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Anesthetic management for ommaya reservoir placement in an extremely preterm 500 gr. neonate: case report

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Keypoints

This case demonstrates the feasibility of neurosurgical interventions in infants at the extreme lower limit of viability (500 grams) when supported by precision anesthesia techniques tailored to extreme physiological immaturity.

Abstract

We report the anesthetic management of a 27-day-old, 500-gram female infant (birth weight 580g), born at $24^{6}/_{7}$ weeks gestation, undergoing Ommaya reservoir placement for progressive posthemorrhagic hydrocephalus. It underscores the multidisciplinary perioperative challenges inherent in caring for extremely low birth weight (ELBW) infants with significant comorbidities, including cardiorespiratory compromise and evolving grade III intraventricular hemorrhage (IVH). Critical anesthetic strategies included: strict, milliliter-precise fluid restriction; ventilation management using the existing mobile ventilator in synchronized intermittent mandatory ventilation with volume guarantee (SIMV-VG) mode, maintaining permissive hypercapnia; pharmacologic microdosing with microgram-range opioids and muscle relaxants; and continuous hemodynamic support via titrated inotrope infusion. The infant tolerated the 20-minute procedure without hemodynamic instability, respiratory deterioration, or exacerbation of metabolic acidosis. This case demonstrates the feasibility of neurosurgical interventions in infants at the extreme lower limit of viability (500 grams) when supported by precision anesthesia techniques tailored to extreme physiological immaturity.

Keywords

extreme prematurity; Ommaya reservoir; extremely low birth weight; neonatal anesthesia; hydrocephalus

Introduction

Providing safe and effective anesthesia for extremely preterm infants born weighing less than 1000 grams (Extremely Low Birth Weight, ELBW) at a gestational age below 28 weeks presents profound challenges. These stem from profound immaturity across all organ systems, inherent hemodynamic instability, and critically narrow therapeutic indices for anesthetic and adjunctive medications[1]. While anesthetic management for ELBW infants undergoing general surgery is increasingly documented, specific protocols for neurosurgical interventions in this vulnerable population remain inadequately described. This knowledge gap is particularly pronounced for the most extremely low birth weight infants, specifically those weighing at the time of surgery, where physiological reserves are minimal and pharmacokinetic/pharmacodynamic data are virtually absent. Herein, we report the

first documented case of Ommaya reservoir placement performed in a neonate weighing 580 grams. This report details the perioperative management, with a specific focus on the strategies employed for mechanical ventilation, hemodynamic monitoring, and the administration of anesthetic agents utilizing ultra-low, microgram-range dosing to navigate the precarious physiological balance inherent in such extreme prematurity and low body weight.

Case report

A female infant was born via vaginal delivery at $24^{6}/_{7}$ weeks gestational age weighing 580g, with Apgar scores of 6 and 8 at 1 and 5 minutes, respectively. Her postnatal course was complicated by respiratory distress syndrome necessitating surfactant administration and mechanical ventilation, a hemodynamically significant patent ductus arteriosus (successfully closed with ibuprofen therapy), and progressive posthemorrhagic hydrocephalus. The hydrocephalus, diagnosed on postnatal day 19 as Grade III intraventricular hemorrhage with ventricular dilatation, failed to resolve despite serial therapeutic lumbar punctures. Consequently, neurosurgical intervention was indicated due to worsening ventriculomegaly.

On postnatal day 27, at a weight of 500g (Figure 1A), the infant required preoperative anesthetic evaluation. She remained ventilator-dependent, managed with synchronized intermittent mandatory ventilation plus volume guarantee (SIMV+VG) settings at a fraction of inspired oxygen (FiO_2) of 30% and a tidal volume (VT) of 5.4ml. Laboratory findings revealed a compensated metabolic acidosis (pH 7.338, pCO_2 59 mmHg). Hemodynamic instability was evident with hypotension (blood pressure 54/28 mmHg), managed with a dopamine infusion at 5 µg/kg/min. The infant was normothermic and had a stable hematocrit of 43%. Her overall condition warranted an American Society of Anesthesiologists (ASA) physical status classification of IV-E.

Anesthesia was induced and maintained using an ultra-low dose sequential pharmacologic strategy. The initial induction regimen consisted of fentanyl 5 µg (10 µg/kg), cisatracurium 0.5 mg (1 mg/kg), and midazolam 0.25 mg (0.5 mg/kg). Maintenance included a repeat dose of cisatracurium 0.5 mg at 40 minutes and a supplemental dose of fentanyl 5 µg administered at skin incision. Ventilation management continued using the existing mobile ventilator (SIMV+VG mode) without transitioning to a standard anesthesia machine (Figure 1B,C). Tidal volumes were maintained between 5-6 ml (10-12 ml/kg), employing a strategy of permissive hypercapnia targeting an arterial partial pressure of carbon dioxide (pCO_2) of 55-60 mmHg. Oxygen saturation (SpO_2) was deliberately targeted within a range of 90-95% to minimize the risk of retinopathy of prematurity. Given the infant's extreme prematurity and small size, continuous invasive arterial blood pressure monitoring was deferred. Hemodynamic stability was instead assessed and managed by titrating the existing dopamine infusion (range 5-7 µg/kg/min) based on clinical parameters including capillary refill time and serial lactate measurements. A strict intraoperative fluid restriction protocol was implemented, administering a total volume of only 7.2 ml over the 127-minute perioperative period. This fluid consisted of balanced crystalloid solution (35%), amino acid solution (60%), and calcium-supplemented glucose solution (5%). Temperature control was rigorously maintained using a radiant warmer with a servo-controlled skin probe set to maintain core temperature between 37.0-37.5°C, supplemented by a humidified ventilator circuit.

