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Comparing Transoral Endoscopic Thyroidectomy Approaches: CO_2 Insufflation versus Gasless Technique

ABSTRACT

Transoral endoscopic thyroidectomy vestibular approach (TOETVA) offers a scar-free alternative to traditional thyroidectomy but poses risks when performed with CO_2 insufflation, particularly the risk of CO_2 embolism. This manuscript compares CO_2-insufflated TOETVA with the gasless technique, which uses novel retractors to create a working space, thus minimising insufflation-related complications. While CO_2 insufflation enhances visualisation, it presents physiological risks that limit its use in patients with cardiopulmonary concerns. The gasless approach, though requiring specialised equipment and training, mitigates these risks and may extend TOETVA candidacy. This comparison highlights patient selection considerations and the evolving techniques that enhance safety in minimally invasive thyroid surgery. Further research on long-term outcomes will help refine TOETVA methods.

INTRODUCTION

Thyroid surgery has witnessed significant advancements, with techniques such as Transoral Endoscopic Thyroidectomy Vestibular Approach (TOETVA), which offers a scarless alternative to conventional open surgery. TOETVA, which accesses the thyroid through a vestibular entry, is gaining popularity for its aesthetic benefits and decreased postoperative scarring.[1] However, similar to other endoscopic techniques, it relies on CO_2 insufflation, which is used to create space and visibility for the surgeon, and has the potential risk of CO_2 embolism, a rare but serious complication.[2] This literature explores the safety profiles of TOETVA using CO_2 insufflation techniques vs a gasless approach, focusing particularly on the risk of CO_2 embolism and how it affects clinical decision-making in thyroid surgery.

TOETVA is a minimally invasive thyroidectomy technique performed through incisions inside the mouth, allowing surgeons to access the thyroid without visible neck scars and offering cosmetic benefits that enhance patient satisfaction. Additionally, since TOETVA is minimally invasive, it typically results in faster recovery times and less postoperative pain than with traditional open procedures. This has been noted in recent literature, such as the analysis of 110 cases in 2021 showing positive surgical outcomes with this technique.[3] However, of these 110 cases, two had to be converted to open techniques, one of which was due to the suspicion of CO_2 embolism.

Side-effects of TOETVA include potential increased infection risks and minor trauma within the mouth, so much so that antibiotic prophylaxis has been suggested to avoid the complication of infection and abscess formation.[3] Additionally, TOETVA poses the risk of mental nerve injury with subsequent hypoesthesia of the lower mandible and neck.

CO_2 insufflation is commonly used in endoscopic and laparoscopic surgeries and facilitates an expanded operative space by inflating the body cavity to create the working space required, which in TOETVA, inflates the operative field around the thyroid gland. This ability to create a stable and clear visual field is crucial for procedures requiring precise navigation, such as thyroidectomy. In TOETVA, the CO_2 pressure displaces tissues gently but effectively, allowing the surgeon to access the thyroid gland without major disturbance to surrounding structures. Additionally, CO_2 is highly soluble in blood, thus in the event of minor absorption, the gas can typically be eliminated without significant risk of harm. Although this setup allows better visualisation, it also raises safety concerns as it has been associated with complications such as gas embolism, particularly when venous access points are inadvertently created. An embolism occurs when gas enters a blood vessel and travels through the bloodstream, potentially blocking blood flow and leading to severe cardiovascular complications. This risk, while infrequent, is heightened in the head and neck areas as the proximity to major vessels increases the potential for gas to enter the bloodstream, creating embolic events that can compromise patient safety. Even a small amount of CO_2 entering the bloodstream at these points can result in systemic embolization, causing life-threatening cardiovascular or respiratory issues.[3] This has been recorded in 2016 where a patient suffered this rare, potentially life-threatening complication during endoscopic thyroidectomy.[4]

Incidents of embolism have varied across studies, with higher rates typically reported in surgeries involving high-pressure CO_2 insufflation or prolonged procedural times. Factors such as pre-existing cardiovascular conditions, vessel integrity, and procedural techniques all influence embolism risk.[5] The occurrence of CO_2 embolism can have severe outcomes, including hypotension, arrhythmias, and in extreme cases, cardiovascular collapse. For this reason, monitoring systems are often in place to detect early signs of embolism, allowing the surgical team to take immediate corrective action if necessary. The risk of delayed bleeding is another complication noted due to the CO_2 insufflation used during this procedure, as it has been noted to be concealed intra-operatively due to the tamponade effect the insufflation of CO_2 offers.[3]

CO_2 insufflation was also linked to subcutaneous emphysema and hypercarbia. Subcutaneous emphysema occurs when CO_2 gas accumulates in the subcutaneous tissues, leading to swelling and discomfort. Although generally self-limiting, this can be concerning for patients and may require further treatment to resolve. Hypercarbia, or elevated CO_2 levels in the blood, is another risk, especially if the gas is absorbed rapidly. While the body can often compensate for mild increases in CO_2, patients with compromised respiratory function or underlying lung disease may be at higher risk of complications. One of these complications is increased intracranial and intraocular pressure, which is particularly of note in patients suffering from glaucoma. Many patients with glaucoma are undiagnosed, and are susceptible to 'potential damage induced by having intermittent rise in IOP' induced by CO_2 insufflation.[6] Due to this, glaucoma has been recommended as a contra-indication for the use of CO_2 insufflation, and further studies have been recommended for the evaluation of such cases.

Other complications have been reported, as was evident in a published report in 2020, which mentioned a case where side-effects of TOETVA included pneumo-peritoneum and pneumo-mediastinum.[7] Documented cases of these complications underscore the importance of careful patient selection and monitoring.

