



REVISTA BRASILEIRA DE ANESTESIOLOGIA

Official Publication of the Brazilian Society of Anesthesiology
www.sba.com.br



CLINICAL INFORMATION

Hyperkalemia by Euro-Collins Solution in Anesthesia for Renal Transplantation: A Case Report

Eunice Sizue Hirata^{*,a}, Rosa Inês Costa Pereira^a, Gentil Alves Filho^b,
Angélica de Fátima Assunção Braga^b

^a Department of Anesthesiology, Faculdade de Medicina, Universidade Estadual de Campinas, Campinas, SP, Brazil

^b Department of Clinical Medicine, Faculdade de Medicina, Universidade Estadual de Campinas, Campinas, SP, Brazil

Study conducted at Hospital das Clínicas, Faculdade de Medicina, Universidade Estadual de Campinas, Campinas, SP, Brazil

Submitted on November 28, 2011; accepted on August 20, 2012

KEYWORDS

Hypertonic Solutions/
Euro-Collins' solution;
Hyperkalemia;
Kidney Transplantation

Abstract

Objective: To describe anesthesia for renal transplantation that progressed to a sharp potassium increase after kidney reperfusion with Euro-Collins' solution in the operative field. We will also report on diagnosis and treatment used.

Conclusion: The use of infusion solutions in the surgical field requires careful monitoring, such as electrocardiography, measurement of serum potassium, and availability of calcium gluconate, insulin, and albuterol for immediate use. The replacement of Euro-Collins' solution for saline solution immediately before the implant may be a useful option in patients with high levels of potassium.

© 2013 Sociedade Brasileira de Anestesiologia. Published by Elsevier Editora Ltda. All rights reserved.

Introduction

Hyperkalemia in anesthesia for renal transplantation used to be a more common complication.¹ Succinylcholine administration for tracheal intubation^{2,3} and poor dialysis patients⁴ and/or insulin-dependent diabetic patients⁵ have been responsible for serious anesthetic accidents. Preoperative care and stricter use of nondepolarizing muscle relaxants during general anesthesia induction have significantly reduced this complication. However, there are few recommendations

regarding risks of hyperkalemia resulting from the use of infusion solutions in organ transplantation.^{6,7} The most commonly used solutions are Euro-Collins and University of Wisconsin (UW),⁸ which have high concentration of potassium in common similar to that of intracellular fluid.⁹ There are reports of complications such as rapid increase in serum potassium⁷ and heart failure⁶ immediately after release of vascular anastomoses in perfused kidneys with Euro-Collins' solution.

*Corresponding author. Cidade Universitária Zeferino Vaz, Rua Vital Brasil, 251, Campinas, SP, Brasil. CEP: 13083-888.

E-mail: eshirata@hotmail.com (E.S. Hirata)

0104-0014/\$ - see front matter © 2013 Sociedade Brasileira de Anestesiologia. Published by Elsevier Editora Ltda. All rights reserved.

<http://dx.doi.org/10.1016/j.bjane.2013.10.001>

Case report

Male patient, aged 32 years, who underwent a second kidney transplant from a living-related donor, with a history of uneventful general anesthesia for renal transplantation nine years ago. The patient was on dialysis for 16 months, reported hypertension four years ago, and urinary infection three months ago.

On preanesthetic visit, the patient was in good condition and had no complaints. He underwent hemodialysis in the morning and had an assessed hemofiltration of 4 kg. On physical examination, the patient was afebrile, weighing 79 kg with a height of 1.71 m, blood pressure was 130/80 mm Hg, and heart rate of 70 bpm. Cardiac auscultation showed mild systolic murmur at the apex. We also noted the presence of an arteriovenous fistula in the left upper limb (LUL) and a central catheter inserted into the right internal jugular vein. The patient was taking azathioprine, prednisone, and propranolol. Preoperative test results were Hb = 9.93 g%; Ht = 29.28%; INR = 1.02; R = 1.12; urea = 80 mg%; creatinine = 5.75 mg%; Na⁺ = 134 mEq.L⁻¹; K⁺ = 5.10 mEq.L⁻¹. Electrocardiogram (ECG) showed left ventricular overload and chest X-ray an increased heart area by left ventricular overload. Patient status was considered ASA 3. Midazolam intramuscular (7.5 mg) was prescribed as pre-anesthetic medication 30 minutes before surgery, and general anesthesia was the anesthetic technique indicated.

Anesthesia induction was performed with fentanyl (0.5 mg), etomidate (16 mg), and cisatracurium (12 mg) and maintained with isoflurane vaporized in a 50% mixture of nitrous oxide and oxygen. We administered fractionated doses of fentanyl and cisatracurium when necessary.

