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Anesthetic Management of a Child with Severe Hydrocephalus, Predicted Difficult Airway, Obstructive Ileus, and Sepsis Undergoing Exploratory Laparotomy: A Case Report

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A B S T R A C T

Introduction: Severe hydrocephalus with macrocephaly creates a predicted difficult airway and raised intracranial pressure (ICP), a challenge magnified when it coexists with obstructive ileus and sepsis. The simultaneous demand to protect the brain, secure a distorted airway, prevent aspiration, and preserve perfusion in a septic, malnourished child makes anesthetic planning exceptionally complex.

Case presentation: A 5-year-old boy with cerebral palsy and untreated severe communicating hydrocephalus (head circumference 81 cm) presented with vomiting, abdominal distension, and obstipation. He was septic, severely dehydrated, and marasmic, with imaging confirming severe hydrocephalus, agenesis of the corpus callosum, and low small-bowel obstruction. Exploratory laparotomy was prioritized over ventriculoperitoneal shunting. Anesthesia used a modified rapid sequence induction with a ketamine-based regimen and ramp positioning to align the head-body axis for intubation. Surgery lasted 2.5 hours with stable hemodynamics. The child was transferred intubated to the pediatric intensive care unit for controlled ventilation and neurological monitoring.

Conclusion: Integrated, individualized planning allowed safe anesthesia in a child with colliding neurological, surgical, infectious, and nutritional emergencies. A ketamine-based modified rapid sequence induction with ramp positioning, neuroprotective maintenance, surgical sequencing, and planned postoperative ventilation balanced ICP control against septic hemodynamic stability.

1. Introduction

Hydrocephalus is the pathological accumulation of cerebrospinal fluid within the cerebral ventricles, arising from obstruction to flow, impaired absorption, or, less commonly, overproduction of fluid. It is broadly classified as non-communicating (obstructive) when flow is blocked within the ventricular system and communicating when the obstruction lies in cerebrospinal fluid absorption, a distinction that continues to shape contemporary diagnostic and treatment frameworks.[1] When hydrocephalus is severe and longstanding in a young child, the cranial vault expands far beyond the proportions of the facial skeleton and trunk, producing macrocephaly that distorts the anatomical axes on which safe laryngoscopy depends.

Hydrocephalus is among the most common neurosurgical conditions of childhood, and in low- and middle-income settings a substantial proportion of affected children present late, after the cranium has already expanded markedly, because access to early imaging and timely shunting is limited. Longstanding ventricular dilatation stretches the periventricular white matter, thins the cortical mantle, and, in the youngest patients whose cranial sutures remain open, allows the skull to enlarge progressively rather than to generate an early rise in pressure. The open anterior fontanelle and unfused metopic, sagittal, and coronal sutures seen in this child are the structural correlates of that process, and they explain how a vault can reach extraordinary dimensions while the patient remains, for a time, neurologically compensated. Coexisting malformations such as agenesis of the corpus callosum frequently accompany severe congenital hydrocephalus and signal the antenatal origin and chronicity of the disease, which in turn influences how acutely the intracranial situation must be treated.

From the anesthesiologist's perspective, severe macrocephalic hydrocephalus presents two intertwined threats. First, the enlarged occiput forces extreme neck flexion in the supine position, misaligning the oral, pharyngeal, and laryngeal axes and converting a routine intubation into a predicted difficult airway; case series of children with giant cranial or neural-tube anomalies report difficult tracheal intubation in roughly half of patients.[2,3] Second, the intracranial compartment is operating near the limit of its compliance, so that small increases in cerebral blood volume, carbon dioxide tension, or venous pressure during induction can precipitate dangerous rises in intracranial pressure and threaten cerebral perfusion.[4] Induction agents must therefore be chosen with neuroanesthetic principles in mind, favoring drugs and techniques that keep intracranial pressure and cerebral metabolism in check while preserving perfusion.

These priorities are usually reconciled with propofol, which reliably lowers intracranial pressure and is the agent most often recommended for hydrocephalus when intracranial dynamics are the dominant concern.[3] The calculus changes abruptly, however, when the same child is also septic. Sepsis lowers systemic vascular resistance and threatens global perfusion, and the very agent that protects the brain can produce profound hypotension that injures it through a different mechanism.[5] A third emergency compounds the dilemma in the present case: obstructive ileus, which mandates a full-stomach approach to prevent aspiration and forces the anesthesiologist to weigh rapid airway control against the hemodynamic and intracranial consequences of induction.[6]

Underlying all of these considerations is the relationship between cerebral perfusion pressure, mean arterial pressure, and intracranial pressure, in which cerebral perfusion pressure equals mean arterial pressure minus intracranial pressure. In a brain whose compliance is already exhausted, perfusion can be lost from either direction: a rise in intracranial pressure or a fall in mean arterial pressure will each narrow the perfusion margin. Sepsis attacks the arterial side of this equation while the hydrocephalus threatens the intracranial side, so that the anesthesiologist must defend perfusion pressure on two fronts at once. This conceptual framework, rather than any single drug recommendation, guided the management described below.

The convergence of severe macrocephalic hydrocephalus, a surgical abdomen, sepsis, and severe acute malnutrition in a single pediatric patient is rarely described, and existing reports tend to address these problems in isolation. The novelty of this report lies in presenting an integrated anesthetic strategy for their simultaneous occurrence, in which the usual neuroanesthetic default of propofol is deliberately set aside in favor of a ketamine-based modified rapid sequence induction, ramp positioning compensates for the distorted airway axes, the surgical sequence is reordered to treat the bowel before the brain, and postoperative ventilation is planned rather than improvised. The aim of this case report is to describe how anesthetic management maintained hemodynamic stability without

aggravating intracranial pressure or precipitating secondary brain injury in a child with these colliding emergencies, and to situate each decision within the current evidence base.

