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Interplay of electrolytes: To establish correlation between calcium, magnesium and potassium and role of magnesium in management of peri-operative arrhythmias: A case series.

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Abstract

Perioperative arrhythmias can have multiple etiologies but electrolyte imbalance has its own important role. We include three cases of arrhythmias encountered perioperatively, that explains the correlation between hypokalaemia, hypocalcaemia and hypomagnesaemia and all were well managed by correcting the underlying electrolyte imbalance. Further complications like myocardial infarction or on table cardiac arrest could be well prevented by timely recognition and correction of these dyelectrolytaemia based arrhythmias.

This review will summarize the current evidence-based approaches for the prevention and treatment of dyselectrolytemia and perioperative cardiac arrhythmias. Strategies such as electrolyte replacement, pharmacological interventions and optimization of perioperative care will be explored, providing clinicians with practical recommendations for reducing the incidence and impact of these arrhythmias.

In conclusion, dyselectrolytaemia is a significant risk factor for the development of perioperative cardiac arrhythmias. Understanding the mechanisms, risk factors and management strategies associated with these conditions is crucial for healthcare providers involved in the perioperative care of surgical patients. This review aims to enhance awareness and knowledge, ultimately improving patient outcomes and safety during the perioperative period vital for all the perioperative

physicians for better perioperative management of arrhythmias.

Case 1: 45 -year woman with no comorbidities posted for Right Laparoscopic Transperitoneal Simple Nephrectomy with preoperative four to five premature ventricular contractions (PVCs) per minute, already on preoperative correction for hypomagnesaemia and hypokalaemia developed intraoperative ventricular trigeminy and could be reverted to baseline electrocardiogram rhythm with timely pharmacological intervention and correction of potassium, calcium and magnesium.

Case 2: 61 year man posted for simple cystectomy with ileal conduit, with normal preoperative serum electrolytes, known case of hypertension and diabetes mellitus, with echocardiogram showing changes of regional wall motion abnormalities and three to four PVCs preoperatively, developed intraoperative ventricular bigeminy and was reverted to baseline electrocardiogram rhythm with timely correction of metabolic acidosis, hypocalcaemia and hypomagnesaemia.

Case 3: 56 years man posted for unilateral Double-J stenting with no co-morbidities with preoperative three to four PVCs, developed intraoperative ventricular bigeminy and hypotension, correction of hypomagnesaemia alone reverted it to complete sinus rhythm postoperatively.

Keywords: hypokalemia, hypocalcemia, magnesium, Perioperative arrhythmias.

Introduction

Perioperative arrhythmias are abnormal heart rhythms that can occur during or after surgery. The surgical procedure, anesthesia, and physiological changes during this period can stress the cardiovascular system and contribute to arrhythmias. Electrolyte imbalances, such as hypocalcaemia, hypokalaemia, and hypomagnesaemia, further exacerbate the risk of developing arrhythmias by disrupting the delicate electrical balance of the heart.

Sudden emergence of perioperative arrhythmias, while uncommon in non-cardiac surgical patients, can be potentially life-threatening.[1] It is imperative to promptly recognize and diagnose the underlying cause in order to effectively manage perioperative arrhythmias. Dyselectrolytaemia stands out as a key contributor to the occurrence of these arrhythmias.

Magnesium, ranking as the fourth most abundant cation within the human body,[2] plays a critical role in the intracellular tissues, holding the position of the second most prevalent cation. Moreover, magnesium functions as a physiological antagonist to calcium, exerting a comparable effect to that of calcium channel blockers.[3]

Case Series

Case 1: 45 -year woman with no comorbidities was posted for Right Laparoscopic Transperitoneal Simple Nephrectomy for Right poorly functioning kidney due to renal calculi. Preoperative ECG reported premature ventricular contractions (4-5 per minute). Echocardiogram was normal. Preoperative cardiology reference done and patient was started with beta-blockers 10 days prior surgery and cardiac fitness given with due risk for anaesthesia and surgery. She was on hypomagnesaemia and hypokalaemia correction since 4 days before surgery as per nephrologist advice. Preoperative serum potassium, serum calcium and serum magnesium were 3.2mmol/L, 9.6mg/dL and 2mg/dL respectively (Normal reference ranges: 3.5-5 mmol/L, 9-11 mmol/L and 1.6-2.6 mg/dL respectively). Intraoperatively, she developed tachycardia with increased frequency of PVCs and trigeminy rhythm followed by ventricular bigeminy. Blood gas analysis and serum magnesium were ordered. Intravenous injection

