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Ultrasound-Guided Regional Anesthesia for Clavicle Fixation in a Pregnant Patient with Traumatic Brain Injury: A Case Report and Pathophysiological Review

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A B S T R A C T

The anesthetic management of a third-trimester pregnant patient with a concurrent traumatic brain injury (TBI) and a surgical fracture presents a profound clinical dilemma. The conflicting demands of maternal neuroprotection, fetal stability, and surgical anesthesia necessitate a carefully considered approach, as standard general anesthesia carries significant risks for both mother and fetus. A 25-year-old female at 28 weeks' gestation presented after a motor vehicle accident with a displaced right clavicle fracture and a TBI characterized by a clinically mild presentation (Glasgow Coma Scale 14) and a radiologically significant acute subdural hemorrhage. To provide surgical anesthesia for open reduction and internal fixation while circumventing the risks of general anesthesia, a primary regional anesthetic was performed. An ultrasound-guided single-shot interscalene brachial plexus block, supplemented with a superficial cervical plexus block, provided dense surgical anesthesia. This technique ensured remarkable maternal hemodynamic stability, maintained a reassuring Category I fetal heart tracing throughout, and completely avoided intraoperative systemic opioids and sedatives. The postoperative course was notable for excellent, opioid-sparing analgesia and an uncomplicated recovery for both mother and infant. In conclusion, this case provides an illustrative example of how a meticulously executed regional anesthetic technique can serve as a primary and potentially superior modality in this high-risk patient population. It successfully navigated the competing pathophysiological demands, suggesting that regional anesthesia should be a first-line consideration in select, complex trauma scenarios involving pregnancy and TBI.

1. Introduction

Trauma is a significant and devastating cause of non-obstetric maternal mortality and morbidity, affecting an estimated 6-8% of all pregnancies worldwide.[1] It imposes a dual burden on healthcare systems, requiring the simultaneous and urgent care of two patients: the mother and the fetus. The etiology of trauma in pregnancy is varied, with motor vehicle accidents, domestic violence, and falls representing the most common causes. The maternal physiological response to trauma is profoundly altered by the anatomical and functional adaptations of pregnancy.[2] These changes, including a 40-50% increase in plasma volume and cardiac output, a state of chronic compensated respiratory alkalosis, decreased functional residual capacity, and significant airway edema, complicate resuscitation efforts and anesthetic management. A critical tenet in managing these cases is that maternal stability is the unequivocal cornerstone of fetal well-being; therefore, all initial resuscitative efforts must be directed at the mother.[3]

The complexity of trauma management is exponentially magnified when the central nervous system is involved.[4] Traumatic brain injury (TBI) introduces an urgent need for neuroprotection to prevent secondary brain injury, which evolves in the hours and days following the initial impact.[5] The foundational principle of TBI management is the Monro-Kellie doctrine, which describes the cranial vault as a rigid container with a fixed volume comprising brain parenchyma, cerebrospinal fluid (CSF), and blood. An expanding intracranial hematoma, such as a subdural hemorrhage (SDH), increases the volume of one component, forcing a compensatory displacement of venous blood and CSF. When this compensatory mechanism is exhausted, intracranial pressure (ICP) rises exponentially, leading to decreased cerebral perfusion pressure (CPP), ischemia, and potential brain herniation.[6]

The primary goals of anesthetic and critical care management in TBI are therefore to maintain CPP (defined as Mean Arterial Pressure minus Intracranial Pressure) and to meticulously avoid the "four H's" of secondary brain injury: hypotension, hypoxia, hypercarbia, and hypocapnia. Even brief episodes of hypotension (systolic blood pressure <90 mmHg) can double mortality in TBI patients.[7] Furthermore, laryngoscopy and endotracheal intubation, routine components of general anesthesia, are potent noxious stimuli that can elicit a profound catecholamine surge, causing hypertension and tachycardia that may acutely elevate ICP and trigger hematoma expansion.

When a pregnant patient with a TBI requires surgical fixation for an orthopedic injury, the anesthesiologist is faced with a formidable conundrum.[8] General anesthesia, while a conventional choice for such surgeries, presents a cascade of risks. In addition to the dangers of ICP elevation during airway manipulation, pregnant patients have a notoriously higher risk of difficult and failed intubation—up to eight times that of the non-pregnant population—due to airway edema and other anatomical changes. They are also considered to have a "full stomach" from the first trimester onwards, placing them at high risk for pulmonary aspiration of gastric contents. From a fetal perspective, nearly all systemic anesthetic agents, including induction agents, volatile anesthetics, and opioids, freely cross the placenta. These agents can depress fetal cardiovascular function, decrease fetal heart rate variability—a key marker of fetal well-being—and lead to neonatal respiratory depression if delivery occurs or is required emergently.[9]

