriding priority. Elective or non-urgent procedures are optimally scheduled during the second trimester, when the risks of miscarriage and preterm labor are lowest, whereas in early pregnancy patients can often be managed similarly to non-pregnant individuals [7].

Ethicolegal considerations further complicate urgent decision-making. Informed consent must address potential maternal and fetal risks under time-critical conditions, while jurisdiction differences in maternal autonomy and fetal rights influence clinical and legal responsibility. Comprehensive documentation of ethical reasoning and risk-benefit assessment is therefore essential [8]. Emerging strategies, such as awake craniotomy in selected pregnant patients, have demonstrated feasibility and may reduce fetal exposure to anesthetic agents while allowing real-time neurological assessment [10]. Similarly, evidence from intracranial hemorrhage and TBI case series suggest that

timely, evidence-based intervention can yield favorable maternal and neonatal outcomes when guided by structured neurocritical care protocols adapted for pregnancy [11,12]. Collectively, these observations underscore the need for structured, ethically grounded, and evidence-based clinical pathways capable of addressing the inherent dual-patient complexity of neurosurgical emergencies during pregnancy (**Table 1**). Despite advances in clinical management, significant gaps remain in the development of standardized guidelines for pregnant patients requiring urgent neurosurgical care. Many current recommendations are derived from case reports or extrapolations from non-pregnant populations, highlighting the need for multicenter prospective studies and registries to generate robust data [6,9]. Ethical dilemmas, legal constraints, and logistical challenges in acute care settings further hinder standardization. Nevertheless, the integration of contemporary evidence with ethical frameworks and close multidisciplinary collaboration remains the most reliable strategy for optimizing both maternal and fetal outcomes.

Conclusion

Neurosurgical emergencies during pregnancy require rapid, individualized, and ethically grounded decision-making within a multidisciplinary team. Clinicians must navigate dual responsibilities toward both mother and fetus, guided by evolving evidence, expert consensus, and jurisdiction-specific ethical and legal frameworks. Continued research is essential to establish standardized guidelines capable of optimizing outcomes in these high-risk clinical scenarios.

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