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Patient with Hyperkalemia for Surgery: Proceed or Postpone?

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Abstract

Hyperkalemia is a medical condition that anesthesia providers frequently have to deal with. Anesthetics (succinylcholine) and anesthesia practice (hypoventilation) may worsen hyperkalemia. The decision to proceed with a scheduled surgical procedure in a patient with hyperkalemia can be very challenging; it is usually decided by a mutual agreement between surgery team and anesthesia providers. Intraoperative management strategies can include intravenous administration of calcium, sodium bicarbonate, insulin with/without glucose, or other alkalizing agent; inhalation of albuterol; hyperventilation can often be adopted to induce mild respiratory alkalosis to lower metabolic acidosis-induced hyperkalemia.

Keywords

Hyperkalemia, Acidosis, Renal failure, Arteriovenous graft

Introduction

Hyperkalemia is a very common clinical condition that anesthesiologist will need to deal with in surgical patients and perioperative settings. Hyperkalemia can potentially be life-threatening when serum potassium significantly exceeds 5.5 mmol/L. The etiologies of hyperkalemia include acute and chronic renal failure, excessive potassium release from the intracellular space, hypoaldosteronism, massive tissue injury as in rhabdomyolysis, etc. Symptoms of hyperkalemia are usually non-specific, most likely related to muscular or cardiac dysfunction. With great interest we read the articles by Chen [1] and accompanying editorial by Meng [2]. We would follow up this discussion with a case we provided anesthesia service recently, so we can further discuss the intraoperative management of hyperkalemia, and the decision-making process for patients with hyperkalemia scheduled for surgery. An IRB exemption was obtained from Hahnemann University Hospital.

Case Review

A 57-years-old male patient scheduled for revision of left arteriovenous graft which was placed in about three months ago. He had past medical history including hypertension and end-stage renal disease on hemodialysis. There was an abnormality in his arteriovenous graft which necessitated a surgical revision so it can be used for future hemodialysis. The surgery team informed anesthesia group that it is a 20 minutes procedure, and patient can get hemodialysis immediately post-procedure. The patient's serum potassium level was 6.3 mmol/L in the morning of surgery. The patient was dialyzed the day before. The chief surgeon was a very competent and efficient surgeon; he usually gave very accurate estimate of surgical duration. The surgeon emphasized that he wanted to get the procedure done before heading to the airport in about 3 hours to deliver a speech out of town. The surgery team trusts anesthesia team who can deal with anything in the operating room and the anesthesia team trusts surgery team who can get it done as promised. It was this "mutual trust" that led to a flawed decision-making process. And a cascade of un-expected events occurred. We proceeded with the surgical procedure with a left supraclavicular block (performed by our regional anesthesia team) and light sedation. Preoperative EKG showed high T waves with heart rate at 90s/minute. Preoperatively we placed defibrillation pads in case we needed transcutaneous pacing and/or cardiac defibrillation, we discussed to avoid deep sedation to minimize the incidence of hypoventilation which may worsen the acidosis and hyperkalemia. We intravenously administered calcium chloride 1 gram, sodium bicarbonate 50 mEq as treatment to his hyperkalemia. After the surgery started, we realized that supraclavicular nerve block did not work adequately, we therefore induced general anesthesia with propofol and placed a laryngeal mask airway (LMA). Surgery resumed smoothly. Then the unexpected occurred. The surgery team messed up the graft. The so called "20 minutes quick case" evolved into a two hour "arteriovenous graft replacement", a brand-new arteriovenous graft was inserted, which meant that we could not use the new arteriovenous graft to dialyze the patient immediately after surgery. About 40 minutes into the procedure, the patient's serum potassium level increased to a dangerously high level 6.9 mmol/L. Immediately we took following measures to lower the serum potassium level: intravenous calcium chloride 1 gram, sodium bicarbonate 50 mEq, 50% glucose 50 ml and regular insulin 10 units; hyperventilation with low tidal volume and high

frequency; endotracheal inhalation of albuterol 5 puffs. About 15 minutes later, we had a potassium level at 6.2 mmol/L. We switched our normal saline infusion to 5% glucose infusion and repeated another round of 50% glucose 50 ml and intravenous regular insulin 10 units therapy, and repeated doses of sodium bicarbonate and inhalation of albuterol. During the procedure, except one transient episode of bradycardia, all vital signs were stable. We arranged nephrology team to be ready for hemodialysis for the patient. At the end of the procedure, the serum potassium level was lowered to 5.8 mmol/L, we placed a hemodialysis catheter via femoral vein, and we switched LMA to endotracheal tube. The patient was transported to Surgical ICU and underwent hemodialysis immediately after his arrival at Surgical ICU. His serum potassium level returned to normal after hemodialysis, he was extubated later in the afternoon. The patient was discharged home two days later.

What we learned from this case?

1. Should we have proceed with the scheduled surgical procedure? Retrospectively speaking, we should have insisted on getting a hemodialysis for the patient before proceeding to the scheduled procedure. This patient needed dialysis and the procedure was to repair/revise the dialysis graft, and the surgery was supposed to be 20 minutes, they would need 20 minutes to insert a hemodialysis catheter, so we decided to proceed. The surgery team is a very good one with an excellent surgeon in charge. The anesthesia team is well known for "never cancel a case" in this hospital. We anesthesia and surgery teams have a great relationship and overly entrusted each other in this case. We should have not let our over-confidence and "mutual trust" affect our decision-making process.

2. The non-medical conditions should not have affected our decision-making process. We should not have let the non-medical condition "the surgeon needed to go to catch a flight to deliver a lecture out of town" to affect our decision-making process.