2. Case Presentation

Written informed consent for anesthesia, the surgical procedure, and the anonymized publication of clinical images and data was obtained from the patient's parents. Identifiable ocular regions in all clinical photographs have been masked.

History

A 5-year-old boy was brought to the emergency department with a progressively enlarging abdomen and vomiting. His parents described abdominal bloating and nausea, and he had been unable to pass stool for four days. One day before admission a rectal tube had been placed, after which he passed hard, dark, pellet-like stool under pressure. Urine output had been scant. He had a known history of cerebral palsy and severe congenital hydrocephalus; his last neurology clinic review for the hydrocephalus had been in August 2024, and a ventriculoperitoneal shunt had not yet been placed. The combination of obstipation, abdominal distension, and vomiting raised immediate concern for intestinal obstruction superimposed on his chronic neurological disease.

Physical examination

On initial assessment the child appeared to have a depressed central nervous system and metabolic state, with a Glasgow Coma Scale of E4M4V2. He was hypotensive at 80/50 mmHg, tachycardic at 157 beats/min, tachypneic at 28 breaths/min, and febrile at 38.5 °C, with a peripheral oxygen saturation of 97% on room air. Examination of the head revealed marked macrocephaly with a head circumference of 81 cm and a bilateral sunset-eye sign. Abdominal examination showed distension with reduced bowel sounds, shifting dullness, and sluggish skin turgor. The extremities were cool with a capillary refill time of 3 seconds, and his hydration status was judged to be severe dehydration. He weighed 15 kg and measured 93 cm, placing him in the marasmic category of severe acute malnutrition. The constellation of fever, tachycardia, hypotension, and an identifiable intra-abdominal source was consistent with sepsis of abdominal origin. The complete preoperative findings are summarized in Table 1.

Table 1. Summary of preoperative clinical and anthropometric findings on emergency department admission.

Clinical parameter	Detailed finding
1. General characteristics and history	
Demographics	5-year-old boy
Anthropometry	**Weight 15 kg; height 93 cm — marasmic severe acute malnutrition**
Relevant history	Cerebral palsy; severe congenital communicating hydrocephalus without ventriculoperitoneal shunt; 4-day obstipation; reduced urine output
Hydration status	**Severe dehydration**
2. Vital signs and hemodynamics	
Blood pressure	**80/50 mmHg (hypotension)**
Heart rate	**157 beats/min (tachycardia)**
Respiratory rate	28 breaths/min
Temperature	**38.5 °C (febrile)**
Peripheral oxygen saturation (room air)	97%
Capillary refill time	**3 s; cool extremities**
3. Focused neurological and systemic examination	
Level of consciousness	**Impaired; Glasgow Coma Scale E4M4V2**
Head	**Macrocephaly, head circumference 81 cm; bilateral sunset-eye sign**
Abdomen	Distension; reduced bowel sounds; shifting dullness; sluggish skin turgor

Notes: GCS, Glasgow Coma Scale. Findings outside the expected reference range for age are shown in red.

The clinical gestalt at the bedside is captured in Figure 1, which demonstrates the striking disproportion between the enlarged head and the wasted trunk, together with the tense abdominal distension that dominated the presentation. As shown in Figure 1, the simultaneous presence of macrocephaly, marasmus, and a surgical abdomen framed every subsequent anesthetic decision.

Investigations

Non-contrast multislice computed tomography of the head demonstrated severe communicating hydrocephalus, agenesis of the corpus callosum, and macrocephaly, with the anterior fontanelle and the metopic, sagittal, and coronal sutures still open. The degree of vault expansion relative to the facial skeleton is shown in Figure 2 and provided the anatomical explanation for the anticipated airway difficulty. As shown in Figure 2, the cranial enlargement was severe enough that conventional supine positioning would have produced extreme cervical flexion.

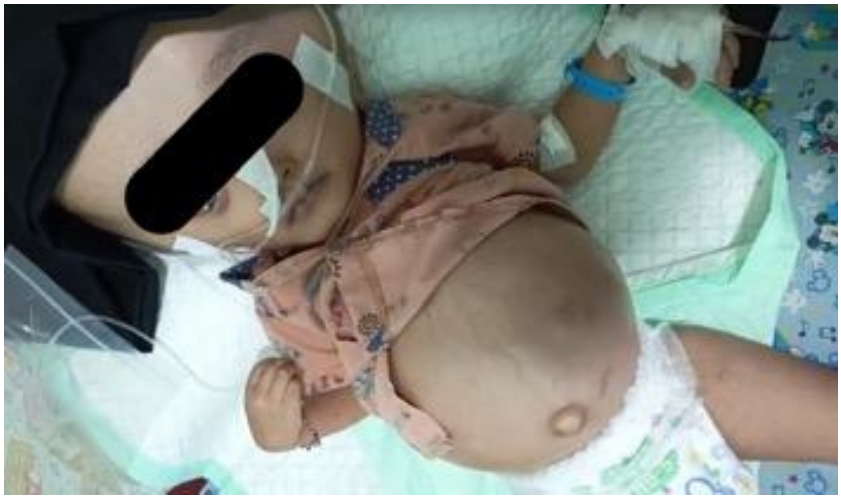

Figure 1. Preoperative clinical photograph demonstrating marked macrocephaly relative to the trunk and a grossly distended abdomen in a marasmic child. The ocular region has been masked to preserve patient privacy.