Regional anesthesia offers a compelling theoretical solution to this multifaceted problem. By confining the anesthetic effect to the operative region, it can avoid airway instrumentation, preserve spontaneous ventilation, maintain superior hemodynamic stability, and drastically minimize systemic drug exposure to the fetus. The advent of ultrasound guidance has transformed the field, enabling anesthesiologists to visualize neural structures, vasculature, and needle trajectory in real-time, thereby maximizing block success while minimizing complications like vascular puncture or local anesthetic systemic toxicity (LAST).[10]

Despite these advantages, the medical literature describing the use of a primary, definitive regional anesthetic technique for major orthopedic surgery in the specific context of a pregnant patient with a concurrent, radiologically significant TBI is exceedingly sparse. This case report aims to address this knowledge gap by providing a highly detailed, illustrative example of the successful perioperative management of this exact clinical scenario. This report aims to describe the step-by-step decision-making, technical execution, and pathophysiological rationale for using an ultrasound-guided interscalene and cervical plexus block in this complex case. The novelty lies in its comprehensive, multidisciplinary approach and its demonstration of regional anesthesia not merely as an alternative, but as a potentially superior strategy for navigating the intricate and competing demands of maternal neuroprotection, fetal safety, and surgical necessity.

2. Case Presentation

This case report was prepared in accordance with the CARE (CAse REport) guidelines to ensure accuracy, transparency, and completeness. A 25-year-old, previously healthy, primigravida (G1P0) woman at 28 weeks and 2 days of gestation was transported to our Level I trauma center via ambulance following a high-speed motor vehicle accident. She was a restrained front-seat passenger. Her primary complaints upon arrival were severe, debilitating pain in her right shoulder and a moderate, holocranial headache. She reported no loss of consciousness, seizures, or vomiting, but was amnestic to the event itself. An obstetric review of systems was positive for active fetal movement and negative for abdominal pain, uterine contractions, vaginal bleeding, or leakage of fluid. Her past medical, surgical, and anesthetic histories were unremarkable.

On arrival in the Emergency Department, the patient's initial vital signs revealed a blood pressure of 110/65 mmHg, a heart rate of 105 beats per minute in a sinus rhythm, a respiratory rate of 22 breaths per minute, and an oxygen saturation of 98% on room air with a temperature of 37.0°C. A primary survey according to Advanced Trauma Life Support protocols was conducted and found to be unremarkable, confirming a patent airway with clear bilateral breath sounds and intact circulation. Her initial neurological examination revealed a Glasgow Coma Scale score of 14, with deficits attributed to confusion and disorientation to time and place. Her pupils were 3 millimeters, equal, round, and reactive to light and accommodation, with no focal motor or sensory deficits noted in the uninjured extremities. The secondary survey identified a closed, visibly deformed right clavicle with marked tenderness, swelling, and crepitus over the middle third. A comprehensive neurovascular examination of the right upper extremity was normal. The obstetric examination was reassuring, revealing a gravid, non-tender uterus with a fundal height consistent with dates and a fetal heart rate of 145 beats per minute confirmed by Doppler (Table 1).

An urgent diagnostic assessment was initiated to fully characterize the extent of her injuries. A non-contrast computed tomography scan of the head revealed a thin, left-sided frontotemporoparietal acute subdural hemorrhage with a maximal thickness of 4 millimeters. There was mild adjacent sulcal effacement consistent with cerebral edema, but no evidence of midline shift, herniation, or skull fracture. Radiographs of the right clavicle, including anteroposterior and cephalic tilt views, confirmed a displaced, comminuted fracture of the middle third, with approximately 2 centimeters of shortening and significant inferior displacement of the distal fragment. A Focused Assessment with Sonography for Trauma scan was negative for any free fluid in the pericardial, perihepatic, perisplenic, or pelvic spaces. Initial laboratory analysis was also reassuring. Her complete blood count showed a hemoglobin of 11.5 g/dL, a hematocrit of 34.5%, and a platelet count of 220,000/μL. Her coagulation panel was within normal limits, with a prothrombin time of 12.5 seconds and an activated partial thromboplastin time of 28 seconds. A complete metabolic panel was unremarkable.

Following admission, a multidisciplinary management plan was formulated through collaborative discussion (Table 2). The neurosurgery service recommended non-operative management of the subdural hemorrhage with hourly neurological checks, strict systolic blood pressure control to a target of less than 140 mmHg, and avoidance of any maneuvers that could increase intracranial pressure. They explicitly advised against the hemodynamic volatility associated with general anesthesia induction if it could be safely avoided. Concurrently, the orthopedic surgery team evaluated the clavicle fracture and determined that open reduction and internal fixation was indicated due to the significant displacement and comminution, in order to restore length, ensure anatomical alignment, and optimize functional recovery. The maternal-fetal medicine team conducted a comprehensive fetal assessment, which included a continuous electronic fetal heart rate

monitoring strip that showed a reassuring Category I tracing and a biophysical profile score of 8 out of 8. Based on these expert inputs, the anesthesiology team classified the patient as American Society of Anesthesiologists Physical Status III-E and formulated a primary regional anesthetic plan designed to meet the competing clinical goals. The risks and benefits of this approach versus general anesthesia were discussed at length with the patient and her family, and informed consent was obtained for the proposed procedure.

