Case Report

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Anaesthesia Section

The Domino Effect: Hyperventilation, Hypocapnia, and Tetany in Airway Management

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ABSTRACT

Airway management represents one of the most critical challenges in anaesthesiology, particularly in patients with history of head and neck surgeries due to altered anatomy. Routine procedures like tracheostomy can occasionally present with unforeseen challenges, demanding prompt adaptability. We describe a case involving a 60-year-old female with bilateral vocal cord palsy following thyroidectomy for Hashimoto's thyroiditis four years ago. The patient had undergone a modified Dennis Kashima procedure, which involves injecting a bulking agent or placing a graft into the affected vocal cord to reposition it towards the midline, improving voice quality and airway protection in cases of vocal cord paralysis. The patient was tracheostomised for the first time under Local Anesthesia (LA) followed by Intensive Care Unit (ICU) stay for recovery two years ago and now came in for microlaryngoscopic biopsy under general anaesthesia in view of new onset persistent hoarseness of voice and progressive dyspnoea. The complication in our case arose due to repeated failed attempts in securing the airway, prompting anxiety and rapid breathing which in no time led to systemic complications like hyperventilation induced hypocapnia and hypocalcaemia which eventually landed patient to present with classical signs of tetany, supported by arterial blood gas analysis, confirmed hypocalcaemia (0.59 mmol/L). The condition was managed successfully with rebreathing using a Bain's circuit and intravenous calcium gluconate, which restored patient stability. This case shows the importance of the anaesthesiologist in unpredictable airway management scenarios along with neutralising the systemic complications like hypocalcaemia a potentially life-threatening condition that can precipitate neuromuscular irritability, seizures, arrhythmias, and cardiac arrest, if left uncorrected at the same time. Preparation, teamwork, flexibility, and vigilant monitoring in such a difficult situation are far more elemental to the practice of true optimal patient care.

Keywords: Acid-base imbalance, Anxiety, Calcium gluconate, Capnography, Muscle spasticity

CASE REPORT

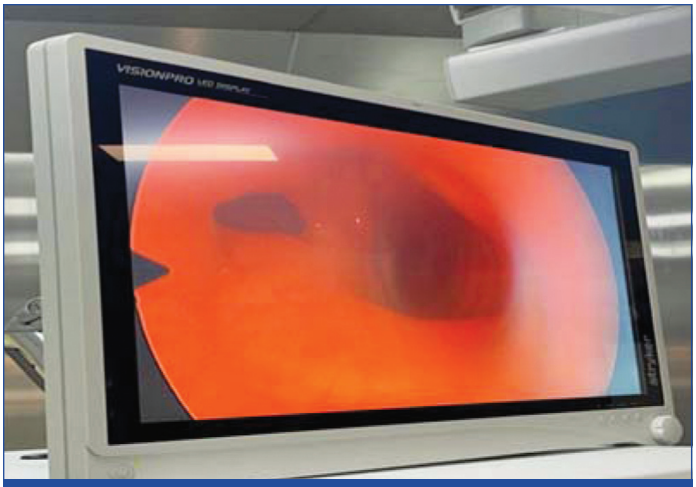
A 60-year-old female patient was admitted in our hospital for tracheostomy under sedation followed by microlaryngoscopic biopsy under general anaesthesia to determine the cause of persistent hoarseness and progressive dyspnoea. The patient underwent thyroidectomy for Hashimoto's thyroiditis four years ago; however, posttreatment, she developed bilateral vocal cord palsy. The patient's vocal cords remained paralysed, resulting in critical airway compromise. Two years later, she underwent a modified Dennis Kashima procedure with tracheostomy in view of vocal cord paralysis. Now she came to the hospital with new onset complaints of persistent hoarseness and progressive dyspnoea since two months.

The preoperative evaluation suggested a challenging airway. On examination, Mallampati Class IV with adequate three finger mouth opening was noted. The patient presented with stridor, and a compromised cardiopulmonary reserve with the metabolic equivalents of task score of 3. Routine investigations were mostly unremarkable except for mild left ventricular hypertrophy, trivial aortic regurgitation, pulmonary hypertension, and an ejection fraction of 60% on echocardiography.