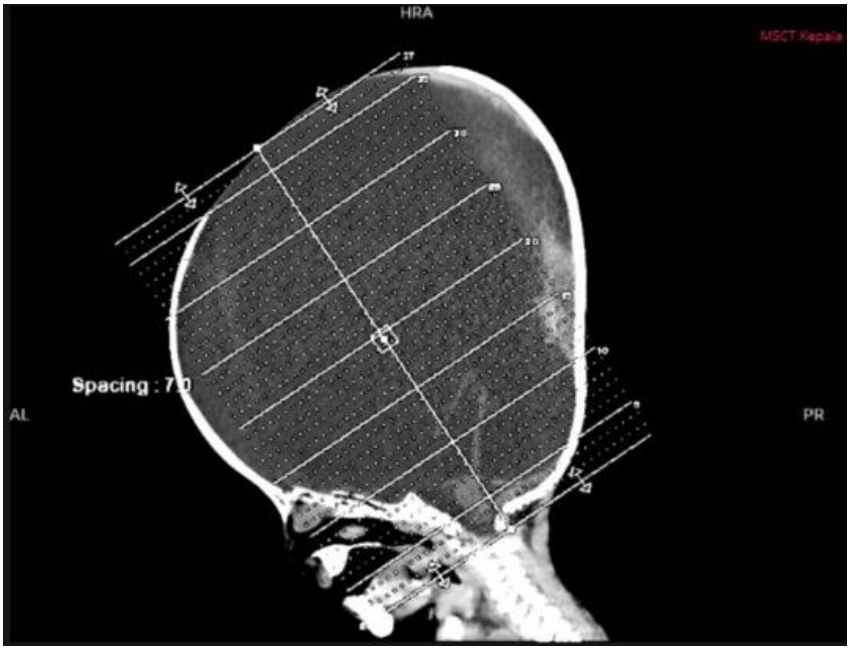

Figure 2. Non-contrast multislice computed tomography of the head (lateral view) showing a massively enlarged cranial vault disproportionate to the facial skeleton, consistent with severe communicating hydrocephalus and macrocephaly.

Plain abdominal radiography in three positions revealed multiple long air-fluid levels exceeding three in number, forming a pathological step-ladder pattern indicative of low small-bowel obstruction; there was no free subdiaphragmatic or subhepatic gas to suggest perforation. Taken together, the imaging confirmed two coexisting structural problems—an intracranial process and an intra-abdominal surgical emergency—whose treatments were, at least in their timing, mutually exclusive.

Anesthetic approach

Preoperative evaluation assigned a high anesthetic risk, classified as American Society of Anesthesiologists physical status III-E, reflecting features of raised intracranial pressure together with signs of sepsis. The large head-to-body ratio predicted a difficult intubation, and the child had presented with severe dehydration that had already been addressed with fluid resuscitation by the pediatric team before transfer to the operating room. Given the surgical urgency of the bowel obstruction, a rapid yet meticulously planned anesthetic strategy was essential, and a difficult-airway plan with video laryngoscopy and alternative airway equipment was prepared in advance.[7,8]

Immediately before induction the vital signs were a systolic blood pressure of 85 mmHg, a diastolic pressure of 55 mmHg, a heart rate of 115 to 122 beats/min, a peripheral oxygen saturation of 93 to 95%, and a respiratory rate of 22 to 24 breaths/min. Anesthesia was induced with a modified rapid sequence technique using ketamine 7.5 mg, fentanyl 15 mcg, dexamethasone 1.5 mg, ondansetron 1.5 mg, and rocuronium 8 mg. A nasogastric tube was in situ and aspirated to decompress the obstructed stomach before induction, and ketamine was used as a co-induction agent in combination with fentanyl rather than as a sole anesthetic. Intubation was performed with the patient in the ramp position so that the head-body axis was brought into alignment, and a 4.5 mm internal-diameter endotracheal tube was secured at a depth of 12 cm. The intraoperative appearance after the airway had been secured, with the head-body axis aligned by ramp positioning, is shown in Figure 3, in which the disproportionate cranial size that necessitated this maneuver is again evident. Anesthesia was maintained with an additional 5 mcg of fentanyl intraoperatively under continuous controlled ventilation.

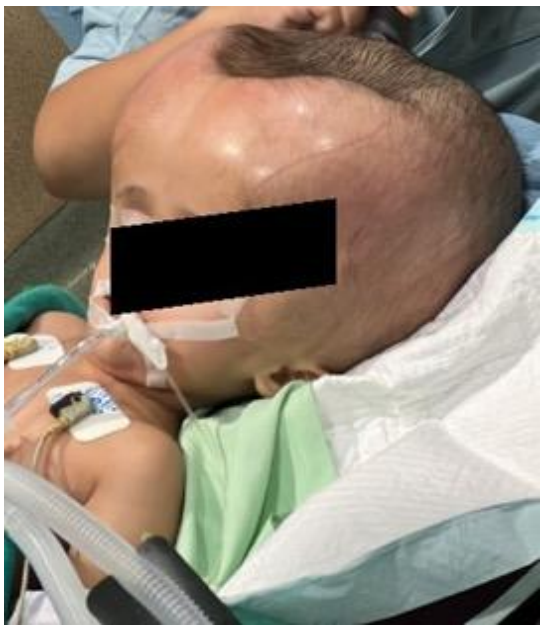

Figure 3. Intraoperative photograph after securing the airway, illustrating the disproportionate head-to-body ratio that mandated ramp positioning for intubation. The ocular region has been masked to preserve patient privacy.