Approximately 1 hour and 45 minutes after the beginning of surgery, implantation in the receiver started with anastomosis of donor renal artery to hypogastric artery of receptor and renal vein of donor to hypogastric vein of receptor. Total duration of vascular anastomosis was 30 minutes. After observing the transplanted organ for 5 minutes, we found the kidney to be pale, ischemic, and presenting no signs of tissue perfusion. The procedure was then re-clamping the hypogastric artery and external iliac vein; the arterial anastomosis was undone and an incision was made in the renal vein near the anastomosis. Immediately after this procedure, we initiated graft reperfusion with Euro-Collins' solution in the surgical field. This procedure lasted 15 minutes. We initiated arterial anastomosis and renal vein suture after vessel patency.

We diagnosed hyperkalemia shortly after the vascular sutures, identified by a change in T-wave morphology that was high, symmetrical, and peaked. Arterial blood gas confirmed our clinical suspicion (Table 1).

We immediately initiated rapid administration of polarized solution (1 U of insulin per 5 g of glucose). At this time, we also noted the onset of diuresis enhanced by the administration of furosemide (60 mg). The results of subsequent tests to control serum potassium are shown in Table 2.

During the entire procedure, systolic blood pressure ranged from 130 to 170 mm Hg, heart rate 45 to 80 bpm, central venous pressure 5 to 19 cm of water, and pulse oximetry 97% to 99%. We maintained hydration with 0.9% saline (3.5 L) and furosemide (60 mg), and diuresis at the end of surgery

Table 1 Arterial Gasometry and other complimentary results.

pH = 7.21 mm Hg	Na ⁺ = 125 mmol.L ⁻¹
pO ₂ = 152 mm Hg	K ⁺ = 8.5 mmol.L ⁻¹
pCO ₂ = 58.1 mm Hg	Ca ⁺⁺ = 1.38 mmol.L ⁻¹
HCO ₃ ⁻ = 22.6 mmol.L ⁻¹	Cl ⁻ = 101 mmol.L ⁻¹
tCO ₂ = 24.4 mmol.L ⁻¹	Glicemia = 134 mg%
BE = -5.1 mmol.L ⁻¹	Hb = 11.3 gr%
SO ₂ = 99.4%	Ht = 35%

Table 2 Results of Subsequent Tests to Control Serum Potassium.

Time (hour:minutes)	11:50	12:53	15:00	16:37
Na ⁺ mmol.L ⁻¹	125	125	126	128
K ⁺ mmol.L ⁻¹	8.2	6.9	6.2	5.4
Ca ⁺⁺ mmol.L ⁻¹	1.32	1.27	1.27	1.22
Cl ⁻ mmol.L ⁻¹	101	102	102	102
Glicemia mg%	136	155	155	73
Hb g%	11.1	10.9	11.1	10.3
Ht %	34.2	33.8	34.2	31.8

Table 3 Euro-Collins' Solution Characteristics.

Potassium	115 mmol.L ⁻¹
Sodium	10 mmol.L ⁻¹
Phosphate	100 mmol.L ⁻¹
Chloride	15 mmol.L ⁻¹
Bicarbonate	10 mmol.L ⁻¹
Dextrose	198 mmol.L ⁻¹
Osmolarity	406 mOsm.L ⁻¹

was 1.5 L. We reversed neuromuscular block with standard doses of atropine and prostigmine, followed with tracheal extubation. The entire procedure lasted 5 hours.

Discussion

The strategies used for organ preservation aim to reduce the adverse cellular effects following ischemia and reperfusion. Simply cooling the kidney surface does not allow an adequate preservation for longer periods. Kidney perfusion with appropriate electrolyte solutions is one of the strategies used for organ preservation because it allows cold ischemic periods exceeding 24 hours. It is the time often required for organ transportation, histocompatibility testing, and transplant recipient preparation in case of deceased donor⁹. One of the first solutions used for preservation is Euro-Collins, whose characteristics are shown in Table 3.⁶

Other more recent solutions, such as the University of Wisconsin (UW), represent a breakthrough because they protect organs very susceptible to ischemia, such as liver and pancreas for longer periods. It is the most used perfusion

solution in organ transplantation but, similar to the Euro-Collins' solution, it has high potassium concentrations like the intracellular fluid.⁶