To further mitigate these risks, surgeons using CO_2 insufflation in TOETVA often adhere to strict pressure limits, ideally less than 5mmHg,[3] which minimises gas absorption. The patient's positioning during surgery, commonly in a slight Trendelenburg – patient lies supine with feet elevated above head - also influences the distribution and retention of CO_2. Additionally, careful monitoring of end-tidal CO_2 levels is imperative to detect hypercarbia early.[3] Some studies suggest that implementing intermittent insufflation, wherein CO_2 is periodically stopped to allow for gas reabsorption, may reduce embolism risk. However, this requires a highly skilled surgical team capable of rapidly adjusting techniques based on real-time patient feedback.[3]

These effects have led to the development of a gasless technique, which eliminates CO_2 usage while preserving the key benefits of the procedure. This gasless technique utilises novel retractors to create a working space. These retractors elevate the soft tissue without the need for insufflation, maintaining adequate visualisation while avoiding the physiological complications associated with CO_2. A paper published in 2019[8] reviewed 15 cases of gasless TOETVA using a self-retaining retractor, with no reported serious postoperative complications, and no visible scarring on the neck. This showed that surgery was indeed possible and successful without the use of CO_2 insufflation. The retractor utilised comprised a newly developed retractable blade, which was fixed after insertion, to the body of the self-retaining retractor system. Notably, to aid visualisation, 'a percutaneous suture was placed on the roof akin and hung from a retractor'.[8] In comparison, another paper published recently in 2023[9] also reported positive outcomes with gasless submental-transoral combined approach endoscopic thyroidectomy (STET), where all 75 patients were performed using this technique without necessitating the conversion to open procedures.

Furthermore, Camenzuli *et al* also developed a specialised retracting device for TOETVA (US Patent No. 957634S1). This device was evaluated through the use of Thiel embalmed cadavers to replicate the surgical technique, with blinded questionnaires to thyroid surgeons who compared images from standard TOETVA and the gasless route. The results were promising, showing that the new retraction device offered similar visibility and reduced risks of CO_2 embolism.[10,11]

IN OUR OPINION, COMBINING GASLESS TECHNIQUES WITH LIMITED INSUFFLATION COULD STRIKE A BALANCE, USING MINIMAL CO_2 ONLY WHEN CRITICAL FOR VISUALISATION, THEN REVERTING TO RETRACTION-ONLY TECHNIQUES

Using retractors, however, is not without its own challenges. The absence of CO_2 can limit the surgeon's view of deeper anatomical structures, requiring more adept handling of instruments to maintain a clear operative field. Surgeons may experience difficulty with visibility, which could increase operative time and fatigue. Furthermore, gasless TOETVA requires specialised equipment and additional training. Familiarity with the specific retraction systems, along with increased experience in transoral techniques, is critical to achieving optimal visualisation without insufflation. A recent review highlighted that while gasless endoscopic thyroidectomy techniques, including TOETVA, avoid the complications associated with CO_2 insufflation, such as subcutaneous emphysema and hypercapnia, the trade-off is a potentially steeper learning curve due to the reliance on mechanical retraction for exposure.[12] Findings suggest that operative times may be prolonged initially as surgeons adapt to these methods, underscoring the importance of structured training and increased experience in optimising surgical efficiency. Consequently, adopting the gasless approach may require a steeper learning curve, especially for surgeons accustomed to traditional insufflation methods.[3]

A critical factor in choosing between insufflation and gasless TOETVA is patient selection. Identifying patients at risk for CO_2 related complications is essential to determine the most suitable technique. Patients with a history of respiratory or cardiovascular disorders may not tolerate CO_2 insufflation, as the added gas load and positioning required for TOETVA could exacerbate underlying conditions. In such cases, the gasless method becomes a safer alternative. For younger patients with a high priority on aesthetic outcomes, the choice of TOETVA itself aligns well with their goals, but the use of gasless techniques allows for an added safety buffer if they are at risk for embolism or related complications.[3]

In our opinion, combining gasless techniques with limited insufflation could strike a balance, using minimal CO_2 only when critical for visualisation, then reverting to retraction-only techniques. This hybrid approach presents an area for further exploration, particularly in patients for whom both visualisation and safety are equally high priorities.

As TOETVA continues to gain traction, advancements in surgical equipment and techniques will likely address the limitations of both insufflation and gasless methods. For instance, there is potential for more refined, less invasive retraction systems that could allow for clearer visualisation without CO_2 or with only minimal insufflation. Additionally, optical technologies such as 3D endoscopy and intraoperative imaging may offer improved visualisation, reducing the need for CO_2 and allowing for safer manipulation in delicate anatomical spaces.

Further studies comparing clinical outcomes, complication rates, and patient satisfaction between insufflation and gasless TOETVA are needed to validate each technique's efficacy. As more data emerges, protocols for patient selection can be refined, and hybrid approaches optimised. Multicentre trials comparing embolism risk, operative time, and learning curve for the gasless method versus insufflation-dependent TOETVA will provide valuable insights for surgeons adopting these approaches.

CONCLUSION

TOETVA represents a significant advancement in minimally invasive thyroid surgery, offering a scar-free approach with improved aesthetic outcomes. However, the choice between CO_2 insufflation and a gasless approach should be tailored to individual patient profiles, considering the safety risks and technical demands of each technique. While CO_2 insufflation provides easier visualisation, its associated complications, particularly embolism, limit its use in high-risk patients. The gasless approach, by contrast, eliminates these risks but requires specialised equipment and a skilled surgical team for effective application. Combining gasless techniques with limited insufflation could be another option. With ongoing technological developments and increased understanding of patient risk factors, TOETVA can continue to evolve toward a safer and more accessible option for patients and surgeons alike.

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