The complete induction and maintenance pharmacologic regimen, with weight-based doses, is detailed in Table 2; as detailed in Table 2, ketamine was administered at 0.5 mg/kg, induction fentanyl at 1 mcg/kg, and rocuronium at approximately 0.5 mg/kg, with antiemetic dexamethasone and ondansetron each at 0.1 mg/kg.

Table 2. Pharmacologic regimen for modified rapid sequence induction and intraoperative maintenance (body weight 15 kg).

Agent	Dose	Weight-based dose	Principal role
Ketamine	7.5 mg	0.5 mg/kg	Induction; maintains systemic vascular resistance and cerebral perfusion
Fentanyl (induction)	15 mcg	1 mcg/kg	Analgesia; blunts the pressor response to laryngoscopy
Rocuronium	8 mg	≈ 0.5 mg/kg	Neuromuscular blockade to facilitate modified RSI
Dexamethasone	1.5 mg	0.1 mg/kg	Antiemetic and adjunct
Ondansetron	1.5 mg	0.1 mg/kg	Antiemetic
Fentanyl (maintenance)	5 mcg	0.33 mcg/kg	Intraoperative analgesia
Metamizole (postoperative)	150 mg every 8 h	10 mg/kg	Postoperative analgesia in the PICU

Notes: RSI, rapid sequence induction; PICU, pediatric intensive care unit. A cuffed endotracheal tube of internal diameter 4.5 mm was secured at 12 cm at the lips.

Throughout the procedure the patient's hemodynamics remained stable, with systolic pressures of 80 to 90 mmHg, diastolic pressures of 50 to 65 mmHg, a heart rate of 100 to 110 beats/min, and oxygen saturations of 96 to 98%. Ventilation was controlled in a pressure-control mode with an inspiratory pressure of 15 cmH_2O, a positive end-expiratory pressure of 5 cmH_2O, a fraction of inspired oxygen of 50%, and an end-tidal carbon dioxide maintained between 30 and 35 mmHg. These intraoperative parameters are presented alongside the pre-induction values in Table 3. Maintaining end-tidal carbon dioxide in the low-normal range was a deliberate neuroprotective choice intended to avoid the cerebral vasodilation and rise in intracranial pressure that accompany hypercapnia.

Table 3. Hemodynamic and ventilatory parameters before induction and during maintenance of anesthesia.

Parameter	Pre-induction	Intraoperative
Systolic blood pressure (mmHg)	85	80–90
Diastolic blood pressure (mmHg)	55	50–65
Heart rate (beats/min)	115–122	100–110
Peripheral oxygen saturation (%)	93–95	96–98
Respiratory rate (breaths/min)	22–24 (spontaneous)	22 (controlled)
Ventilation mode	—	Pressure control
Inspiratory pressure (cmH_2O)	—	15
Positive end-expiratory pressure (cmH_2O)	—	5
Fraction of inspired oxygen (%)	—	50
End-tidal carbon dioxide (mmHg)	—	30–35

Notes: Operative time was 2.5 hours. Intraoperative fluid ledger: intravenous drug volume 9.8 mL and dextrose 1% 100 mL administered; urine output 15 mL, estimated blood loss 20 mL, and nasogastric output 5 mL, yielding a net positive balance of +61 mL.

The operation lasted 2.5 hours with an estimated blood loss of 20 mL. The intraoperative fluid ledger comprised 9.8 mL of intravenous drug volume and 100 mL of dextrose 1%, against a urine output of 15 mL, blood loss of 20 mL, and nasogastric output of 5 mL, leaving a modest net positive balance of 61 mL. At the conclusion of surgery the child was deliberately not extubated. He was transferred to the pediatric intensive care unit with the endotracheal tube in place, where he was observed with a Glasgow Coma Scale of E2V(ett)M1 and ventilated in an assist-control pressure-control mode with a fraction of inspired oxygen of 50%, a positive end-expiratory pressure of 5 cmH_2O, and an inspiratory pressure of 8 cmH_2O. The full intraoperative fluid ledger and ventilatory settings are tabulated in Table 3. Postoperative analgesia was provided with metamizole 150 mg every 8 hours.

3. Discussion

This case illustrates how four concurrent emergencies—severe macrocephalic hydrocephalus, low intestinal obstruction, sepsis, and marasmic malnutrition—can converge in one small child and force the anesthesiologist to reconcile recommendations that, taken individually, point in opposite directions. The discussion that follows examines each axis of the problem and explains how the competing imperatives were balanced.

Classifying the hydrocephalus and reordering the surgical priorities

Hydrocephalus is conventionally divided into obstructive (non-communicating) disease, in which cerebrospinal fluid flow is blocked within the ventricular system, and communicating disease, in which the impairment lies in absorption.[1] In this child the non-contrast computed tomography of the head concluded that there was severe communicating hydrocephalus. Untreated hydrocephalus can lead to permanent brain injury and even death from uncontrolled intracranial pressure, and the definitive treatment is usually placement of a ventriculoperitoneal shunt, which drains the accumulated cerebrospinal fluid into the peritoneal cavity for absorption.[4] In this patient, however, the peritoneal cavity was precisely the site of disease. He presented with vomiting and the supporting features of obstructive ileus, and a three-view plain abdominal radiograph demonstrated low intestinal obstruction with the abdomen severely distended.