Since the introduction of infusion fluids, few cases reported the association of these solutions with complications such as hyperkalemia. Severe cases of increased serum potassium progressing to sudden cardiac arrest have been reported with Euro-Collins' solution, seconds after the release of vascular anastomoses.^{7,8} In a subsequent study, Hirshman noted that immediately after the release of vascular anastomoses, the levels of potassium in blood samples taken from the right atrium could present values abnormally high and that a slow and gradual release of vascular clamps attenuated this effect.¹⁰

Studies showing serum potassium variations caused by perfusion fluid passing through the systemic circulation found no significant changes. However, there are recommendations for some special situations, such as transplantation of adult kidneys into very small children and renal transplant in which anastomosis is done with the receptor's artery and aorta and remains clamped throughout the period of vascular sutures.¹⁰

Euro-Collins' solution has been routinely used in our service for renal perfusion in transplantation in adults and children from living relatives and deceased donors. It is also used in the actual surgical field in situations where there is no adequate renal perfusion requiring vascular anastomosis remake.

We suggest three possible explanations for this complication:

1. Intravascular administration of Euro-Collins' solution (600 mL) with high concentrations of potassium, resulting from double renal perfusion;
2. Intravascular absorption of Euro-Collins' solution by the bloody areas exposed during surgery due to inadequate suction of irrigation fluid;
3. Accidental instillation of fluid infusion near the renal vein opening.

Although it is not usual we have performed renal reperfusion in the surgical field with Euro-Collins' solution in other opportunities during our service. We have never seen a similar complication requiring special care.

In this particular patient, we believe that all three factors, in addition to serum potassium concentration over the upper limit of the normal range, were the cause of this complication.

However, it is worth remembering that there are other causes of hyperkalemia during anesthesia for renal transplantation which can overlap with the perfusion solution, such as potassium release induced by succinylcholine administration^{2,3} and rapid blood transfusion.¹¹

Potassium concentration above 7.5 mEq.L⁻¹ is considered a severe hyperkalemia¹² which may progress to heart rhythm disorder and be life-threatening.¹³ However, in many patients it is asymptomatic and perceived only in laboratory tests. Although there are studies showing that approximately half of patients with serum potassium greater than 6.5 mEq.L⁻¹ present no ECG changes.¹⁴ ECG is the first indicator of

hyperkalemia, showing symmetric and peaked tall T-waves, absence of P-wave, QRS enlargement, arrhythmias, and cardiac arrest.¹⁵

Treatment of severe hyperkalemia should meet three basic stages. The first is stabilizing the myocardium - which has decreased its susceptibility to cardiac arrhythmias - with intravenous administration of 10% calcium gluconate over 3-5 minutes and ECG monitoring. The effects can be observed when the infusion starts, and duration of action is 30 to 60 minutes. The second stage consists of diverting potassium to intracellular space with insulin (10 U in 25 g glucose); β_2 agonists, such as nebulization of salbutamol (10-20 mg in 4 mL saline and sodium bicarbonate solution), are used if the patient is in metabolic acidosis. The administration of insulin/glucose decreases plasma potassium levels in 15 to 30 minutes after the start of infusion, and duration of action is 2 hours. Salbutamol is the most widely used β_2 agonist for hyperkalemia treatment. It is administered by nebulization, has a rapid onset of action, and the effects can be noticed 30 minutes after starting administration. Salbutamol may also be administered intravenously at a dose of 0.5 to 2.5 mg. The effects of different routes of administration in serum potassium are not well defined; however, complications such as tachycardia, increased blood pressure, and palpitations are more common with intravenous administration. Salbutamol may be used concomitantly with insulin, whose effects are potentiated. The effect of sodium bicarbonate on hyperkalemia is less than that of insulin and β_2 adrenergic receptors and seems to occur only in the presence of metabolic acidosis.^{16,17} Thus, the systematic use of sodium bicarbonate to treat hyperkalemia is controversial and not recommended.¹⁸ The third stage is removing potassium from the body, which can be achieved with the use of diuretics, cation exchange resins, and dialysis that is the most effective treatment for serum potassium removal.¹⁹ Furosemide acts on the tubular lumen of the thick loop of Henle and inhibits sodium and potassium cotransport across the apical membrane. It is a potent diuretic and, thus, may be used in the treatment of hyperkalemia, provided there is some residual function. The dose used is 40-80 mg intravenously. Ion exchange resins are administered orally or by enemas and remove potassium from the extracellular fluid in exchange for cation, such as sodium or calcium, through the intestinal wall. The effect can take up to 6 hours to be achieved, hence its limited use in emergencies. The definitive treatment of hyperkalemia is dialysis in its various forms. The most effective is hemodialysis, which can be adapted to quickly remove potassium by decreasing its concentration or increasing bicarbonate concentration in dialysis fluid or by increasing the rate of blood flow in the dialysis machine.²⁰

In our case, treatment consisted of administration of furosemide and polarized solution. Salbutamol was not used because it was not available in the operating room. Calcium gluconate was not administered because the response to the treatment used was immediate and effective, probably by early concomitant diuresis.