MgSO4 1g was given. Injection Loxicard bolus as per 1.5 mg/kg intravenously followed by intravenous infusion at 3ml/hr (as per 0.05µg/kg/min) was started. Blood gas analysis reported normal except serum potassium 2.7 mmol/L (N:3.5 -5 mmol/L) and ionized calcium 0.8 mmol/L (N: 1.2 to 1.4 mmol/L) and serum magnesium 1.4 mg/dL (N:1.6-2.6 mg/dL). KCl correction was started through central venous catheter and supplementation in intravenous fluids and intravenous calcium gluconate 2g given. ECG rhythm showed PVCs at every 4th beat and she was shifted to ICU postoperatively with ongoing KCl infusion; and loxicard infusion advised to be continued at 1 ml/hr for 2 hours postoperatively. She was shifted toward after 24 hours of observation with normal sinus rhythm and serum electrolytes and echocardiogram within normal range.

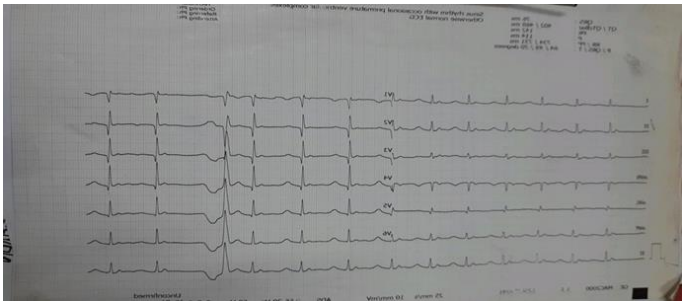

Figure 1: Pre-operative ECG showing sinus rhythm and premature ventricular contractions.

Case 2: 61 year man posted for simple cystectomy with ileal conduit; known case of hypertension on beta blocker and angiotensin receptor blocker and diabetes controlled with OHA since 6 years and known alcoholic and smoker since 30 years. Preoperative ECG showed PVCs (3-4 per minute) and echocardiogram reported Ef 45% with mid and basal anterior wall hypokinesia and moderate LVD. Stress echocardiogram suggested persistence of RWMA with moderate LVD with LAD territory hypokinesia; LVEF at the end of test remained 40%. Patient was shifted to diuretics, dapagliflozin and statins and was advised to add beta-blockers, ACE inhibitors and aspirin postoperatively as per preoperative cardiology reference and cardiac fitness with intermediate risk given. Preoperative serum electrolytes were normal. Intraoperatively, patient's ECG developed ventricular bigeminy rhythm with tachycardia. Injection Loxicard bolus was given as per 1.5 mg/kg intravenously. Blood gas analysis reported metabolic acidosis [pH 7.24, base excess (-9.3)], bicarbonate [17.5 mEq/L](N:22-26 mEq/L) , hypokalaemia (3 mmol/L)(N:3.5-5 mmol/L), hypocalcaemia (ionized calcium 0.7 mmol/L) (N:1.2 to 1.4 mmol/L) and serum magnesium (1.59 mmol/L)(N:1.6-2.6 /dL). His blood glucose was normal. Adequate sodium bicarbonate correction (10ml/hr infusion) and Injection MgSO4 1g intravenously started with KCl supplementation in intravenous fluids through central venous catheter and calcium gluconate (2g) given mg intravenously. Serial blood gas analysis were ordered hourly throughout the intraoperative period and infusions tapered accordingly. Postoperatively patient was shifted to intensive care unit with baseline ECG rhythm and ABGA reported normal. Postoperative echocardiogram reported same as preoperative report and antiplatelets started as per cardiologist advice. He was ward shifted after 48 hours with normal serum electrolytes.

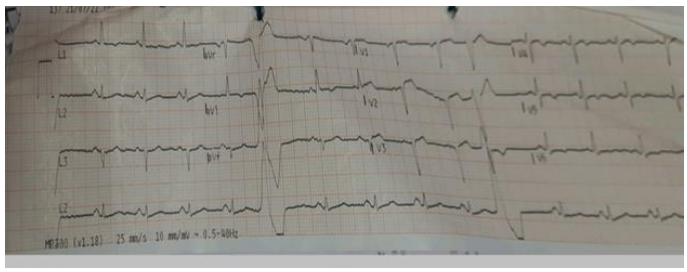

Figure 2: Pre-operative ECG showing sinus rhythm and premature ventricular contractions.