The Ommaya reservoir placement procedure was successfully completed within 20 minutes, with an estimated blood loss of only 1 ml. Throughout the surgery, the infant remained hemodynamically and physiologically stable. Oxygen saturation was maintained between 95-97%, heart rate ranged from 150-180 beats per minute, and non-invasive blood pressure measurements remained within the range of 50-60/30-40 mmHg. Importantly, there was no exacerbation of the pre-existing metabolic acidosis, with a lactate level of 0.9 mmol/L recorded intraoperatively.

The infant was successfully extubated to high-flow nasal cannula (HFNC) support on postoperative day 43. She survived to postnatal day 50, maintaining stable respiratory status on FiO_2 25%, with evidence of resolving hydrocephalus.

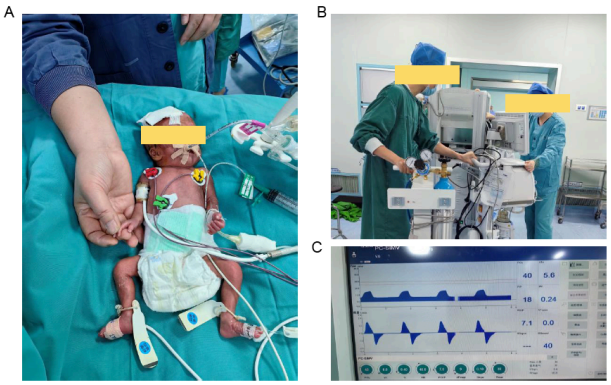

Figure 1. Perioperative management and anthropometri c characteristics of an extremely low birth weight (ELBW) neonate. *(A) Developmental scale perspective: The 500g neonate was shown in comparison to an adult hand. (B) Intra-hospital transport protocol: The ELBW infant was stabilized in a temperature-controlled isolette with integrated mobile ventilator, demonstrating multidisciplinary coordination during NICU-to-OR transition.(C) Ventilator interface during surgery: Pressure-controlled parameters are maintained using the neonatal transport ventilator to ensure continuity of respiratory support.*

Discussion

This report details the successful anesthetic management for Ommaya reservoir placement in a 27-day-old ELBW infant (500 g), representing one of the smallest neonates to undergo neurosurgery under general anesthesia. The case exemplifies the critical interplay between extreme prematurity, evolving cardiorespiratory compromise, and neurosurgical imperatives, necessitating precision anesthesia tailored to microphysiology.

ELBW infants exhibit profound physiological immaturity: reduced alveolar surface area, labile cerebral autoregulation, and immature hepatic/renal drug metabolism amplify perioperative risks. Our patient's preoperative metabolic acidosis (pH 7.338) and ventilator dependence (FiO_2 30%) reflected marginal cardiorespiratory reserve, while dopamine-dependent hypotension underscored catecholamine-resistant vascular tone—a known complication of extreme prematurity and PDA closure. Crucially, avoiding volatile anesthetics mitigated myocardial depression and preserved cerebral perfusion pressure (CPP), aligning with evidence that inhalational agents impair autoregulation in premature brains[2].

The decision to continue mobile pressure-controlled ventilation (SIMV-VG) without transitioning to an anesthesia machine was pivotal. Maintaining identical ventilator settings (VT 5–6 mL, ~10–12 mL/kg) prevented volutrauma and minimized oxygen flux fluctuations.

Permissive hypercapnia (pCO_2 55–60 mmHg) balanced cerebral blood flow modulation against acidosis exacerbation—a strategy validated in neonatal neurocritical care but rarely applied intraoperatively[3]. Targeting SpO_2 90–95% mitigated retinopathy risk without compromising oxygen delivery, demonstrating that neuroprotection and retinal safety are reconcilable goals[4,5].

Conventional weight-based dosing fails in ELBW infants due to altered drug distribution, protein binding, and blood-brain barrier permeability.

Our ultra-low-dose sequential regimen (fentanyl 10 μg/kg total, cisatracurium 1 mg/kg) provided adequate anesthesia while avoiding hemodynamic collapse[6,7]. Notably, the total fentanyl dose (10 μg/kg) was 50–80% lower than reported in larger preterm infants, reflecting heightened opioid sensitivity[7]. Midazolam (0.5 mg/kg) was minimized due to GABAergic neurotoxicity concerns in developing brains[8].

The strict fluid restriction (7.2 mL over 127 min) countered capillary leak syndrome risks while supporting intravascular volume.

The crystalloid-amino acid-glucose formulation prioritized oncotic pressure and metabolic demands[9]. Invasive arterial monitoring was deferred due to limb ischemia risks; instead, dynamic titration of dopamine (5–7 μg/kg/min) guided by capillary refill and lactate exemplified pragmatic hemodynamic stewardship in microvascular beds[10].

Conclusion

This case validates that meticulous physiologic preservation—through ventilator continuity, pharmacologic microdosing, and goal-directed hemodynamic/fluid management—enables safe neurosurgery in ELBW infants. Future protocols should integrate these principles into standardized frameworks for anesthesia in the tiniest patients.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Ethic

This case report has been approved by the Medical Ethics Committee of the Women and Children's Hospital of Ningbo University (NBFE-2025-KY-020).

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