Table 1. Summary of Clinical Findings on Admission

PARAMETER	FINDING ON ADMISSION
Patient Demographics & History	
Age	25 years
Gravidity/Parity	G1P0 (Primigravida)
Gestational Age	28 weeks, 2 days
Mechanism of Injury	Motor Vehicle Accident (restrained front-seat passenger)
Vital Signs	
Blood Pressure	110 / 65 mmHg
Heart Rate	105 bpm (Sinus Tachycardia)
Respiratory Rate	22 breaths/min (Tachypnea)
Oxygen Saturation (SpO_2)	98% on Room Air
Neurological Assessment	
Glasgow Coma Scale (GCS)	14 (E4, V4, M6)
GCS Deficit	Confusion and disorientation (Verbal = 4)
Pupils	3mm, equal, round, and reactive to light (PERRL)
Head CT Finding	Left frontotemporoparietal acute subdural hemorrhage (4mm thickness)
Orthopedic Assessment	
Injury Location	Right Clavicle, Middle Third
Clinical Signs	Visible deformity, marked tenderness, swelling, crepitus
Radiograph Finding	Displaced, comminuted fracture with 2cm shortening
Obstetric & Fetal Assessment	
Uterine Status	Soft, non-tender, fundal height consistent with dates
Fetal Heart Rate (Doppler)	145 bpm
Electronic Fetal Monitoring	Category I Tracing (Reassuring)
Biophysical Profile (BPP)	8 / 8 (Reassuring)

Table 2. Therapeutic Intervention and Management

DOMAIN	DETAILS OF INTERVENTION
Preoperative Multidisciplinary Plan	
Neurosurgery	Non-operative management of SDH. Strict SBP goal <140 mmHg. Strong recommendation to avoid hemodynamic lability from general anesthesia.
Orthopedic Surgery	Open Reduction and Internal Fixation (ORIF) of the clavicle indicated due to fracture displacement and comminution.
Maternal-Fetal Medicine	Recommended continuous intraoperative and postoperative Electronic Fetal Monitoring (EFM).
Anesthesiology Plan	**Primary Regional Anesthetic. ASA Status III-E. Backup plan for general anesthesia established. Informed consent obtained.**
Intraoperative Management	
Monitoring	Standard ASA monitors plus an invasive arterial line for continuous blood pressure measurement. Continuous EFM.
Patient Positioning	**Semi-recumbent (30°) with left uterine displacement via a wedge to prevent aortocaval compression.**
Surgical Procedure	ORIF of right clavicle. Duration: 90 minutes. Estimated Blood Loss: <50 mL.
Patient Status	**Remained awake, comfortable, and hemodynamically stable. No supplemental sedatives or opioids required.**
Anesthetic Technique Details	
Primary Block	**Ultrasound-Guided Single-Shot Interscalene Block**
Supplemental Block	**Ultrasound-Guided Superficial Cervical Plexus Block**
Local Anesthetic Solution	**1.5% Lidocaine with Epinephrine 1:400,000**
Volume Administered	20 mL (Interscalene) + 5 mL (Cervical Plexus) = 25 mL Total
Postoperative Course & Outcomes	
Immediate Analgesia	**Visual Analog Scale (VAS) pain score 0/10 in PACU. Block provided analgesia for ~4 hours.**
Opioid Consumption (24h)	**Minimal. Only two doses of oral Oxycodone 5mg required.**
Hospital Course	Follow-up Head CT showed stable SDH. Discharged home on Postoperative Day 3.
Long-Term Maternal Outcome	**Complete neurological recovery. Excellent functional outcome from clavicle fixation.**
Long-Term Fetal/Neonatal Outcome	**Uncomplicated pregnancy progression. Spontaneous vaginal delivery of a healthy infant at 39 weeks.**

The patient was brought to the operating room for the scheduled surgery. In addition to standard monitors, a 20-gauge arterial line was placed in the left radial artery under local anesthesia for beat-to-beat blood pressure monitoring. She was positioned semi-recumbent at 30 degrees with a wedge under her right hip to provide left uterine displacement and prevent aortocaval compression. Continuous intraoperative electronic fetal monitoring was initiated. The regional anesthetic procedure was then performed under strict sterile conditions using ultrasound guidance. A high-frequency linear probe was used to visualize the brachial plexus in the interscalene groove. Using an in-plane technique, a 22-gauge, 50-millimeter insulated nerve block needle was advanced. After negative aspiration, a total of 20 mL of 1.5% lidocaine with a dilute epinephrine concentration of 1:400,000 was injected incrementally, with real-time visualization of appropriate spread around the plexus. This dilute epinephrine concentration was a deliberate choice to provide a marker for intravascular injection while minimizing systemic beta-adrenergic effects that could be confounding in a trauma patient. Subsequently, an additional 5 mL of the same solution was injected to perform a superficial cervical plexus block. After 20 minutes, a dense sensory and motor block was confirmed, and the orthopedic team proceeded with the 90-minute open reduction and internal fixation of the right clavicle. The patient remained awake, comfortable, and required no supplemental sedation or analgesia throughout the case (Figure 1).