Placing a ventriculoperitoneal shunt into an obstructed, distended, and potentially infected abdomen would have been inappropriate. It would have aggravated the ileus, exposed the shunt to an infected intra-abdominal field with a high risk of shunt infection, and failed to address the surgical emergency that was the immediate threat to life. The team therefore elected to perform exploratory laparotomy first to relieve the bowel obstruction, deferring definitive treatment of the hydrocephalus. This sequencing rests on a clear risk hierarchy: obstructive ileus is a surgical emergency carrying the risk of bowel ischemia and perforation, whereas the hydrocephalus, although severe, was chronic and showed no signs of acute herniation, so that shunt placement could be planned electively once the abdominal and systemic condition had stabilized. The decision exemplifies the principle that, when two structural pathologies compete for priority, the more rapidly lethal and the more reversible problem is addressed first.

Intracranial compliance and the defense of cerebral perfusion pressure

The pressure-volume relationship of the intracranial compartment is non-linear. As cerebrospinal fluid accumulates, compensatory mechanisms—displacement of fluid into the spinal compartment and reduction of cerebral venous blood volume—initially keep intracranial pressure near normal, which is precisely why a child can develop an enormous head while remaining alert. Once these reserves are exhausted, however, the curve steepens sharply, and small additional volumes produce large rises in pressure. Several routine events during anesthesia add exactly such volumes: hypercapnia and hypoxemia dilate the cerebral vasculature, coughing and straining on the tube raise intrathoracic and hence cerebral venous pressure, head-down or flexed positions impede venous drainage, and the pressor response to laryngoscopy transiently increases cerebral blood flow. A neuroanesthetic plan for this

child therefore had to anticipate and blunt each of these, which explains the attention paid to smooth induction, adequate fentanyl to obtund the laryngoscopy response, neutral head positioning achieved through ramping, and tight control of carbon dioxide.

Equally important was the arterial side of the perfusion equation. Because cerebral perfusion pressure is the difference between mean arterial pressure and intracranial pressure, a septic fall in mean arterial pressure is as dangerous to the brain as a rise in intracranial pressure, and in a child whose autoregulatory range may be narrowed by chronic disease the dependence of perfusion on arterial pressure becomes more direct.[5] Prior fluid resuscitation, a vasopressor-sparing induction agent, and the avoidance of deep anesthetic-induced vasodilation were the means by which the arterial limb of perfusion was protected. The whole strategy can be read as an effort to keep both terms of the cerebral perfusion equation within safe bounds simultaneously.

The predicted difficult airway and the role of positioning

Managing the airway of a child with massive hydrocephalus is a recognized and formidable challenge. The enlarged occiput and the disproportion between the cranium and the body mean that, in the ordinary supine position, the airway axes from head to trunk are not aligned, and the head tends to fall into extreme flexion.[3] Series of children with giant encephalocele and related cranial anomalies report difficult tracheal intubation in around half of cases and advocate careful positioning, often in the lateral position, with muscle relaxant withheld until the glottis has been visualized.[2] Reports of huge hydrocephalus and of other congenital lesions associated with macrocephaly, including Dandy-Walker syndrome and the vein of Galen malformation, similarly emphasize anticipation of a difficult airway and meticulous preparation.[4,9] The same theme runs through reports of children with mucopolysaccharidosis presenting for emergency shunt surgery, in whom infiltration of the airway tissues compounds the difficulty imposed by hydrocephalus, and through accounts of anesthesia in patients with meningomyelocele and other neural-tube defects, where an anticipated difficult airway is approached with awake or conscious-sedation fiberoptic techniques and careful positioning.[10,11] Even bag-mask ventilation cannot be taken for granted in these patients, as illustrated by a report of mask-ventilation failure during induction in an infant whose large hydrocephalic skull and thoracic abnormality combined to defeat conventional rescue.[12]

In the present case the airway was managed by general anesthesia using a modified rapid sequence technique, and the key positioning maneuver was the ramp. As shown in Figure 2 and again in Figure 3, the cranial vault was so enlarged relative to the trunk that the head would otherwise have rested in marked flexion. Placing folded towels beneath the torso raised the body until it was level with the enlarged head, restoring a neutral head-body axis and bringing the oral, pharyngeal, and laryngeal planes into alignment for laryngoscopy. The benefit of ramping is not merely anecdotal: controlled clinical and manikin-based studies demonstrate that the ramped position, with appropriate operating-table height, shortens intubation time and improves the laryngoscopic view, and that suboptimal patient height degrades intubating conditions.[13,14] A pre-formulated difficult-airway plan incorporating video laryngoscopy, supported by appraisals of difficult-airway guidelines, complemented the positioning strategy.[7,8]

The mechanics of why ramping helps are worth making explicit, because they differ in emphasis between the macrocephalic child and the obese adult in whom the maneuver is more familiar. In the obese patient ramping chiefly counteracts posterior chest and shoulder bulk to bring the sternal notch level with the external auditory meatus. In the macrocephalic child the problem is inverted: the occiput is so prominent that, on a flat surface, the head is pushed into flexion and the chin drops toward the chest, closing the oral axis and burying the larynx from view. Building the torso upward with towel rolls until it matches the height of the enlarged head restores the

neutral sniffing relationship between the oral, pharyngeal, and laryngeal axes that direct laryngoscopy requires. The pediatric airway already sits more anteriorly and superiorly than the adult airway, with a relatively larger occiput even in health, so the macrocephaly of severe hydrocephalus exaggerates an anatomical tendency that pediatric anesthesiologists routinely accommodate. Framing the maneuver in these terms helps the clinician judge how much elevation is needed and confirms why a simple, equipment-light intervention proved decisive here.

