

What is the Ideal CO₂ Insufflation Pressure for Endoscopic Thyroidectomy? Personal Experience with Five Cases of Goiter

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ABSTRACT

Introduction: The endoscopic thyroidectomy (ET) using high CO₂ insufflation pressures (CIP) are prone to complications, such as hypercarbia, acidosis, pneumomediastinum and cardiac arrhythmias. The purpose of this study was to analyse the perioperative events and CO₂ related morbidity in five cases of endoscopic thyroidectomy in our experience.

Methods: Between February 2010 and August 2010 (6 months), five cases of benign goiters operated with extracervical ET technique in endocrine surgery department of a tertiary care hospital of southern India were studied. Clinicopathological, operative and morbidity data were documented and analyzed.

Results: All the five patients were women and mean age was 37.2 years (25-46). CIP of 12 to 14 mm Hg was used for creation of working space and CIP of 8 to 10 mm Hg for its maintenance. Average operative time was 135 minutes (65-212). Two cases had to be converted into open procedure due to gas related complications, such as hypercarbia, acidosis and ventricular tachycardia.

Conclusions: CO₂ insufflation pressure (CIP) of 10 to 12 mm Hg for creation of working space and 6 to 8 mm Hg for maintenance of space is optimal. A protocol based on CIP, monitoring and intermittent desufflation is recommended for safe ET with minimum complications.

Keywords: Endoscopic thyroidectomy, CO₂ insufflation, Hypercarbia, Acidosis, Subcutaneous emphysema.

INTRODUCTION

Endoscopic techniques for thyroidectomy have been increasingly employed, ever since its feasibility was first demonstrated by Gagner in 1996.¹ Various methods, like minimally invasive, video-assisted and totally endoscopic procedures with or without gas insufflation, have been attempted with reasonable success.² But, many reports of complications related to gas insufflation, such as hypercarbia, acidosis, pneumomediastinum, pneumothorax, subcutaneous emphysema and cardiac arrhythmias, have been reported.^{3,4} These gas related complications are attributed to high insufflation pressures and prolonged operative duration, prompting use of reduced insufflation pressures and duration.^{3,5} In this context, we analyzed our own experience with totally endoscopic thyroidectomy using CO₂ insufflation with specific emphasis on its complications.

MATERIALS AND METHODS

This is a retrospective study of prospectively collected data from the endocrine surgery department of a tertiary care teaching hospital in southern India. Eligible patients who agreed to participate and provided informed consent were offered the

procedure and included in this study. Five cases operated with endoscopic thyroidectomy (ET) technique using CO₂ insufflation between February 2010 and August 2010 (6 months) were included in the study. Inclusion criteria were patient age group between 20 and 50 years, small nodular goiter (< 4 cm), no evidence of thyroiditis, invasive malignancy or cervical lymphadenopathy. Exclusion criteria for this procedure were age more than 50 years, evidence of chronic obstructive pulmonary disease, restrictive lung disease or major comorbid illnesses, like severe hypertension, cardiac disease, poorly controlled diabetes and uncooperative patients. All the cases were managed by the same surgical and anesthetic team. All the clinicopathological details were noted. Operative details i.e. CIP at the creation of operative space, CO₂ insufflation pressure for maintenance, operative time, complications, etc. were recorded and analyzed. Related literature with regards to the type of gas, gas insufflation pressure, gas related complications was done.

Operative Technique

We used a totally extracervical route (axillary-breast approach in two cases, transaxillary in two cases and chest approach in

one case) for ET. Three ports—a 10 mm port for camera, a 10 mm and a 5 mm working ports were used in all the cases. Port placements used for axillary-breast approach is shown in Figure 1. Ports were placed atleast 5 cm apart to minimize crowding of instruments. Subcutaneous dissection was done with long dissector bluntly, later assisted by CO₂ insufflation and diathermy. Dissection was done till adequate working space is created. Thyroidectomy was done through the lateral approach, i.e. the space was created between the anterior border of sternocleidomastoid muscle and lateral border of strap muscles. For the creation of working space CIP of 12 to 14 mm Hg was used, and for maintenance of space CIP of 8 to 10 mm Hg was used. End tidal CO₂ (ETCO₂) was continuously monitored and recorded. Whenever ETCO₂ raised to > 50 mm Hg, CIP was reduced to 4 mm Hg or stopped for about 10 minutes, and maintenance of CIP was re-established after ETCO₂ returned to normal levels. During this period, minute volume and tidal volume were increased by about 30%. Arterial blood gas analysis (ABG) was done in two cases who suffered from persistent hypercarbia. ET procedure was abandoned, if persistent hypercarbia or hemodynamic disturbance occurred.