Based on the patient's anatomy and potentially challenging airway, a comprehensive plan was designed. The anaesthetist prepared difficult airway carts that included cricothyrotomy set, fiberoptic bronchoscopes, video laryngoscopes, and bougies to help with airway management in case of complications. Preoperatively, patient was optimised with nebulisation using 1 mcg/kg of dexmedetomidine as a premedication for favourable haemodynamic response without any adverse events [1]. The patient also received nebulisation with duolin and intravenous hydrocortisone at a dose of 100 mg to reduce the reactivity of the airways and potential bronchospasm.

In the operating room, standard ASA monitors were attached before the patient was sedated and positioned for tracheostomy under LA. After premedication with glycopyrrolate and midazolam, LA was administered using lidocaine 2% (5 mL) and bupivacaine 0.25% (5 mL) at the intended site of the proposed tracheostomy to attain proper analgesia. Anatomical dissection and steps of tracheostomy were uneventful. After the successful aspiration of air using a syringe, the surgeons gently exposed the trachea and prepared for the insertion of the tracheostomy tube. However, with a standard-size seven tracheostomy tube, significant resistance was encountered. The resistance suggested that the tube was not progressing into the trachea as expected, a complication that could result from scarring from previous surgeries. The second attempt was done with a smaller tube introduction; however, capnography was still not satisfactory. To evaluate the situation, it was decided to visualise the airway to ensure the tube placement. On endoscopy, a false tract [Table/Fig-1], which was situated lateral to the actual tracheal lumen, was identified as the cause of unsuccessful attempts. The team then placed a bougie under direct visualisation, following which, the tracheostomy tube was railroaded over it. The team was highly cautious and vigilant with their approach in order not to incur further complications, such as subcutaneous emphysema or pneumothorax, that might have resulted from inappropriate insertion techniques.

Due to the unexpected airway complication encountered, to successfully secure the tracheostomy tube, the sedation was deemed inadequate. However, additional sedation during the procedure was avoided as we could not risk airway compromise. The complete process was time consuming due to which the patient started to hyperventilate [Table/Fig-2] as a result of anxiety. In addition to this, patient tried to convey the discomfort caused by stiffness in the hands by raising the hands below the sheets. We



[Table/Fig-1]: Endoscopic image showing false tract lateral to tracheal lumen (identified by tracheal rings).

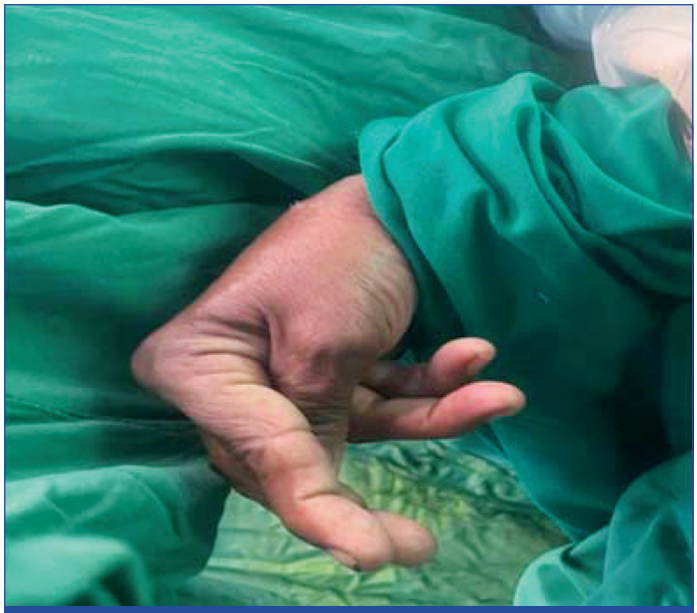
[Table/Fig-2]: Monitor readings showing decreased $EtCO_2$ due to increased respiratory rate of 32 indicating hyperventilation due to anxiety.

then noticed a characteristic spasm in the forearm muscles that caused wrist and thumb flexion and finger extension, provoked by the inflation of the blood pressure cuff, which was identified to be the Trousseau's sign [Table/Fig-3]. Chvostek's sign, characterised by a unilateral spasm of the facial muscles, demonstrated by tapping the facial nerve at the point where it crosses the angle of the jaw, was later elicited positive. After hyperventilation-induced tetany was diagnosed, the patient was given the assurance that it would subside as soon as their breathing returned to normal [2]. We then immediately attached a Bains open circuit and semiclosed the adjustable pressure limiting valve so as to make the patient rebreathe [Table/Fig-4]. In an attempt to increase the $PaCO_2$ and prevent further hypocapnia within 2-3 mins of rebreathing, we could notice the increase in $EtCO_2$ on the monitor, and the return of the respiratory rate to normal.