Case 3: 56 years man posted for unilateral Double-J stenting with no co-morbidities and addictions. His all investigations were within normal range except ECG, that showed PVCs (3-4 per minute). Intra-operatively, he

developed ventricular bigeminy. Injection Loxicard was given as per 1.5 mg/kg intravenously. He was given prone position for PCND later, as DJ stent could not be inserted successfully, following which he developed hypotension (blood pressure 80/50 mm Hg). Injection Noradrenaline was started at 2ml/hr as infusion intravenously. Blood gas analysis reported potassium 3.2 mmol/L, Calcium 0.9 mmol/L, with no metabolic acidosis and magnesium was 1.4 mmol/ L. Injection magnesium 1g was started intravenously. Baseline ECG rhythm achieved and postoperatively after 2 hours normal sinus rhythm with no PVCs was observed.

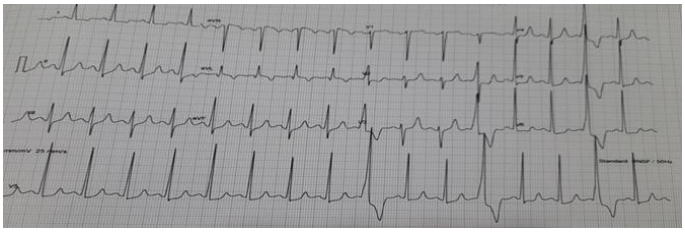

Figure 3: Pre-operative ECG showing sinus rhythm and premature ventricular contractions.

Discussion

Peri-operative arrhythmias elevate the risk of peri-operative myocardial infarction. Hypomagnesaemia can contribute to the development of cardiac arrhythmias through the alteration of Na/K ATPase and the end organ resistant action of PTH, resulting in hypokalaemia and hypocalcaemia, respectively.[4] In case 3, correcting magnesium deficiency alone successfully eliminated baseline PVCs postoperatively, while avoiding calcium correction to prevent further hypokalaemia. Hypokalaemia, hyperkalaemia, hypomagnesaemia, hypocalcaemia, sepsis, history of arrhythmias and cardiovascular disease are the known precipitating factors[5]. In our first patient, preoperative correction for hypocalcaemia and hypomagnesaemia was administered, and all the 3 patients experienced preoperative PVCs, with the second patient also having positive echocardiogram findings.

Hypokalaemia and hyperkalaemia both can interfere with electrical impulse transmission through myocardium and cellular polarization and lead to arrhythmias[5].Muhammad Ali et al. suggest that caution should be exercised when correcting co-existing metabolic acidosis with sodium bicarbonate, as it can further decrease serum potassium levels and potentially trigger refractory ventricular fibrillation.[5] In our second patient, we performed serial blood gas analysis for sodium bicarbonate correction while closely monitoring potassium levels. Perioperative cardiac risk increases when there are more than five PVCs per minute, and hypokalaemia can precipitate perioperative ventricular fibrillation.[6] Hypocalcaemia, hypomagnesaemia, and hypokalaemia are recognized as independent cardiac risk factors associated with prolonged QT intervals. [7] Hypocalcaemia increases myocardial irritability by reducing depolarization threshold and increasing sodium passage, hence impairing both depolarization and repolarization of cardiac myocytes resulting in cardiac arrhythmias.[8] Hypomagnesaemia, on the other hand, enhances sinus node automaticity and poses a potential risk for arrhythmias.[9] Magnesium supplementation has been shown to increase the conduction time of the atrioventricular node. [10]

Conclusion

Dyselectrolytemia should primarily be ruled out in perioperative arrhythmias. Correction of electrolyte imbalances should be approached cautiously, taking into consideration their interrelationship. Magnesium deficiency can contribute to hypokalaemia and hypocalcaemia. In cases of ventricular tachycardia/ventricular fibrillation due to severe hypokalaemia, the administration of bicarbonate and

calcium should be done cautiously to avoid exacerbating hypokalaemia.Timely and strategic treatment of perioperative cardiac arrhythmias is crucial, as they increase the risk of myocardial infarction and cardiac arrest during the perioperative period.

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