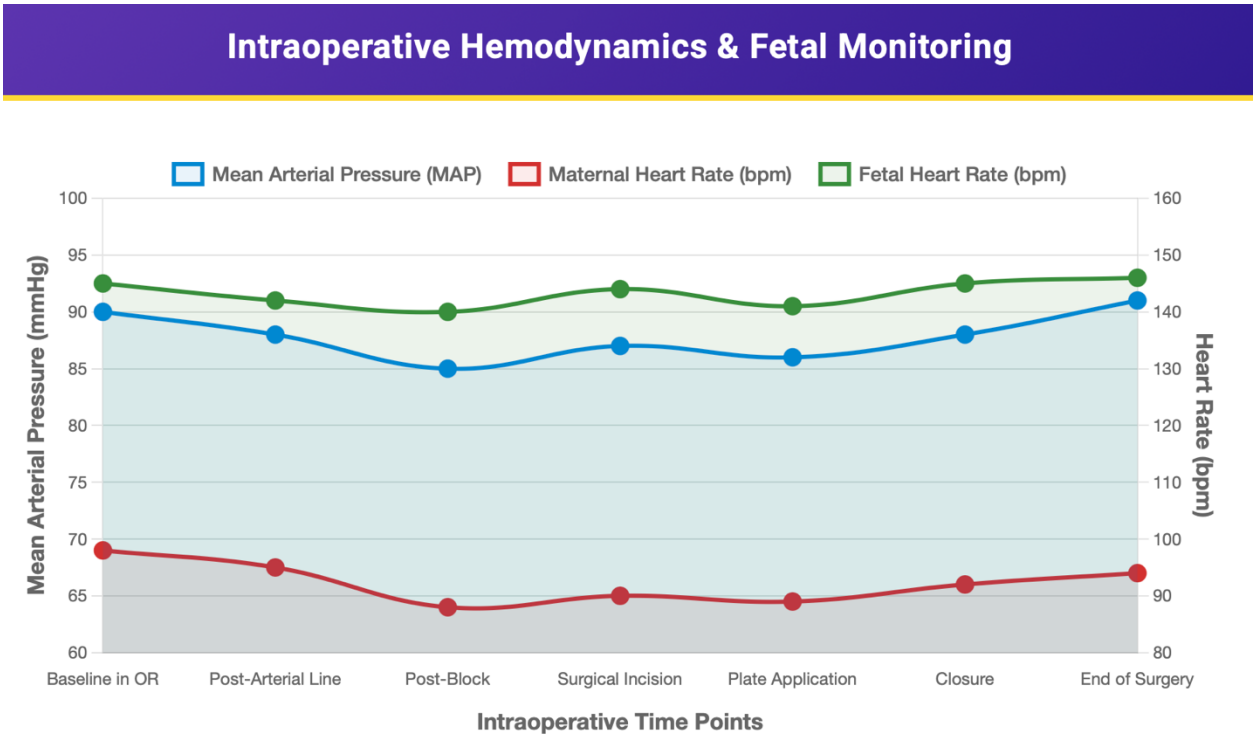

Figure 1. Intraoperative hemodynamics and fetal monitoring.

The patient's postoperative course was uncomplicated. In the Post-Anesthesia Care Unit, she remained hemodynamically stable with a visual analog scale pain score of 0 out of 10. Her neurological checks were unchanged from her preoperative baseline. The sensory block provided excellent analgesia for

approximately four hours, after which she was transitioned to a regimen of scheduled oral acetaminophen. In the first 24 hours, she required only two doses of oral oxycodone 5 mg for breakthrough pain. A repeat head CT on the second postoperative day showed no evolution of the subdural hemorrhage. She was discharged home on postoperative day three with instructions for close follow-up with all specialty services. Her clavicle fracture healed uneventfully with an excellent functional outcome, and her neurological symptoms resolved completely. At 39 weeks' gestation, she underwent a spontaneous vaginal delivery of a healthy male infant with Apgar scores of 9 and 9 at one and five minutes, respectively (Table 3).