RESULTS

All the five patients were women and mean age was 37.2 years (25-46). All the cases were benign goiters and morphologically, three had solitary thyroid nodules, one had multinodular goiter and diffuse goiter in one patient. One case had well-controlled hypertension on anti-hypertensives, but with no evidence of cardiorespiratory illness.

Operative details and events are displayed in Table 1. Three patients were taken up for hemithyroidectomy and two for total thyroidectomy. But, ET procedure had to be abandoned in case 1 and was converted to open technique after 65 minutes, in view of refractory hypercarbia (56 mm Hg on ETCO₂ and 101 mm Hg on ABG), acidosis and ventricular tachycardia. Once hypercarbia occurred, CIP was reduced to 4 mm Hg and later stopped. Simultaneously, she was hyperventilated with



Fig. 1: Port position in endoscopic thyroidectomy

30% in minute volume and tidal volume. Ventricular tachycardia required lignocaine injection for correction. She was kept on ventilator in postoperative period for 12 hours. In case 4, only one side lobe could be dissected and completion of total thyroidectomy was precluded by refractory hypercarbia (60 mm Hg on ETCO₂ and 74 mm Hg on ABG) and severe subcutaneous emphysema. Similar anesthetic management as in the case 1 was done for case 4, except for the use of lignocaine. Rest of the procedure was completed by conventional open technique. She had uneventful recovery and did not require postoperative ventilation. Postoperative chest radiography showed no evidence of pneumothorax or pneumomediastinum in both these cases. Subcutaneous emphysema resolved within 5 hours in case 1 and 3 hours in case 4. We used ABG in two of our cases who suffered from hypercarbia. The arterial to alveolar CO₂ difference was 45 mm Hg in case 1 and 14 mm Hg in case 4.

Table 2 shows comparison of CIP and gas related complications among various series with ours. It can be seen that procedures using CIP of < 8 mm Hg had no gas related complications, while complications occurred in 2/5 cases of our series using > 8 mm Hg and Gottlieb et al case using CIP of 15 to 20 mm Hg. Mean operative time was remarkably similar in majority of the studies, lasting between 128 and 136 minutes.

DISCUSSION

Interest in endoscopic neck surgery gained momentum after successful demonstration of subtotal parathyroidectomy by Gagner in 1996.¹ This was extended to thyroid nodules in 1997, by Huscher et al, who employed skin incision at the anterior border of sternocleidomastoid.⁶ The endoscopic thyroidectomy (ET) techniques may be broadly divided as mini-incision minimally invasive, video-assisted gasless and purely endoscopic with gas insufflation methods.² Based on anatomical access, ET can be done through cervical,⁷ extracervical (chest wall, breast, transaxillary) and combined approaches. The obvious advantage of extracervical approach is absence of skin mark in the visible area of neck and upper chest. Park et al reported a breast approach⁸ and Shimazu et al reported an axillabilateral-breast approach.⁹ The feasibility of transaxillary approach has been demonstrated by many investigators, which further improves the cosmesis.^{10,11} The lateral cervical approach through the plane between the carotid sheath laterally and the strap muscles medially was reported by Henry et al.¹² Even novel access routes and methods like postauricular approach,¹³ transoral approach¹⁴ and robotic ET¹⁵ have been explored with reasonable success rates. We used an access technique of totally extracervical approach and internal dissection through the plane between carotid sheath and strap muscles.

