

## CASE REPORT

# TEE Effects of CO<sub>2</sub> Insufflation during Video-Assisted Thoracoscopic Thymectomy

<sup>1</sup>Andrew W Murray, <sup>2</sup>Stephen M McHugh**ABSTRACT**

Thymectomies have traditionally been performed via a midline sternotomy but are now increasingly being conducted via a thoracoscopic approach. Insufflation of CO<sub>2</sub> into the hemithorax during this procedure can create severe compression of the right atrium and ventricle with resultant hemodynamic instability as well as lead to hypercapnia with possible pulmonary vasoconstriction and right heart strain. Transesophageal echocardiography allows monitoring of both the effects of CO<sub>2</sub> insufflation on the heart and the efficacy of interventions to restore hemodynamic stability.

**Keywords:** Transesophageal echocardiography, Video-assisted thoracoscopic surgery, Video-assisted thoracoscopic surgery, Thymectomy, Pneumothorax.

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**INTRODUCTION**

Thymectomy via a midline sternotomy is the traditional surgical approach for thymomas. This approach provides wide visualization of the surgical field and allows exploration of structures adjacent to the thymoma. Recently, reports of thymectomy via video-assisted thoracoscopic surgery (VATS) have been described with the goals of reducing postoperative pain and speeding recovery and discharge. This approach utilizes CO<sub>2</sub> insufflation, typically into the right hemithorax, to displace the lung and to aid in dissection of anterior mediastinal tissue. An effect of pressurized insufflation of CO<sub>2</sub> into the hemithorax is creation of an iatrogenic tension pneumothorax with resultant obstruction of venous return and hypotension.

We report the case of a 64-year-old man with severe mitral regurgitation who was incidentally found to have a

thymoma during preoperative radiological imaging for a minimally-invasive mitral valve repair. Plans were made for a combined operation consisting of a VATS thymectomy followed immediately by a minimally-invasive mitral valve repair. Transesophageal echocardiography (TEE) was vital in assessing the cardiovascular effects of CO<sub>2</sub> insufflation during VATS thymectomy in addition to its use during the mitral valve repair. The patient provided consent for this report.

**CASE REPORT**

A 64-year-old man was scheduled for a minimally-invasive mitral valve repair due to severe eccentric regurgitation due to a flail P2 segment of the posterior mitral valve leaflet. His presenting symptoms consisted of mild dyspnea on exertion and sporadic chest burning but no impairment in his regular exercise routine. The patient's past medical history included only benign prostatic hypertrophy and he had no history of tobacco use or lung pathology. Preoperative testing included a normal chest radiograph and a cardiac catheterization showing 50% stenosis of the distal left main coronary artery, pulmonary artery pressure (PAP) of 53/28 mm Hg (mean PAP 39 mm Hg), and pulmonary wedge pressure of 25 mm Hg. Transthoracic echocardiography revealed a borderline dilated left ventricle (end-diastolic diameter [EDD] of 5.5 cm) with a 60 to 65% ejection fraction, normal right ventricular size and function (tricuspid annular plane systolic excursion [TAPSE] of 2.8 cm), a thickened and flail posterior mitral valve leaflet with severe eccentric regurgitation, severe left atrial enlargement, mild tricuspid regurgitation, and an estimated pulmonary artery systolic pressure of 39 mm Hg based upon the peak tricuspid regurgitant jet velocity. Additional workup for the surgery revealed a 3.9 × 3.0 cm anterior mediastinal mass on CT scan that was consistent with a thymoma. Discussion between the patient, his cardiac surgeon, and a thoracic surgeon resulted in a plan for a combined surgery consisting of a right-sided VATS thymectomy followed by a minimally-invasive mitral valve repair via right-sided thoracotomy. The left main coronary artery stenosis was deemed borderline hemodynamically significant by fractional flow reserve and the decision was made not to intervene upon it.

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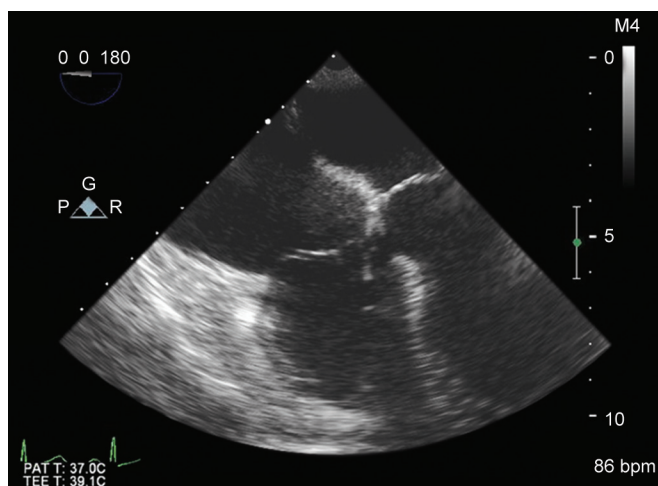
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On the morning of surgery, the patient was brought into the operating room and standard ASA monitoring was initiated. A left brachial arterial line was placed, intravenous induction of anesthesia was performed, and a 39-French left-sided double-lumen endobronchial tube was placed. Initial TEE examination revealed a dilated left ventricle (EDD of 6.3 cm) with an ejection fraction of 55%, non-compressed right atrium and right ventricle, normal right ventricular size and function (TAPSE of 2.6 cm), mild tricuspid regurgitation, a flail P2 segment of the mitral valve, and severe mitral regurgitation (Figs 1 to 3).