Table 3. Postoperative Course, Follow-up, and Outcomes

TIMEFRAME / DOMAIN	DETAILS AND FINDINGS
Immediate Postoperative Course (PACU)	
Pain Management	Visual Analog Scale (VAS) score: 0/10 on arrival.
Regional Block Duration	Effective sensory blockade provided complete analgesia for approximately 4 hours post-surgery.
Neurological Status	Patient remained at her baseline GCS of 14. No new deficits.
Fetal Monitoring	Continuous EFM for 4 hours remained a reassuring Category I tracing.
In-Hospital Management (Postoperative Days 1-3)	
Analgesic Regimen	Opioid-Sparing: Scheduled oral Acetaminophen (1000mg q6h).
Total Opioid Use (First 24h)	Minimal: Only two doses of oral Oxycodone 5mg for breakthrough pain.
Follow-up Imaging	Repeat Head CT on Postoperative Day 2 showed a stable subdural hemorrhage with no expansion.
Discharge	Discharged home on Postoperative Day 3 after meeting all clinical stability criteria.
Long-Term Follow-up & Outcomes	
Maternal Neurological Outcome	**Complete resolution of all TBI-related symptoms.**
Maternal Orthopedic Outcome	**Uneventful fracture healing with excellent functional recovery and full range of motion of the shoulder.**
Obstetric Outcome	**Pregnancy progressed without further complications.**
Delivery	**Spontaneous vaginal delivery of a healthy male infant at 39 weeks' gestation.**
Neonatal Outcome	**Apgar scores: 9 at 1 minute, 9 at 5 minutes. No neonatal complications.**

3. Discussion

This case report provides a detailed account of the successful management of a rare and perilous clinical triad: a surgical trauma, an acute TBI, and a third-trimester pregnancy. The favorable outcome was predicated on a strategic decision to utilize primary regional anesthesia, an approach that uniquely navigated the competing pathophysiological demands of the patient.[11] The core anesthetic challenge in this case was not merely to manage a single complex condition, but to navigate the treacherous intersection of three distinct and often antagonistic physiological states. The presence of an acute subdural hemorrhage, a third-trimester pregnancy, and the need for surgical intervention created a clinical triad where a suboptimal choice could lead to catastrophic failure in one or all domains.[12] The decision-making process required a profound understanding of how an intervention in one area would reverberate through the others. The anesthetic plan had to be a masterstroke of physiological reconciliation, actively protecting the brain, stabilizing the mother, and shielding the fetus simultaneously.

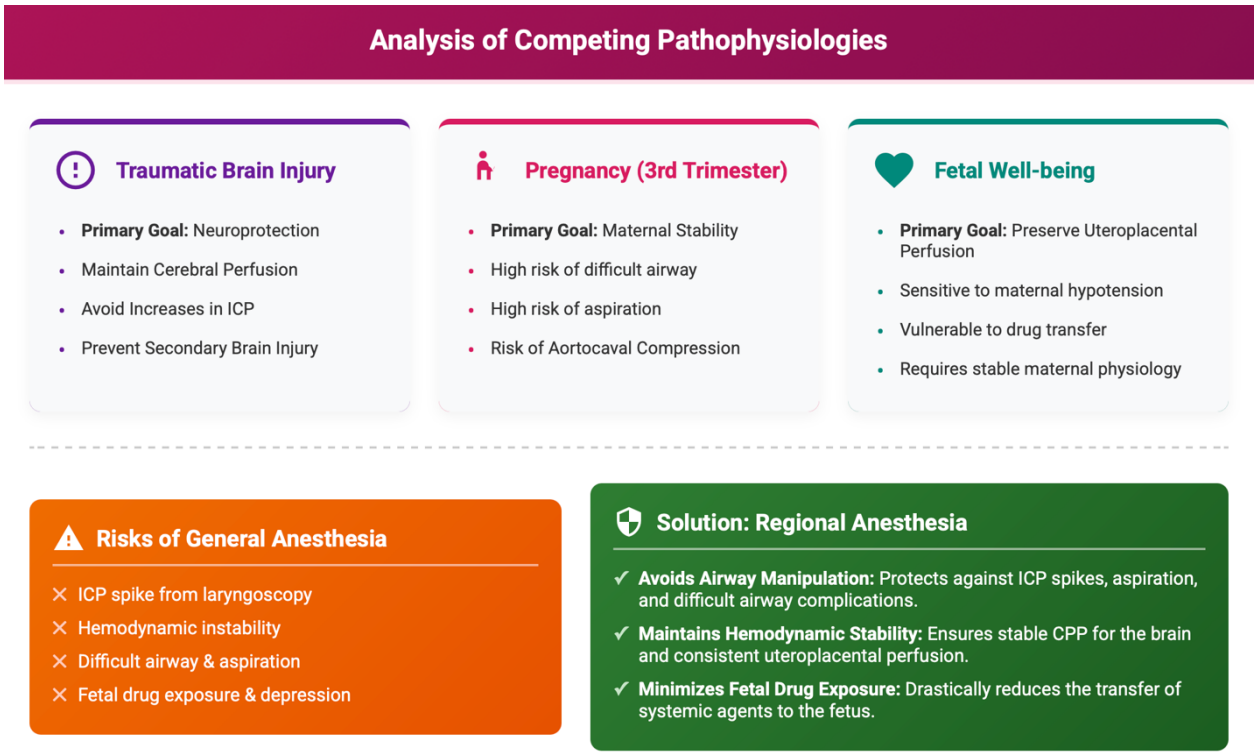

Figure 2. Analysis of competing pathophysiologies.