All the ET techniques necessitate creation of a subcutaneous working space by using external or internal maneuvers. The commonest internal maneuver is gas insufflation at a predetermined pressure. Various gases tried in both animal and human subjects are carbon dioxide, nitrogen, nitrous oxide, helium, air, krypton and argon. The CO₂ insufflation proved to

Table 1: Operative and morbidity details

Case	Surgery	Operative time (in minutes)	CIP I (mm Hg)	CIP II (mm Hg)	Outcome	Morbidity
1	HT	65	12	9	A	1, 2, 3, 4
2	HT	164	14	8	C	–
3	HT	130	12	9	C	–
4	TT	105	14	10	I	1, 4
5	TT	212	12	8	C	–

HT–hemithyroidectomy, TT–total thyroidectomy, CIP I–CIP at creation of working space, CIP II–CIP for maintenance of working space, A–abandoned, C–Completed surgery, I–incomplete surgery, Morbidity–(1) hypercarbia, (2) acidosis, (3) ventricular tachycardia, (4) subcutaneous emphysema

Table 2: Comparison of operative parameters between various studies

Author (ref no.)	Number of cases (N =)	Surgery	CIP (mm Hg)	Morbidity (in %)	Average operative time (in minutes)
Our study	5	ET	8-10	40	135
Park et al ⁸	100	ET	6	0	136
Chantawibul ¹⁷	45	ET	4	0	131.2
Duncan et al ¹¹	3	ET	7	0	128
Gottlieb et al ³	1	ET	15-20	100	420

ET–endoscopic thyroidectomy, CIP–CO₂ insufflation pressure, morbidity–gas related complications only

be the best option due to its high solubility, low cost and noncombustibility.¹⁶

Due to lack of pre-existing anatomical cavity in the region, creation of a new space requires use of gas insufflation pressure as high as 20 mm Hg or prolonged low pressure insufflation. Various animal studies have been performed to study the hemodynamic and metabolic changes at different pressures of CO₂ insufflation in endoscopic neck surgery. CO₂ insufflation pressure of < 8 mm Hg is found to be safe in many studies.^{8,11,17} When higher pressure was required, the level lower than 15 mm Hg is recommended and the insufflation duration should be reduced to limit the complications.^{18,19} Ryoichi et al used a long subcutaneous dissector to create a subcutaneous space. After dissection, an insufflation pressure of 6 mm Hg was high enough to maintain the surgical space and also low enough to avoid significant CO₂ absorption through the subcutaneous tissue.²⁰ An anterior cervical approach using CIP of 10 mm Hg was described by Gagner et al.⁴ Palazzo et al reported the use of CIP of 8 mm Hg to maintain operative space and decrease the possibility of minor bleeds.²¹ A breast approach for ET with a low CIP of 4 to 6 mm of Hg was reported by Park et al.⁸ We used CIP of 12 to 14 mm Hg till the creation of working space and CIP of 8 to 10 mm Hg for maintenance of the created working space.

Complications unique to endoscopic neck surgery are mostly related to insufflation of CO₂ gas and CO₂ diffusion into the body tissues and spaces, which can lead to devastating consequences. Complications due to CO₂ may range from severe hypercarbia, subcutaneous emphysema, tension pneumothorax, pneumomediastinum, CO₂ embolism to cardiac arrhythmias and myocardial suppression.³⁻⁵ Excessive exposure of CO₂ can lead to diffusion and absorption of gas through available tissue planes to cause severe hypercarbia and other complications. Moreover,

massive subcutaneous emphysema may act as a reservoir for continuous CO₂ absorption leading to pneumomediastinum and pneumothorax.²² Murdock et al showed operative time of > 200 minutes and ET/CO₂ of > 50 mm Hg as independent risk factors for hypercarbia, subcutaneous emphysema, pneumothorax and pneumomediastinum.⁵ Glottlieb et al reported massive subcutaneous emphysema with severe hypercarbia and refractory supraventricular tachycardia in a case of endoscopic parathyroidectomy.³ Improved anesthetic and perioperative management were proposed to reduce the gas related complications. CO₂ absorption can be estimated with reasonable accuracy using indirect calorimetry during surgery.²⁰ Continuous ET/CO₂ monitoring with appropriate ventilatory adjustments ensures safe surgery, though ET is not recommended as a routine procedure.^{2,3} Hypercarbia and acidosis can be controlled by enhancing the ventilation rate and minute ventilation.²⁰ Some investigators suggested routine use of arterial blood gas (ABG) analysis for better monitoring of CO₂ levels.^{3,23,24}

CONCLUSIONS

CO₂ insufflation pressure (CIP) of 10 to 12 mm Hg for creation of working space and 6 to 8 mm Hg for maintenance of space during endoscopic thyroidectomy appears to be optimal. A protocol based on proper patient selection, intraoperative monitoring and intermittent CO₂ desufflation is desirable to ensure safe surgery with minimal gas related complications.

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