An arterial blood gas analysis was done from the right dorsalis pedis artery, which showed the calcium levels to be 0.59 mmol/L. We postulated that the hypocalcaemia was secondary to hyperventilation during airway management and one gram of intravenous calcium gluconate was administered to correct the electrolyte abnormality. This quick response successfully brought about stability in the patient, thus preventing significant complications.

DISCUSSION

Managing the airway of a patient with a complex medical history presents significant challenges for any anaesthesia team. Patients with



[Table/Fig-3]: Trousseau's sign-characteristic muscle spasm seen in hypocalcaemia.

[Table/Fig-4]: Monitor showing rebreathing pattern on $EtCO_2$ with optimised respiratory rate of 14.

a history of neck surgeries, such as thyroidectomy or tracheostomy may exhibit substantial anatomical changes, reduced neck mobility, scarring, and potential vocal cord palsy, that complicate intubation and other airway management techniques. These cases necessitate meticulous, multidisciplinary management, thorough preoperative and perioperative planning and monitoring with standard ASA monitors, and the application of advanced airway management techniques to mitigate the risk of complications. Techniques like McCoy blades, fiberoptic bronchoscopy, video laryngoscopy, and bougie guided intubation or similar devices may be utilised to navigate anatomical difficulties while ensuring safe intubation [3].

In many nations, conscious sedation has become an essential component of the pain and anxiety management of patients undergoing procedures involved in securing airway in order to battle this type of worry. Nevertheless, inspite of sedation, anxiety can develop into panic, making it more difficult to regain emotional control [4].

Complications would need advanced airway equipment and an expert team. Multidisciplinary teamwork allowed for rapid adjustment as first-line attempts at tracheostomy were not successful. Innovative problem-solving through endoscopic guidance and bougie-assisted placement assured the safety of the patients [5]. The preoperative evaluation was crucial in identifying challenges and forming a strategy for managing the patient's airway during surgery. The patient had

a history of thyroidectomy and vocal cord paralysis with physical findings of stridor and decreased metabolic equivalents of task score denoting both anatomically difficult airway and compromised pulmonary function. It points towards the possibility of complications arising not only while intubating but also during ventilation. Hence, proper planning and preparation are needed [6,7].

Hyperventilation, often triggered by anxiety during surgery presents with tachypnoea, or unusually rapid breathing, and an increased minute ventilation that surpasses metabolic demand [8], which in turn leads to decreased Carbon Dioxide (CO_2) levels in the blood, causing hypocapnia and respiratory alkalosis, a condition where the blood pH is elevated due to the loss of CO_2 (acidic component). Hydrogen ions compete with ionised calcium for the same binding sites on protein molecules that are negatively charged. The increase in blood pH causes a shift in the protein binding of calcium, by increasing the binding of ionised calcium to plasma proteins. As a result, the amount of ionised (or free) calcium in the bloodstream decreases, leading to hypocalcaemia. Ionised calcium is the biologically active form of calcium and plays a critical role in muscle function, nerve transmission, and other physiological processes. The sodium permeability of neuronal membranes is impacted by decreased extracellular calcium concentration, which also impacts how easily action potentials are generated. Because it lowers the threshold for the creation of an action potential, hypocalcaemia can cause spontaneous action potentials to occur in nerves. Muscle tetany, or hypocalcaemic tetany, can occur when motor neurons are affected [4]. Patient presents with an involuntary contraction of skeletal muscles termed tetany. These signs signify the necessity for vigilant monitoring by the anaesthesiology team, as timely recognition and intervention are vital to prevent complications like seizures, arrhythmias, or other serious outcomes such as cardiac arrest due to hypocalcaemia [4].