The management of the patient's acute subdural hemorrhage was governed by the rigid principles of neurocritical care, where the primary objective is the prevention of secondary brain injury.[13] The initial trauma causes the primary injury, but the subsequent cascade of hypotension, hypoxia, and intracranial hypertension is what often leads to irreversible neurological damage and mortality. Our strategy was anchored in the Monro-Kellie doctrine, which dictates that the intracranial volume is a fixed sum of brain, blood, and cerebrospinal fluid (CSF). The introduction of a new volume, the subdural hematoma, forces the displacement of CSF and venous blood. Once this compensatory capacity is exhausted, even minor increases in volume can cause an exponential and devastating rise in intracranial pressure (ICP).

This delicate balance makes the induction of general anesthesia a period of extreme peril. The act of laryngoscopy and endotracheal intubation is one of the most potent noxious stimuli in anesthesia, triggering a massive sympathetic nervous system discharge.[14] This catecholamine surge results in abrupt hypertension and tachycardia. In a patient with a TBI, this response can be catastrophic. The sudden spike in mean arterial pressure (MAP) can increase cerebral blood flow and volume, directly raising ICP and potentially causing the subdural hematoma to expand. This hypertensive crisis places immense stress on the injured cerebral vasculature, risking further bleeding.

Conversely, nearly all intravenous and volatile anesthetic agents used to induce and maintain general anesthesia are vasodilators and myocardial depressants, creating a significant risk of profound hypotension immediately following induction.[15] A drop in MAP directly compromises cerebral perfusion pressure (CPP), which is the critical driving force of blood and oxygen to the brain (CPP = MAP - ICP). In a patient with an already elevated ICP, even a modest decrease in MAP can drop CPP below the ischemic threshold, leading to cerebral hypoxia and cell death. The anesthesiologist is thus trapped in a dangerous balancing act, trying to avoid both the hypertension of laryngoscopy and the hypotension from anesthetic agents. By selecting a regional anesthetic technique, we completely sidestepped this entire cascade of risk. There was no airway instrumentation, no catecholamine surge, and no administration of systemic vasodilating agents. The remarkable hemodynamic stability, as evidenced by the intraoperative monitoring data, was not a fortunate side effect; it was the central, intended therapeutic benefit of the chosen plan, providing an unwavering shield of neuroprotection.

The physiological adaptations of the third trimester of pregnancy transform the patient into a high-risk anesthetic candidate, even in the absence of trauma. From an airway perspective, hormonal changes lead to capillary engorgement and edema throughout the respiratory mucosa. Combined with weight gain and the physical impediment of large breasts, these changes make both mask ventilation and tracheal intubation notoriously difficult. The incidence of failed intubation is eight times higher in the pregnant population compared to the non-pregnant population.[16] A "can't intubate, can't oxygenate" scenario, while rare, is a terrifying possibility with life-threatening consequences for both mother and fetus. Furthermore, progesterone reduces the tone of the lower esophageal sphincter, while the gravid uterus increases intra-abdominal pressure, placing the patient at an extremely high risk for the regurgitation of acidic gastric contents and subsequent aspiration pneumonitis.

Hemodynamically, the gravid uterus, now a large and heavy organ, exerts significant pressure on the inferior vena cava and aorta when the patient is in the supine position. This "aortocaval compression" can sequester a large volume of blood, drastically reducing venous return to the heart, which in turn causes a precipitous drop in cardiac output, blood pressure, and, critically, uteroplacental perfusion. Our meticulous attention to patient positioning with left uterine displacement was essential to mitigate this risk. The regional anesthetic approach elegantly circumvented all of these obstetric-specific dangers. By keeping the patient awake and breathing spontaneously, her protective airway reflexes remained fully intact, eliminating the risk of aspiration. The avoidance of airway instrumentation nullified the challenge of a potentially difficult pregnant airway. The patient’s own respiratory drive ensured optimal oxygenation and ventilation without the complexities of positive pressure ventilation.

The fetus is a completely passive participant, entirely dependent on the physiological stability of the mother for its survival.[17] The uteroplacental circulation is a low-resistance vascular bed that lacks the capacity for autoregulation. This means that blood flow to the fetus is directly and linearly proportional to the maternal mean arterial pressure. Any episode of maternal hypotension, however brief, translates directly into a reduction in fetal oxygen and nutrient

supply, potentially leading to fetal hypoxia, acidosis, and distress. The stable maternal hemodynamics achieved with our regional block were therefore not only neuroprotective for the mother but were the primary guarantee of fetal safety, ensuring a constant and adequate perfusion of the placenta.

