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Anaesthetic management in a paediatric patient with nephrogenic diabetes insipidus during hypospadias repair: A case report

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Abstract

Nephrogenic diabetes insipidus (NDI) is a rare condition characterized by impaired renal responsiveness to antidiuretic hormone, leading to fluid and electrolyte imbalances. Perioperative management of paediatric patients with NDI presents significant challenges, especially in maintaining fluid and electrolyte homeostasis. This case report details the anaesthetic management of a 4-year-old boy with NDI undergoing hypospadias repair. The patient, weighing 13.5 kg, presented with polyuria and polydipsia, managed with hydrochlorothiazide. Preoperative investigations revealed normal serum electrolytes and partial renal responsiveness to antidiuretic hormone. The anaesthetic plan included general anaesthesia with intravenous ketamine and succinylcholine for induction, providing haemodynamic stability and minimal renal impact.

Keywords: Nephrogenic diabetes insipidus, paediatric anaesthesia, hypospadias repair

Introduction

Nephrogenic diabetes insipidus (NDI) is a rare condition characterised by the kidneys' inability to concentrate urine, leading to significant fluid and electrolyte imbalances. Perioperative management of paediatric patients with NDI poses unique challenges, particularly in maintaining fluid balance and haemodynamic stability. This case report describes the anaesthetic management of a 4-year-old boy with NDI undergoing hypospadias repair, focusing on risk mitigation strategies to achieve a stable perioperative course.

Patient History

A 4-year-old, 13.5 kg male with a known diagnosis of NDI was scheduled for hypospadias repair. His medical history included polyuria and polydipsia, managed with hydrochlorothiazide 25 mg daily. Preoperative investigations revealed normal serum electrolytes: sodium 138 mmol/L, potassium 4.2 mmol/L, and chloride 102 mmol/L. Urine osmolality was 500 mOsm/kg, indicating partial renal responsiveness to antidiuretic hormone.

Clinical Presentation

The patient presented haemodynamically stable, with no signs of dehydration or hypernatraemia. Maintaining precise hydration was paramount, as even minor deviations could lead to complications such as hypovolaemic shock or hypernatraemia.

Anaesthetic Plan

A tailored anaesthetic plan was essential to minimise perioperative risks. General anaesthesia was induced with intravenous ketamine and succinylcholine. Ketamine was chosen for its haemodynamic stability and minimal renal impact, while succinylcholine was selected for its rapid onset and short duration^[1]. Maintenance was achieved with sevoflurane and nitrous oxide, ensuring stable anaesthesia without exacerbating fluid imbalances. A caudal epidural block using 13 mL of 0.25% bupivacaine and 13 mcg dexmedetomidine provided effective postoperative analgesia, minimising the need for systemic opioids^[2]. The airway was secured with a 2.0 laryngeal mask airway (LMA), and mechanical ventilation was initiated in SIMV pressure-controlled mode.

Intraoperative Management

Intraoperative fluid management was guided by the Holliday-Segar formula, with adjustments based on hourly urine output (target: 4 mL/kg/hr) and pulse pressure variability (PPV) index (maintained between 7-14%) using an arterial catheter. Dextrose-normal saline with potassium chloride was administered to match the patient's ongoing hypotonic urinary losses. Advanced monitoring, including PPV and continuous urine output measurement, ensured precise fluid titration, preventing both hypovolaemia and fluid overload [3, 4].

Outcome

The procedure was completed without complications, and the patient remained haemodynamically stable throughout. Postoperatively, serum electrolytes and urine osmolality were closely monitored, and the patient was extubated uneventfully. Recovery was smooth, with no signs of dehydration or electrolyte imbalance. The team's proactive approach, including meticulous fluid management and advanced monitoring, ensured a stable perioperative course.

Analysis of the Case

This case highlights the unique anaesthetic challenges of managing a paediatric patient with NDI during hypospadias repair. Paediatric NDI presents distinct complexities, including smaller intravascular volumes, which heighten the risk of rapid electrolyte shifts. Even slight fluid imbalances can swiftly escalate to hypovolaemia or hypernatraemia, necessitating meticulous intraoperative management [5]. The team proactively addressed these challenges by employing a tailored anaesthetic plan and advanced monitoring techniques. Ketamine was chosen for its haemodynamic stability and minimal renal impact, while the caudal epidural block reduced the need for systemic opioids [1, 2]. Intraoperative fluid management, guided by the Holliday-Segar formula and PPV monitoring, ensured precise titration and prevented complications [3, 4].

Comparison to Literature

Our findings align with existing literature emphasising the importance of meticulous fluid management in NDI patients [5, 6]. However, this case stands out for its use of PPV monitoring to guide fluid administration, a technique rarely reported in paediatric NDI cases. Hourly urine output remains a mainstay of fluid management, but it reflects past fluid losses rather than providing real-time data. PPV, in contrast, offers dynamic assessment, allowing for more responsive fluid adjustments [3, 4].

Recommendations for Clinical Practice

This case offers several actionable insights for clinicians managing paediatric NDI patients:

- 1. Preoperative Optimisation:** Ensure adequate hydration and electrolyte balance before surgery, with close monitoring of serum and urine osmolality [5].
- 2. Tailored Anaesthesia:** Use haemodynamically stable agents like ketamine and regional techniques (e.g., caudal epidural blocks) to minimise systemic opioid use [1, 2].
- 3. Advanced Monitoring:** Incorporate PPV and continuous urine output measurement to guide precise fluid titration [3, 4].
- 4. Proactive Postoperative Care:** Monitor trends in urine output and electrolytes, adjusting fluid regimens proactively to prevent complications [7, 8].

Limitations

This case report is limited by its single-patient focus and the absence of long-term follow-up. The use of advanced monitoring techniques like PPV may be limited in resource-constrained settings, highlighting the need for adaptable strategies [3, 4]. Future studies, such as case series or comparative analyses of fluid management strategies in paediatric NDI, could build on this work [7, 8].

Ethical Considerations

Written informed consent was obtained from the patient's guardians for the publication of this case report, including all clinical details and images. Ethical approval was obtained from the institutional review board (IRB) prior to publication.

Conflict of Interest

Not available

Financial Support

Not available

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