Although rare, hyperkalemia associated with the use of infusion solutions is a complication that cannot be ignored. We therefore recommend that ECG monitoring should be done effectively with kidney perfusion with these solutions within the surgical field, and a dosage of potassium can be

quickly administered for diagnosis. The ready availability of calcium gluconate, insulin, and albuterol for immediate use is a practice that should be disseminated. Using electrolytic solutions, such as saline solution, as a substitute for Euro-Collins' solution is a useful option in patients with elevated potassium levels.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Lemmens HJM - Kidney transplantation: recent developments and recommendations for anesthetic management. *Anesth Clin North Am.* 2004;22:651-662.
2. Koide M, Waud, BE - Serum potassium concentrations after succinylcholine in patients with renal failure. *Anesthesiology.* 1972;36:142-145.
3. Miller RD, Way WL et al. Succinylcholine-induced hyperkalemia in patients with renal failure? *Anesthesiology.* 1972;36:138-141.
4. Jankovic Z, Sri-Chandana C - Anaesthesia for renal transplant: recent developments and recommendations. *Curr Anaesth Crit Care.* 2008;19(4):247-253.
5. Rosenbaum R, Hoffstein PE, Cryer P et al - Hyperkalemia after renal transplantation. Occurrence in patients with insulin-dependent diabetes. *Arch Intern Med.* 1978;138(8):1270-1272.
6. Soulillou JP, Fillaudeau F, Keribin JP, Guenel J - Acute hyperkalemia risks in recipients of kidney graft cooled with Euro-Collins solution. *Nephron.* 1977;19:301-304.
7. Myles OS, Buckland MR, Pastoriza-Pinol JV et al - Massive hyperkalemia during combined heart-lung transplantation: inadvertent contamination with modified Euro-Collins solution. *J Cardiothorac Vasc Anesth.* 1992;6(5):600-602.
8. Alshaibani K, Nizamuddin N, Raza S et al - University of Wisconsin versus Euro-Collins solution for kidney preservation: analysis of clinical outcome. *Transplant Proceedings.* 1998;30:3681-3682.
9. Mühlbacher F, Langer F, Mittermayer C - Preservation solution for transplantation. *Transplant Proc.* 1999;31:2069-2070.
10. Hirshman CA, Edelstein G - Intraoperative hyperkalemia and cardiac arrests during renal transplantation in an insulin-dependent diabetic patient. *Anesthesiology.* 1979;51:161-162.
11. St Peter SD, Imber CJ, Friend PJ - Liver and kidney preservation by perfusion. *Lancet.* 2002;356:604-613.
12. Hirshman CA, Leon D, Edelstein G et al - Risk of hyperkalemia in recipients of kidneys preserved with an intracellular electrolyte solution. *Anesth Analg.* 1980;59:283-286.
13. Smith HM, Farrow SJ, Ackerman et al - Cardiac arrests associated with hyperkalemia during red blood cell transfusion. *Anesth Analg.* 2008;106(4):1062-1069.
14. Lehnhardt A, Kemper MJ - Pathogenesis, diagnosis and management of hyperkalemia. *Pediatr Nephrol.* 2011;26:377-384.
15. Montague BT, Ouellette Jr, Buller GK - Retrospective review of the frequency of ECG changes in hyperkalemia. *Clin J Am Soc Nephrol.* 2008;3:324-330.
16. Nyirenda JM, Tang JI, Padfield PL et al - Hyperkalaemia. *Brit Med J.* 2009;339:1019-1024.
17. Elliott MJ, Ronksley PE, Clase CM et al - Management of patients with acute hyperkalemia. *Can Med Ass J.* 2010;182(15):1631-1635.
18. Kamel SK, Wei C - Controversial issues in the treatment of hyperkalemia. *Nephrol Dial Transplant.* 2003;18:2215-2218.
19. Acker CG, Johnson JP, Palevisky PM et al - Hyperkalemia in hospitalized patients: causes, adequacy of treatment, and results of an attempt improve physician compliance with published therapy guidelines. *Arch Intern Med.* 1998;158:917-924.
20. Alfonzo AVM, Isles C, Geddes C et al - Potassium disorders - Clinical spectrum and emergency management. *Resuscitation.* 2006;70:10-25.