Furthermore, the choice of anesthesia has profound pharmacological implications for the fetus. The lipid barrier of the placenta is readily crossed by most anesthetic drugs. A general anesthetic would have exposed the fetus to a combination of induction agents, volatile anesthetics, and potent opioids. These drugs can cause direct myocardial and central nervous system depression in the fetus, often manifesting as a loss of fetal heart rate variability—a critical indicator of fetal neurological well-being. By utilizing a regional block, we confined the pharmacological intervention to the mother's brachial plexus. While a small amount of local anesthetic is absorbed systemically, the total dose reaching the fetus is orders of magnitude lower than that from a general anesthetic. The persistent, reassuring Category I fetal heart tracing observed throughout the procedure was the objective, real-time evidence that our strategy was successful in creating a stable and safe intrauterine environment.[18] It was a testament to a technique that protected the silent patient as effectively as it did the mother.

While the chosen regional anesthetic technique proved resoundingly successful, a robust and intellectually honest discussion requires a critical examination of the plausible alternatives that were considered and ultimately rejected. In high-stakes clinical medicine, the justification for a chosen path is strengthened not only by its own merits but also by a thorough deconstruction of the risks inherent in other options. Both a planned "neuroprotective" general anesthetic and a sedation-based approach were contemplated. However, a granular analysis revealed that each was laden with significant and, in this specific clinical context, unacceptable risks that threatened the delicate balance between maternal neuroprotection, obstetric stability, and fetal well-being. On the surface, a modern neuroanesthetic technique for general anesthesia appears to be a viable option. Such a plan would be multifaceted, aiming to control every physiological variable with pharmacological precision. The theoretical "best-case" scenario would involve pre-induction placement of an arterial line for beat-to-beat blood pressure monitoring, followed by the administration of agents designed to blunt the sympathetic response to laryngoscopy, such as a short-acting opioid like remifentanil, intravenous lidocaine, or an alpha-2 agonist like dexmedetomidine. Induction would be performed with a hemodynamically stable agent, such as etomidate, which has the added benefits of reducing cerebral metabolic rate and intracranial pressure. Maintenance could be achieved with a total intravenous anesthetic (TIVA) technique using propofol and remifentanil infusions, which allows for rapid titration and a swift emergence, or a low concentration of a modern volatile agent like sevoflurane, which has relatively favorable effects on cerebral blood flow.[19]

However, this "ideal" plan is an illusion of control that begins to unravel when confronted with the realities of this patient's intersecting pathologies. The primary flaw is the unavoidable problem of hemodynamic lability. Even with a battery of blunting agents, the hypertensive and tachycardic response to laryngoscopy remains unpredictable and can be profound. In a patient with an acute subdural hemorrhage and impaired cerebral autoregulation, the brain's ability to maintain constant blood flow in the face of changing systemic pressure is compromised. A sudden spike in blood pressure can be transmitted directly to the fragile intracranial vasculature, risking the expansion of the hematoma. Conversely, the moment the stimulus of intubation is removed, the powerful combination of induction agents and opioids can lead to a precipitous drop in blood pressure. This post-induction hypotension is just as dangerous, as it can cause cerebral perfusion pressure to fall below the ischemic threshold, extending the area of brain injury.

This hemodynamic tightrope walk is further complicated by the second major flaw: the absolute

necessity of securing the airway. The physiological changes of pregnancy create a notoriously difficult airway, characterized by mucosal edema, tissue friability, and a reduced functional residual capacity that leads to rapid oxygen desaturation during periods of apnea. A failed intubation attempt in this patient would be a multi-faceted catastrophe. The repeated attempts at laryngoscopy would generate a massive and prolonged catecholamine surge, dangerously elevating ICP. The ensuing hypoxia and hypercarbia from the inability to ventilate would both be potent secondary insults to the injured brain. The risk of aspiration pneumonitis from regurgitated gastric contents is also exceptionally high, which would introduce a new and life-threatening pulmonary complication.[20]

Finally, even if the airway is secured without incident, the patient would require positive pressure ventilation. This intervention, while essential for oxygenation, can be detrimental to cerebral physiology. The use of Positive End-Expiratory Pressure (PEEP) increases intrathoracic pressure, which in turn impedes venous drainage from the head via the jugular veins, thereby passively increasing ICP. The anesthesiologist would also be tasked with managing ventilation to maintain a precise arterial carbon dioxide tension ($PaCO_2$), as both hypercarbia (a potent cerebral vasodilator) and hypocapnia (a vasoconstrictor that can cause ischemia) are profoundly harmful. This entire complex and high-risk endeavor would be undertaken while simultaneously exposing the fetus to a continuous infusion of potent anesthetic and analgesic agents, all of which freely cross the placenta and carry the potential to depress the fetal central nervous and cardiovascular systems. When weighed against the stability and non-invasiveness of the regional technique, the risks of even a perfectly executed general anesthetic were deemed unacceptably high.