3. When the nerve block was found not providing adequate surgical anesthesia, was induction of general anesthesia a wrong step? Did we have other options and what were the rationale? At the beginning of the procedure, we realized the supraclavicular block did not work adequately, we subsequently induced general anesthesia and placed a LMA. What other options we could have had? We could have asked the surgery team to infiltrate local anesthetics to the surgical sites, which may not work out either because the patient was not very cooperative, and local anesthetic toxicity was also a concern; we could have asked the surgery team to abort the procedure, which would surely have upset the surgery team and the patient; we could have induced general anesthesia and placed an endotracheal tube instead of LMA. We placed a LMA with the belief that the duration of the surgical procedure would be 20 minutes.

4. When the surgery team encountered technical difficulty, what can be done differently? When we realized that surgery team encountered technical difficulty and surgical procedure was expected to be significantly longer, we could have asked the surgery team to place a hemodialysis catheter and dialyzed the patient intraoperatively, which would have avoided the spiking increase of potassium level to 6.9 mmol/L.

Effects of hyperkalemia on cardiac electrophysiology

Potassium is mainly stored inside the cells while sodium is the major cation in the extracellular fluid and has a much lower concentration in the cells.The differential distribution of the two cations is maintained by the Na-K-ATPase pump in the cell membrane. The ratio of the potassium concentrations inside the cells and the extracellular fluid is the key determinant of the resting membrane potential. When the resting membrane potential becomes less due to hyperkalemia, the percentage of available sodium channels will decrease, which leads to decreased inward sodium current and a concurrent decrease in the Vmax. Hyperkalemia therefore results in electrophysiological perturbations: decreased myocardial resting membrane potential, increased cardiac depolarization and myocardial excitability, cardiac instability and conduction abnormalities, ultimately leading to potentially fatal arrhythmias as ventricular fibrillation and asystole. Hypokalemia may also cause muscle paralysis and potentially fatal cardiac arrhythmias [3].

Etiologies of perioperative hyperkalemia

1. Chronic or acute renal insufficiency: reduced glomerular filtration rate with low urine flow and decreased renal excretion of potassium.

2. Medications interfering with urinary potassium excretion: potassium-sparing diuretics (amiloride or spironolactone), cyclosporine, trimethoprim; Non-steroidal anti-inflammatory drugs (ibuprofen, naproxen), angiotensin converting enzyme inhibitors, angiotensin receptor inhibitors, trimetoprim, ß-blockers, nifedipine and amlodipine, Cyclosporin, succinylcholine, heparin, digoxin [4], and mannitol [1].

3. Increased potassium shifting from intracellular to extracellular space: metabolic and respiratory acidosis, diabetes mellitus, acute increase in osmolality secondary to mannitol infusion, acute cell-tissue breakdown-induced intracellular potassium release (in rhabdomyolysis, tumor lysis hemolysis, or after massive transfusion), digoxin and beta-blockers can inhibit the Na^+/K^+-ATPase, and immobilization postoperatively.

4. Some disease status: hyperkalemic periodic paralysis, hypoaldosteronism, pseudohypoaldosteronism, congestive heart failure, and constipation.

Perioperative considerations in the management of patient with hyperkalemia

1. Decision-making process for a patient with hyperkalemia scheduled for surgery (this is authors' personal experience, not a guideline): if potassium level is 6.5 mmol/L or higher, we absolutely postpone the surgery; If potassium level is between 6 and 6.4 mmol/L, we will consider postpone the procedure, but discuss with surgery team to reach a mutual agreement; if potassium level is between 5.5 to 5.9 mmol/L, the decision will be made based on the patient's overall condition, the nature and duration of the procedure, and other factors.
2. Avoidance of hypoventilation and hypoxemia: hypoventilation can lead to hypercarbia, hypoxemia and respiratory acidosis, which will worsen the metabolic acidosis-induced hyperkalemia. Perioperative sedation with opioids and other sedatives may cause hypoventilation. All anesthesia providers need to be highly alert in identifying patient developing hypoventilation and hypoxemia.
3. Avoidance of any medication which may cause increase in potassium level, succinylcholine is well known to cause potassium level to increase.
4. Calcium has been believed to have myocardial protective effects in patient with hyperkalemia [4]. So we routinely administer calcium intravenously in patient with hyperkalemia, especially those with potassium level over 6 mmol/L.
5. Insulin administration and potassium level: One of the effects of insulin administration is the increased shift of potassium into the cells, thus lowering the serum potassium level. Insulin use is also associated with hypoglycemia. For the purpose of lowering potassium level, insulin is often given with glucose to avoid severe hypoglycemia, unless patient has pre-existing hyperglycemia. Closely monitoring blood glucose level is critical in managing these patients appropriately.
6. No potassium-containing intravenous fluid should be used in patient with hyperkalemia. It is a routine practice in many hospitals to avoid Lactated ringers or Plasmolyte in renal patient scheduled to undergo a surgical procedure.
7. Other potassium-binding agents (sodium polystyrene sulfonate) and alkalizing agents.

Summary

In summary, hyperkalemia is a medical condition often encountered by anesthesia providers. Anesthesia per se may further worsen hyperkalemia (administration of succinylcholine, hypoventilation, etc.). The decision to proceed with or postpone a scheduled surgical procedure in patient with hyperkalemia can be very challenging; it is often decided by a mutual agreement between surgery team and anesthesia providers, influenced by the interplay of multiple perioperative factors. Intraoperative management strategies include intravenous administration of calcium, sodium bicarbonate, insulin with/without glucose, or other alkalizing agent; inhalation of albuterol; hyperventilation can also be helpful by inducing mild respiratory alkalosis to offset metabolic acidosis-induced intracellular to extracellular migration of potassium.

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