Aspiration risk and the rationale for a modified rapid sequence induction

The obstructive ileus, with its vomiting and distended bowel, identified this child as having a full stomach and therefore a high risk of pulmonary aspiration, the classic indication for rapid sequence induction. Pediatric rapid sequence practice is, however, far from uniform; survey data reveal wide variation among anesthesiologists in the choice of muscle relaxant, the use of cricoid pressure, and adherence to the technique in children compared with adults, particularly in the setting of intestinal obstruction.[6] A central reason for departing from the classical, apneic form of the technique is that children desaturate considerably faster than adults; hypoxemia during induction is in fact more common than aspiration in many pediatric scenarios, which has driven interest in gentle mask ventilation and in apneic oxygenation to prolong safe apnea time.[15,16] The broader lesson that gastrointestinal pathology raises aspiration risk and favors a secured endotracheal airway over a supraglottic device is reinforced by experience in children with impaired gastric emptying.[17]

For this patient a modified rapid sequence induction was chosen, combining the aspiration protection of rapid airway control with careful, low-pressure ventilation to prevent the precipitous desaturation that a marasmic, septic child with limited reserve would poorly tolerate. Rocuronium at approximately 0.5 mg/kg provided neuromuscular blockade for intubation, as detailed in Table 2. The deliberate avoidance of vigorous positive-pressure ventilation also limited gastric insufflation, which is relevant both to aspiration risk and to the splinting of an already distended abdomen.

The choice of neuromuscular blocking agent deserves comment. Classical rapid sequence induction has historically employed succinylcholine for its rapid onset and short duration, but in this child several considerations favored rocuronium. Succinylcholine can transiently raise intracranial pressure, is relatively contraindicated in the presence of chronic immobilization and neuromuscular compromise such as that accompanying cerebral palsy because of the risk of hyperkalemia, and offers a short duration that would have been undesirable given the anticipated difficult airway and the plan for postoperative ventilation. Rocuronium at a dose of approximately 0.5 mg/kg provided reliable intubating conditions while avoiding these hazards, and its blockade could, if rapid neurological assessment had later been required, be reversed pharmacologically. The availability of sugammadex to restore neuromuscular function quickly enough to permit a meaningful neurological examination is a relevant safeguard in neurologically vulnerable patients, even though in this instance continued blockade and ventilation were the chosen course.[18] Survey data confirm that the relaxant chosen for pediatric rapid sequence induction varies widely in practice, underscoring that the decision should be individualized to the patient rather than dictated by habit.[6]

The central pharmacologic dilemma: protecting the brain without starving it of perfusion

The most demanding aspect of this case was the selection of an induction agent that would respect the neuroanesthetic imperative to control intracranial pressure while honoring the septic imperative to preserve perfusion. In hydrocephalus the safest and most frequently used induction agent is propofol, because it lowers intracranial pressure and cerebral metabolic rate.[3] Yet propofol is also a potent vasodilator and myocardial depressant, and in a child with signs of sepsis and recent severe dehydration it carries a high risk of hypotension and of a fall in

cerebral blood flow. Anesthetic induction in sepsis and septic shock is widely recognized as a period of acute hemodynamic vulnerability, and reviews of the problem recommend agents with a more favorable cardiovascular profile, such as ketamine or etomidate, in preference to propofol, thiopental, or midazolam, provided that adequate fluid resuscitation has been given beforehand.[5] The comparative profile of these agents in the specific context of coexisting raised intracranial pressure and sepsis is summarized in Table 4.

Table 4. Comparative profile of intravenous induction agents relevant to coexisting raised intracranial pressure and sepsis.

Agent	Effect on ICP / cerebral metabolism	Hemodynamic effect	Relevance to this case
Propofol	Lowers ICP and cerebral metabolic rate	Marked fall in blood pressure and vascular tone	Favorable for ICP but hazardous in sepsis and hypovolemia
Ketamine	ICP-neutral when normocapnia is maintained; sympathomimetic	Raises systemic vascular resistance; preserves blood pressure	Preferred here — preserves perfusion with controlled ventilation
Etomidate	Lowers ICP and cerebral metabolic rate	Minimal change	Stable, but adrenal suppression is a concern in sepsis
Thiopental	Strongly lowers ICP and cerebral metabolic rate	Hypotension; negative inotropy	Avoided — risk of hypotension in a septic, dehydrated child
Midazolam	Mildly lowers ICP	Mild fall in blood pressure	Adjunct only

Notes: ICP, intracranial pressure.

Ketamine has traditionally been avoided in hydrocephalus because of a longstanding belief that it raises intracranial pressure. Its sympathomimetic action, however, increases systemic vascular resistance and supports blood pressure, which is exactly what a septic, vasodilated child requires.[5] The historical caution against ketamine has been substantially revised by modern evidence. A study comparing ketamine with other induction agents in 143 pediatric patients with neurologic conditions at risk for intracranial hypertension found no significant difference in peri-intubation neurologic, hemodynamic, or respiratory events, including the need for emergent imaging, an emergent return to the operating room, or hyperosmolar therapy, and reported no increase in adverse outcomes attributable to ketamine.[19] Importantly, the apparent safety of ketamine in this setting is contingent on controlled ventilation that maintains normocapnia, because it is hypercapnia, rather than ketamine itself under controlled conditions, that drives cerebral vasodilation. In the present case the ketamine-based induction was therefore paired with pressure-controlled ventilation targeting an end-tidal carbon dioxide of 30 to 35 mmHg, as shown in Table 3, so that the agent's hemodynamic benefits could be obtained without conceding control of intracranial pressure.