Another theoretical alternative was to combine local anesthetic infiltration by the surgeon with a titrated intravenous sedation to keep the patient comfortable and calm. This approach is often used for minor procedures, but for an open reduction and internal fixation of a clavicle, it is both inadequate and dangerous. The surgical procedure itself is intensely stimulating, involving incision, muscle retraction, bone drilling, and the application of hardware. It is simply not feasible to achieve the absolute patient immobility required for such a procedure with local infiltration and light sedation alone.

To achieve the necessary level of immobility would require deep sedation, which introduces a perilous paradox in the setting of a TBI. The agents used to produce calm can themselves cause physiological harm. Propofol, while an excellent sedative, is a potent respiratory depressant and vasodilator, risking the very hypercarbia and hypotension that must be avoided. Benzodiazepines can cause paradoxical agitation and have long-lasting sedative effects that would interfere with postoperative monitoring. While dexmedetomidine offers the advantage of sedation without significant respiratory depression, it can cause profound bradycardia and unpredictable blood pressure changes.

Most critically, any level of effective sedation would render the single most important monitor of the patient's neurological status—the clinical exam—completely useless. The patient's ability to communicate, follow commands, and report symptoms like a worsening headache is the earliest and most sensitive indicator of an expanding intracranial hematoma. By obtunding the patient with sedatives, we would be blinding ourselves to the most critical data. If the subdural hemorrhage were to expand intraoperatively, the first signs of neurological deterioration would be entirely masked by the pharmacological effects of the sedation. This would create an unacceptable diagnostic delay that could lead to irreversible brain damage. Therefore, this approach was rejected as it provided inadequate surgical conditions while simultaneously increasing the risk to the patient by masking her neurological status. The regional technique, in stark contrast, provided profound surgical anesthesia while

preserving a clear and interactive neurological exam throughout the procedure.

The choice of a combined interscalene and superficial cervical plexus block was anatomically driven. The clavicle's dual innervation from both the brachial (C5-C6) and cervical (C3-C4) plexuses necessitates this dual block for complete surgical anesthesia. The use of ultrasound was paramount, allowing for precise deposition of local anesthetic and the avoidance of critical structures like the vertebral artery and pleura, thereby enhancing both efficacy and safety.

The selection of 1.5% lidocaine with epinephrine was a deliberate choice for an intermediate-duration block, providing sufficient anesthesia for the 90-minute surgery without causing a prolonged motor block that could hinder early postoperative neurological assessment. While longer-acting, highly protein-bound agents like ropivacaine or bupivacaine have less placental transfer, the total dose of lidocaine used was low, and the clinical priority of avoiding a prolonged block outweighed the theoretical benefits of these agents in this case. The dense, high-quality analgesia provided by the block extended well into the postoperative period, as evidenced by the minimal requirement for opioids. This opioid-sparing effect is highly desirable in a patient with a TBI to avoid sedation that could confound neurological exams and to prevent respiratory depression.

This report, while detailed, has the inherent limitations of a single case study. Most importantly, the findings cannot be generalized, as the success reported here was contingent upon a specific constellation of factors, including the patient's unique physiology, a cooperative temperament, and the availability of a skilled multidisciplinary team. Furthermore, this technique was successful in the context of a TBI with a clinically mild presentation and no significant mass effect; the feasibility and safety of performing an awake regional anesthetic on a patient with a more severe TBI would be highly questionable. Moreover, the procedure was a peripheral orthopedic surgery of moderate duration, and the applicability of a sole regional technique for longer, more complex, or intracavitary procedures would be limited. Finally, the patient was lucid enough to understand the procedure and provide informed consent, a crucial prerequisite that may be absent in many trauma patients.

4. Conclusion

The management of the pregnant trauma patient with a concurrent TBI requiring surgery represents a pinnacle of anesthetic complexity, demanding a delicate balance between competing physiological priorities. This case report provides a compelling, illustrative example that a primary regional anesthetic strategy, centered on an ultrasound-guided interscalene and superficial cervical plexus block, can be the optimal approach. It successfully provided excellent surgical anesthesia while simultaneously achieving the critical goals of maintaining maternal hemodynamic stability for neuroprotection, ensuring fetal well-being through preserved uteroplacental perfusion, and avoiding the significant risks associated with general anesthesia and airway manipulation in this high-risk population. This report advocates for the strong consideration of regional anesthesia as a first-line technique by multidisciplinary trauma teams when managing select patients facing these multifaceted and critical challenges.

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