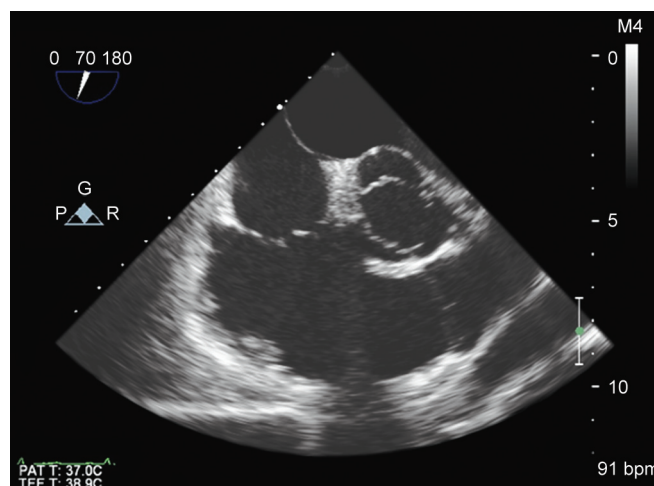
Isolation of the right lung and single-lung ventilation of the left lung was commenced to prepare for insertion of ports for the right-sided VATS thymectomy. Following uneventful port insertion and confirmation of isolation of the right lung, the patient's mean arterial blood pressure (MAP) was 70 mm Hg and oxygen saturation was 98%. Despite complete isolation of the right lung and adequate oxygenation,

the surgeon then requested resumption of double-lung ventilation. His stated reason for this request included his experience and comfort performing this procedure without the aid of single-lung ventilation and using insufflation of CO<sub>2</sub> alone as a means to displace the right lung from the operative field.

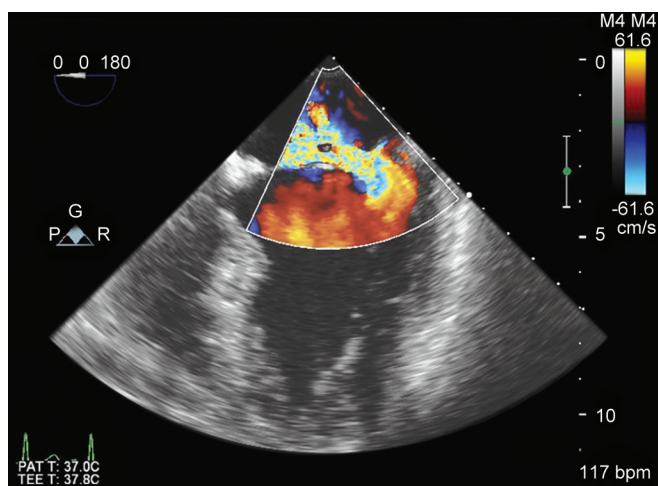
After resuming double-lung ventilation and starting insufflation of CO<sub>2</sub> at 10 mm Hg, immediate hypotension developed with the nadir of MAP reaching 42 mm Hg. Echocardiography revealed severe compression of the right atrium and right ventricle (Fig. 4). Central venous pressure monitoring was consistent with tension pneumothorax physiology as measurements rose from 8 mm Hg to 37 mm Hg after insufflation of pressurized CO<sub>2</sub>. A phenylephrine bolus was administered and the surgeon was notified of the patient's hypotension. CO<sub>2</sub> insufflation was stopped which led to immediate improvement in the patient's blood pressure. Insufflation of CO<sub>2</sub> was subsequently resumed,



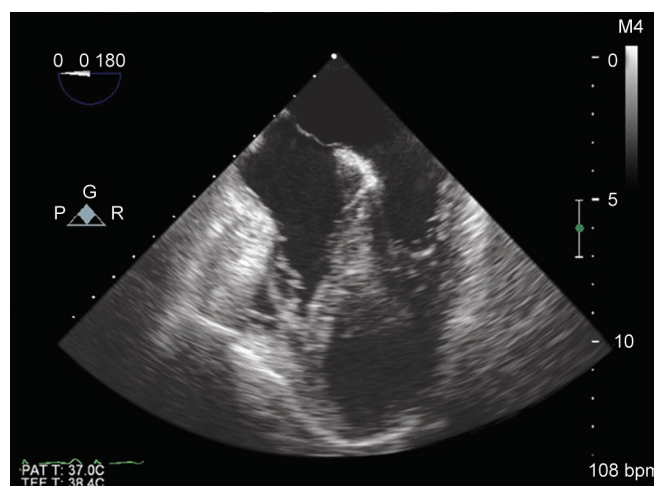
**Fig. 1:** Preoperative midesophageal four-chamber view showing left ventricular dilation and no compression of the right atrium or right ventricle