The result was a stable intraoperative course. Comparison of the pre-induction and intraoperative rows of Table 3 shows that blood pressure, heart rate, and oxygenation were maintained throughout, with no hypotensive episodes despite the septic background. Fentanyl in modest doses blunted the pressor and intracranial response to laryngoscopy without causing hemodynamic instability, while dexamethasone and ondansetron addressed the high emetic risk of an obstructed bowel. This experience supports a pragmatic conclusion: in the child in whom raised intracranial pressure and septic hypotension coexist, the threat to cerebral perfusion from hypotension may outweigh the theoretical risk of a modest, ventilation-controlled rise in intracranial pressure, so that a ketamine-based technique becomes the more rational choice.

Ventilation as a neuroprotective instrument

Control of ventilation was not a background detail but an active part of the neuroprotective strategy, and it was what made the ketamine-based technique defensible. Arterial carbon dioxide is the most powerful physiological regulator of cerebral blood flow; hypercapnia dilates the cerebral vessels and raises intracranial pressure, whereas excessive hypocapnia constricts them and risks cerebral ischemia. The target adopted here, an end-tidal carbon dioxide of 30 to 35 mmHg, corresponds to low-normal arterial values that minimize cerebral blood volume without provoking ischemic vasoconstriction, and it is reported in Table 3 among the intraoperative parameters. Pressure-controlled ventilation with an inspiratory pressure of 15 cmH_2O and a positive end-expiratory pressure of 5 cmH_2O delivered adequate gas exchange while limiting peak airway pressures, an important consideration because high intrathoracic pressure impedes cerebral venous drainage and can itself elevate intracranial pressure. The continuation of controlled ventilation into the postoperative period in the intensive care unit, with a lower inspiratory pressure of 8 cmH_2O once surgical stimulation had ceased, extended this neuroprotective control beyond the operating room and allowed carbon dioxide and oxygenation to be governed precisely during the vulnerable early recovery. It should be acknowledged that end-tidal carbon dioxide is only an approximation of the arterial value, and that the arterial-to-end-tidal gradient may widen in a child with abnormal lung mechanics, so the low-normal target was chosen with a deliberate margin against inadvertent hypercapnia.

Sepsis, dehydration, and the malnourished child

The septic physiology of this child shaped both resuscitation and agent selection. Contemporary pediatric sepsis guidance emphasizes early recognition, timely fluid resuscitation titrated to perfusion, and hemodynamic support to preserve organ function, and the pediatric team had begun this resuscitation before transfer.[20] Adequate volume restoration before induction is precisely the precondition that allows an induction agent to be given with a reasonable margin of hemodynamic safety.[5] Severe acute malnutrition of the marasmic type added a further layer of fragility: malnourished children have diminished physiological reserve, a higher burden of infection and dehydration, and an increased susceptibility to perioperative complications, all of which argue for conservative ventilation, careful fluid accounting, and a low threshold for continued intensive care.[21] The modest net positive fluid balance of 61 mL recorded over the operation reflects the deliberately cautious volume strategy adopted in a child who was at once dehydrated, septic, and at risk of cerebral edema.

The composition as well as the volume of fluid mattered in this child. Malnourished and septic children are prone to derangements of glucose and electrolytes and to impaired thermoregulation, and the intraoperative administration of a dilute dextrose-containing solution reflected the need to guard against hypoglycemia in a marasmic patient with negligible glycogen reserve while avoiding the hyperglycemia that can worsen neurological injury. Maintenance of normothermia, limitation of fasting time, and avoidance of large free-water loads that could aggravate cerebral edema were further considerations characteristic of the malnourished surgical child. The careful intake-and-output accounting documented in Table 3, culminating in a small positive balance, is the practical expression of trying to satisfy these partly competing demands at once: enough volume to support a septic circulation, but not so much as to flood a vulnerable brain.

Antiemesis and analgesia were tailored to the same fragile physiology. The obstructed bowel made the child highly prone to vomiting, and both dexamethasone and ondansetron were given, the former also offering a theoretical benefit against perilesional cerebral edema. For postoperative pain the child received metamizole rather than an opioid infusion, a choice that limited respiratory depression and sedation and thereby preserved the ability to interpret the neurological examination during intensive care monitoring. Opioids were used intraoperatively in deliberately modest doses, sufficient to blunt the stress and pressor responses

without producing the prolonged respiratory depression that would have complicated neurological assessment in a child already at risk of central respiratory failure.

Agenesis of the corpus callosum and the chronicity of the disease

The computed tomography finding of agenesis of the corpus callosum, alongside the open sutures and fontanelle, is more than an incidental observation. It marks the hydrocephalus as a congenital, long-evolving process rather than an acute decompensation, and that distinction carried direct management consequences. A chronically dilated ventricular system without clinical or radiological evidence of impending herniation does not demand emergency cerebrospinal fluid diversion, which is what permitted the team to defer shunting and address the abdomen first. Had there been signs of acute herniation—a deteriorating conscious level out of keeping with the metabolic picture, pupillary changes, or a Cushing response—the calculus would have shifted and emergency neurosurgical intervention might have competed with the laparotomy for priority. Recognizing the chronicity of the intracranial disease was therefore essential to the safe sequencing of care.

