Anesthesia for the *Pediatric* Patient with Hypokalemic Periodic Paralysis

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Quick Reference Guide

Hypokalemic Periodic Paralysis (HypoKPP) is an autosomal dominant disease with possible mutations or variants at CACNA1S, SCN4A, or RyR1.[1,2,3] These patients experience periods of flaccid muscle paralysis based on decreased serum potassium (K^+) levels.[2,4,5] The Malignant Hyperthermia Association website lists HypoKPP as a condition associated with malignant hyperthermia (MH).[1,4,6] With low prevalence in the general population, most treatment comes from anecdotal reports and not all patients respond alike.[4,6,7]

Daily Prevention: HypoKPP patients need a low sodium and carbohydrate diet, avoidance of attack triggers noted below, and no alcohol.[4,8,9] Pharmacological interventions may include a K^+ salt, carbonic anhydrase inhibitor, and a K^+ sparing diuretic.[4,8]

Emergency Treatment: Oral K^+ is preferred if the patient can swallow.[8,10] K^+ may also be given via an oral/nasogastric tube or intravenously. The intravenous (IV) potassium chloride (KCl) must not be mixed in a dextrose solution.[10] The usual pediatric rate of KCl infusion should not exceed 10 mEq per hour, but heart dysrhythmias and respiratory compromise may require temporary higher infusion rates.[10] **Avoid aggressive K^+ replacement as HypoKPP is a shift in K^+, not a loss of K^+.**[4,8,10] Safe practice includes EKG monitoring with frequent serum K^+ level checks.[4] Patients with ongoing paralysis episodes have been shown to benefit from an immediate slow infusion of KCl.[11]

Which HypoKPP patient may be susceptible to a MH crisis? Any patient with a personal or close family history of a MH-like episode**, *OR*** any patient with mutant variants of RyR1, CACNA1S, ***OR*** if unknown genotype, even if no past anesthesia problems.[2,9,12,13,14,15] In the general population, children < 15 years old comprise 52.1% of all MH reactions.[15] Most patients/caretakers know their genetic mutation.

Pediatric Anesthetic Plan

Standard of Care:	Core temperature > 36°C, avoid dehydration, keep serum K^+ at or above patient's target level if known, otherwise use upper normal level (i.e., 5 mEq/L)[16] and avoid triggers.[5,8,9,14,16,17,18,19]
Avoid Attack Triggers:	Serum K^+ level below patient's target level, stress, cold, excitement, fear, pain, fasting, Na^+ and glucose loads via IV or oral intake, **steroids, epinephrine**, **succinylcholine**, insulin, hyperglycemia, metabolic or respiratory alkalosis, certain antibiotics, and anesthesia. [4,5,8,9,12,14,16,18,19]
Regional Anesthesia:	Preferred: Spinal, epidural, regional nerve block, and local infiltration with appropriate sedation and monitoring. Case reports use normal dosing ranges.[16,18,19,20,21]
Local Anesthetics:	May use **plain** lidocaine, bupivacaine, or ropivacaine.[5] Lidocaine is not always effective.[5] **No epinephrine.**[5,20]
Pre-op Testing / Consultations:	Serum Na^+, K^+, Ca^{++}, Mg^{++}, EKG, and possibly PFT. Consult patient primary care physician and specialists.[5,14,18]
Preparations:	Point of Care K^+ monitor, warm the OR, patient warming device, fluid warmer, and pump for KCl drip.[5,14,16]
Intra-op Monitoring:	Core temperature, point of care K^+ levels, nerve stimulation, and end-tidal CO_2 ($ETCO_2$).[5,16,18,19]

Anesthesia Process for HypoKPP Patient

Preoperative	EMLA cream may help IV start & electrolyte monitoring access.[16,17,22] Sedate using benzodiazepine like midazolam or diazepam.[5,16,17,18,19] Watch for respiratory depression.[5,6,18] Preferred fluid is lactated ringers (No dextrose & limit Na^+ load).[5,9,12,14,17,18] Correct electrolyte levels and verify that ***serum K+ is at patient's target level***.[5,14,16,17]
MH Susceptible Anesthesia Plan	Start IV and use propofol for induction. Maintain with a TIVA using a propofol drip.[16,17,23] ***No succinylcholine*** or anesthesia gases except nitrous oxide.[5,13,24] Avoid etomidate→ decreases K^+.[22] Can use remifentanil.[16,17]
***NOT* MH Susceptible Anesthesia Plan**	IV induction with propofol.[16,17] (Avoid etomidate→ decreases K^+)[22] ***OR*** use inhalation induction with sevoflurane and/or nitrous oxide.[18] Don't use halothane[15] or desflurane→ upper airway events.[22] ***No succinylcholine***.[4,5,12,18] Maintain with TIVA (propofol)[16,17,23] ***OR*** inhalation gases→ sevoflurane or isoflurane.[18,19] Can use remifentanil.[16,17]
Maintenance for both plans	Keep $ETCO_2$ around 40 mmHg for hypercarbia to maintain acidosis.[9,12,16,17,18,19] Check serum K^+ with any change in patient condition, vital signs, or EKG and titrate K^+ to patient target level[5,16,18,19,21]. Keep core temperature >36°C, good pain control, minimal muscle relaxation, and avoid dehydration.[5,14,19,21] A slow KCl IV infusion may help.[11,19]
Paralysis	***No succinylcholine***.[4,5,12,18] Short-acting non-depolarizing muscle relaxant-start at 10-20% normal dose.[4,6,9,12,14,17,18,19]
Pain Management	**Regional Anesthesia works best!** [16,18,19,20,21] Weight-based dosing of acetaminophen & ketorolac.[17,22] Opioids given by incremental low doses to the desired effect.[5,16,17] Monitor for chest wall rigidity and respiratory drive.[5,22]
Antiemetics	No steroids→ attack trigger.[5,8,9] No literature was found on antiemetic use with HypoKPP patients.
Emergence	Use short acting nondepolarizing muscle relaxant - Anticholinesterases are not recommended.[18]
Recovery	Consider ICU. Close K^+ control, trigger avoidance, electrolyte management (i.e., post-op vomiting→ may decrease Mg^{++}→ makes K^+ replacement ineffective) to prevent a paralytic attack.[5,6,9,16,17] Carefully manage pain (a paralytic episode does not decrease pain level)[16,18,19,21]. Post-op diet must be low Na+ and low carbohydrate.[8,9] Early family (caretaker) involvement may help identify paralytic attacks.[14] Resume patient's daily medications ASAP.[18]

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This document gives anesthesia providers basic guidelines designed to increase the safe anesthesia care for this patient population. Being a rare disease, most of the information is based on the lower level of the evidence hierarchy and does not consider comorbid conditions. Feedback and comments may be forwarded to PeriodicParalysisResearch@gmail.com

Many thanks to Barbara Grover DNP, CRNA, for her contributions and guidance.
Thanks for the support from the Periodic Paralysis Association and particularly to the
the Periodic Paralysis Association's Panel of Medical Experts for reviewing the content of this guide.

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