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Potential Role of High-Flow Nasal Cannula in Optimizing Oxygenation during Thoracic Segmental Spinal Anesthesia

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Abstract **Review Article**

The application of thoracic segmental spinal anesthesia (TSSA) continues to expand, particularly in patients with respiratory comorbidities and those undergoing upper abdominal and thoracic procedures. While the use of high-flow nasal cannula (HFNC) is not an established method for maintenance of oxygenation during TSSA, it has the potential to optimize oxygen delivery, warranting further exploration. HFNC offers several clinical advantages over conventional oxygenation by providing a high flow of oxygen and thereby reducing the rebreathing of expired gases. HFNC also reduces work of breathing. Additionally, it generates a continuous low level of positive airway pressure, counteracting mild atelectasis and improving pulmonary mechanics, particularly in patients with limited respiratory reserve. These mechanisms suggest that HFNC could serve as a supportive measure in patients undergoing TSSA, particularly those undergoing upper abdominal and thoracic procedures with respiratory compromise.

Keywords: Airway obstruction, high-flow nasal cannula, hypoventilation, non-invasive ventilation, patient comfort, thoracic segmental spinal anesthesia.

BACKGROUND

Day by day the horizon of thoracic segmental spinal anesthesia (TSSA) is getting wider, particularly in patients with respiratory issues and in those undergoing upper abdominal and thoracic surgeries [1, 2]. In these cases, effective oxygen support and intensive monitoring of the patients are crucial for obtaining favorable outcomes. High Flow Nasal Cannula (HFNC) can be used as a promising option for enhancing oxygenation in these patients. However, in otherwise healthy patients, and while using isobaric drugs mostly producing a selective block, its use remains debatable. HFNC can play a decisive role in providing adequate oxygenation during TSSA by delivering warm and humidified oxygen at a high flow rate through the nasal passages. This is specifically important during procedures where spontaneous breathing might be compromised due to the underlying pathology and/or anesthetic effects on the respiratory muscles, ensuring adequate oxygenation throughout the surgery and recovery period. As TSSA continues to evolve with the addition of several modalities, incorporating HFNC as a potential adjunctive therapy could help optimize perioperative respiratory management in high-risk populations and enhance patient safety.

Key benefits of HFNC in TSSA

HFNC offers multiple physiological advantages over conventional oxygen therapy. HFNC is known to deliver a precise and high concentration of oxygen, leading to rapid correction in oxygen saturation in susceptible patients. In high-risk patients with preexisting pulmonary dysfunction, such as chronic obstructive pulmonary disease (COPD) or obesity hypoventilation syndrome (OHS), HFNC provides optimal oxygenation by maintaining higher end-expiratory lung volumes and preventing alveolar collapse [3]. The continuous high flow of oxygen helps to wash out dead space in the upper airways, improving gas exchange and minimizing the need for excessive ventilation during HFNC [4]. This is becoming significant during the conduct of TSSA, where the respiratory drive may be affected due to more cephalad spread of the anesthetic, potentially hindering spontaneous breathing efforts.

Oxygen supplementation through nasal cannula or face masks often causes discomfort due to dryness of

the mucosa and non-compliance while using for prolonged periods. HFNC allows warmed and humidified oxygen supplementation, reducing airway dryness and irritation [5]. This enhances patient comfort, particularly during prolonged surgical procedures where oxygen supplementation is needed. Preoxygenation is particularly useful in cases where mild respiratory depression is expected during anesthesia, ensuring uninterrupted oxygenation and reducing the likelihood of hypoxia and its ill effects. Furthermore, HFNC may serve as a non-invasive supportive measure in mitigating respiratory complications such as mild hypoventilation or airway obstruction during TSSA [6].

Although HFNC has not been widely adopted in TSSA, its use in other perioperative and intensive care settings has been well documented [7]. Studies have shown that HFNC is beneficial in managing acute hypoxemic respiratory failure, reducing the need for invasive ventilation [8]. The clinical benefits observed in these conditions suggest that HFNC could be explored further for its potential role in TSSA, particularly in patients who are at risk for respiratory deterioration during or after surgery. However, its application during TSSA should be tailored to individual patient needs, with careful assessment of risks and benefits.

Important considerations when using HFNC in TSSA

Despite its established advantages, HFNC use warrants careful consideration of its limitations. The flow rate of the HFNC should be adjusted considering the patient's overall clinical condition, oxygen saturation, respiratory effort, and acid-base status to ensure optimal oxygen delivery [9]. Proper patient positioning is important to prevent airway obstruction and ensure efficient delivery of oxygen during HFNC. Prone, lateral, or head-elevated positions can be used if the surgical condition allows it to optimize lung mechanics and prevent airway collapse [10]. Close monitoring of vital signs, including oxygen saturation, is crucial during HFNC use to detect any potential complications and timely management [11]. Continuous pulse oximetry and capnography can provide real-time oxygenation and ventilation status, while arterial blood gas (ABG) analysis may be warranted in certain high-risk patients.

Additionally, excessive flow rates can lead to nasal mucosal injury, patient discomfort, or gastric insufflation [12]. Another consideration is the feasibility and cost-effectiveness of HFNC in the operating room setting [13]. While HFNC has been increasingly used in intensive care and emergency settings, its routine incorporation into TSSA procedures would require infrastructure and training to ensure its proper use. Future studies should assess the benefits of HFNC and the costs incurred along with logistical requirements associated with its implementation in surgical settings [14]. Additionally, exploring the impact of HFNC on long-term recovery and postoperative pulmonary function could further establish its role in anesthetic practice.

CONCLUSIONS

HFNC plays a crucial role in maintaining optimal oxygenation in patients undergoing TSSA, particularly those with preexisting respiratory compromise. By improving oxygen delivery, reducing dead space ventilation, and enhancing patient comfort, HFNC serves as a valuable adjunct in anesthesia management. Its implementation should be tailored to individual patient needs, with careful monitoring and appropriate flow adjustments to maximize benefits and minimize risks. While the physiological effects of HFNC suggest a potential role in TSSA, its use in these settings requires further validation through well-designed clinical studies. Future research and randomized controlled trials are warranted to further establish the potential role of HFNC on perioperative outcomes in patients receiving TSSA.

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