McCarthy C et al., described a case of hyperventilation-induced hypocapnia resulting in tetany in a 16-year-old girl undergoing orthodontic extractions under intravenous conscious sedation using midazolam, cautiously titrated to avoid oversedation and paradoxical reactions [3]. Despite normal SpO_2 levels, capnography detected hyperventilation-induced hypocapnia, leading to transient tetany. The team managed this by having the patient rebreathe into a paper cup to restore CO_2 levels, supported by continuous capnographic and oxygen saturation monitoring. Postoperative tests confirmed hypocapnic tetany, likely triggered by alkalosis-related ionised calcium shifts. The case highlights the importance of capnography in detecting respiratory disturbances during sedation, even in the absence of hypoxia.

Moon HS et al., described a case of previously healthy 51-year-old female, undergoing spinal anaesthesia for lower extremity surgery, developed nausea, headache, paresthesia, perioral numbness, carpal spasm, and flattened T waves on Electrocardiogram (ECG) [4]. Arterial blood gas analysis showed low $PaCO_2$, hypocalcaemia, and hypokalemia. The patient was treated with sedation, electrolyte replacement, and closed mask ventilation, leading to gradual symptom resolution. They concluded that monitoring for Hyperventilation Syndrome (HVS) during anaesthesia is crucial for patient safety.

Bansal E et al., reported a case of a 30-year-old full-term parturient in labour, presenting with symptoms of hypocalcaemia, including circumoral numbness and carpal spasm, due to severe anxiety [9]. The patient was successfully treated with reassurance and intravenous calcium gluconate.

Quick thinking and prompt action, by making the patient rebreathe through a Bain's circuit, along with technical modifications and effective communication, enabled the team to adapt their approach by utilising endoscopic guidance and a bougie for the safe placement of the tracheostomy tube, which ensured the patient's care and well-being [5,10].

CONCLUSION(S)

This case underlines that a multilevel and individualised approach to airway management is essential for a patient with a complex medical history. It just reminds us of how managing the complex airway is not simply a matter of technical expertise but is also a matter of collaboration and adaptation with respect to patient care is of utmost importance.

REFERENCES

[1] Antony T, Acharya KV, Rajgopal Acharya P. Effectiveness of nebulized dexmedetomidine as a premedication in flexible bronchoscopy in Indian patients: A prospective, randomized, double-blinded study. Contemp Clin Trials Commun. 2023;33:101111. Doi: 10.1016/j.conctc.2023.101111. PMID: 36969987; PMCID: PMC10031085.

[2] Langeron O, Amour J, Vivien B, Aubrun F. Clinical review: Management of difficult airways. Crit Care. 2006;10(6):243.

[3] McCarthy C, Brady P, O'Halloran KD, McCreary C. Tetany during intravenous conscious sedation in dentistry resulting from hyperventilation-induced hypocapnia. Anesth Prog. 2016;63(1):25-30. Doi: 10.2344/15-00005R1.1. PMID: 26866408; PMCID: PMC4751516.

[4] Moon HS, Lee SK, Chung JH, In CB. Hypocalcemia and hypokalemia due to hyperventilation syndrome in spinal anesthesia: A case report. Korean J Anesthesiol. 2011;61(6):519-23.

[5] Cook TM. Strategies for the prevention of airway complications: A narrative review. Anaesthesia. 2018;73(1):93-111.

[6] Ahmed A, Azim A. Difficult tracheal intubation in critically ill. J Intensive Care. 2018;6(1):49.

[7] Marchis IF, Negrut MF, Blebea CM, Crihan M, Alexa AL, Breazu CM. Trends in preoperative airway assessment. Diagnostics (Basel). 2024;14(6):610.

[8] Zvolensky MJ, Eifert GH. A review of psychological factors/processes affecting anxious responding during voluntary hyperventilation and inhalations of carbon dioxide-enriched air. Clin Psychol Rev. 2001;21(3):375-400.

[9] Bansal E, Hooda S. Hyperventilation causing symptomatic hypocalcaemia during labour in a parturient. Egypt J Anaesth. 2013;29(4):333-35. Doi: 10.1016/j.egja.2013.05.008. Available from: https://www.sciencedirect.com/science/article/pii/S1110184913000615.

[10] Checketts MR, Alladi R, Ferguson K, Gemmell L, Handy JM, Klein AA, et al. Recommendations for standards of monitoring during anaesthesia and recovery 2015: Association of Anaesthetists of Great Britain and Ireland. Anaesthesia. 2016;71(1):85-93. Available from: https://associationofanaesthetists-publications.onlinelibrary.wiley.com/doi/epdf/10.1111/anae.13316.

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