The decision to defer extubation

At the end of surgery the child was kept intubated and transferred to the pediatric intensive care unit rather than being woken and extubated in theatre. This decision followed directly from the accumulation of risk factors for respiratory failure: severe hydrocephalus with raised intracranial pressure, a documented difficult intubation that would make emergency re-intubation hazardous, cerebral palsy, severe malnutrition, sepsis, and the physiological insult of an exploratory laparotomy. In children with severe hydrocephalus the combination of a difficult airway and raised intracranial pressure carries a particular risk of central respiratory failure, and continued intubation in the intensive care unit allows ventilation to be controlled, hypercapnia to be prevented, and the neurological state to be monitored closely.[4] The literature on congenital central nervous system anomalies specifically anticipates the need for prolonged postoperative ventilation in such patients, reflecting both airway and central respiratory concerns.[4] Where rapid neurological assessment is required after neuromuscular blockade, pharmacological reversal with sugammadex can restore the ability to perform a meaningful examination, illustrating the trade-off between rapid emergence and the controlled ventilation that this child instead required.[18] In his case the priority was unambiguous, and planned postoperative ventilation with neurological monitoring was the safer course.

An anticipatory, multidisciplinary model of care

No part of this child's safe passage through surgery was the work of a single specialty. The pediatric team recognized and began to resuscitate the sepsis and dehydration before the patient reached the operating room, creating the hemodynamic margin on which the induction depended.[20,22] The surgical team established the diagnosis of low intestinal obstruction and accepted the logic of operating on the abdomen while deferring the shunt. The anesthetic team translated the combined picture into a concrete plan: a pre-declared difficult-airway strategy with ramp positioning and video laryngoscopy, an induction agent chosen for the dominant physiological threat, ventilation set to neuroprotective targets, and a postoperative destination in intensive care rather than the recovery room. Intensive care then continued the controlled ventilation and neurological surveillance. This anticipatory, communicative model—in which each team's actions were sequenced around a shared understanding of the competing risks—was as important to the outcome as any individual drug or maneuver, and it is the element most readily transferable to other complex pediatric emergencies.

Lessons and limitations

Several lessons emerge from this case. The reordering of surgical priorities—treating the obstructed abdomen before the chronic hydrocephalus—demonstrates the value of an explicit risk hierarchy when two structural pathologies compete. The use of ramp positioning shows how a simple, inexpensive maneuver can convert a predicted difficult airway into a manageable one. Most

instructive is the induction strategy, in which a textbook default was set aside in favor of an agent matched to the dominant physiological threat, with controlled ventilation used to neutralize that agent's principal drawback. This report is limited by its single-patient design and by the absence of invasive intracranial-pressure monitoring, so that the inference of intracranial stability rests on clinical and ventilatory surrogates rather than direct measurement. Long-term neurological outcome and the timing of definitive shunt placement after recovery of the abdominal condition were beyond the scope of the perioperative period described here. Nonetheless, the favorable intraoperative course supports the generalizable principle that individualized, evidence-aligned planning can render even the convergence of several emergencies safely manageable.

A further limitation is that the conclusions rest on a single favorable outcome and cannot, on their own, establish the superiority of one technique over another; case reports generate hypotheses rather than test them. The intraoperative inferences about intracranial stability were drawn from clinical behavior, hemodynamic trends, and ventilatory targets rather than from invasive monitoring, and capnography reflects arterial carbon dioxide only approximately. Pharmacokinetics and pharmacodynamics may also differ in a marasmic child with altered body composition, so that the weight-based doses used here should be regarded as a careful starting point rather than a fixed prescription. These caveats notwithstanding, the case adds a detailed, reproducible account of how competing priorities were reconciled, and it may assist clinicians who encounter similarly layered emergencies in resource-variable settings where definitive neurosurgical treatment must sometimes wait.

4. Conclusion

Anesthetic management of a child with severe communicating hydrocephalus complicated by obstructive ileus, sepsis, and marasmic malnutrition demands comprehensive, individualized planning. In this patient the ventriculoperitoneal shunt that would ordinarily treat the hydrocephalus was appropriately deferred because of the obstructive ileus, and exploratory laparotomy was prioritized as the more rapidly lethal and more reversible emergency, with the risks of bowel ischemia, perforation, and shunt infection in an infected abdomen all weighing against early shunting; the chronic, non-herniating nature of the hydrocephalus made elective shunt placement after systemic stabilization the safer plan. Ketamine, an agent customarily avoided in hydrocephalus, was chosen deliberately because the signs of sepsis made the preservation of perfusion the dominant concern, and its use was rendered safe by controlled ventilation maintaining normocapnia. Ramp positioning overcame the predicted difficult airway created by macrocephaly, a modified rapid sequence induction protected against aspiration from the obstructed bowel, and the child was kept intubated postoperatively to forestall respiratory failure arising from his many coexisting problems. The case underscores that, when neurological, surgical, infectious, and nutritional emergencies collide, safe anesthesia depends less on any single protocol than on the disciplined balancing of competing physiological priorities.

Declarations

Ethics approval and consent to participate

Written informed consent for anesthesia, the surgical procedure, and the anonymized publication of clinical images and data was obtained from the patient's parents. The report was prepared in accordance with institutional requirements for the publication of case reports, and identifiable ocular regions in all clinical photographs have been masked to protect patient privacy.

Conflict of interest

The authors declare that there is no conflict of interest related to this case report.

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Data availability

The clinical data supporting the findings of this report are available from the corresponding author upon reasonable request, subject to the protection of patient confidentiality.

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