**Fig. 3:** Preoperative right ventricular inflow-outflow view showing normal right ventricular size and normal tricuspid valve morphology



**Fig. 2:** Preoperative midesophageal four-chamber view showing severe, eccentric mitral regurgitation



**Fig. 4:** Midesophageal four-chamber view during CO<sub>2</sub> insufflation of the right hemithorax showing severe compression of the right atrium and right ventricle

this time gradually increasing pressures until reaching a maximum of 6 to 8 mm Hg. Blood pressure was supported with an infusion of norepinephrine. Despite utilizing a lower insufflation pressure, TEE examination continued to show significant compression of the right atrium and right ventricle but left ventricular diastolic function remained normal with no shifting of the interventricular septum. Continued use of CO<sub>2</sub> caused the development of subcutaneous emphysema with the PaCO<sub>2</sub> peaking at >110 mm Hg and the EtCO<sub>2</sub> peaking at 92 mm Hg. At this time, the pulmonary artery systolic pressure was estimated at 33 mm Hg based upon the tricuspid regurgitant jet and the severity of tricuspid regurgitation remained mild as before CO<sub>2</sub> insufflation (Fig. 5). Minute ventilation was increased from 5 liters/min to 9 liters/min in response to this finding, but because the patient was hemodynamically stable and no longer requiring vasopressor support, the surgery was continued. No evidence of extension of the subcutaneous gas into the mediastinum was noted. Only after completion of the thymectomy and

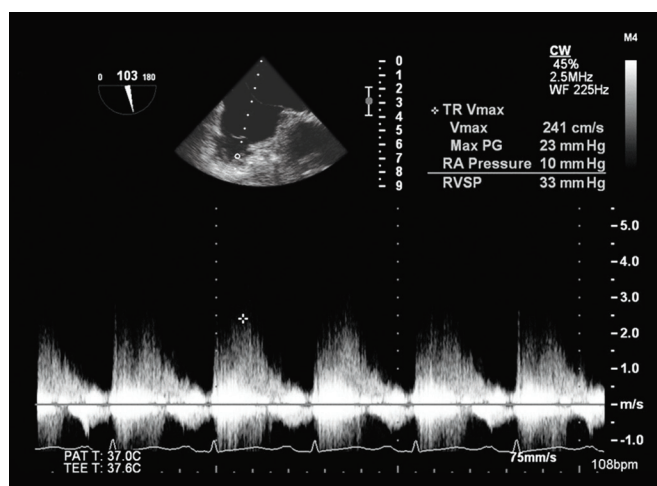
total resolution of CO<sub>2</sub> insufflation did the heart revert to its preoperative appearance.

Repair of the mitral valve was achieved without complications via a right thoracotomy utilizing single-lung ventilation of the left lung. Post-repair TEE showed a mitral annuloplasty ring with trace mitral regurgitation (Figs 6 and 7).

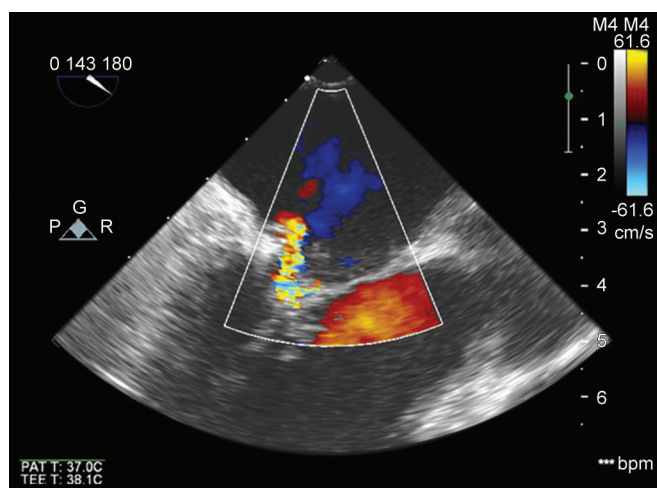
## DISCUSSION

Thymectomy has routinely been performed via midline sternotomy since its first description in 1936.<sup>1</sup> This approach has the major advantage of providing a large surgical field and easy access to all structures surrounding the thymus gland. Direct compression of mediastinal structures such as the innominate vein, superior vena cava, and right atrium with resultant hemodynamic instability is possible during this approach but easily rectified by the surgeon removing the offending instrument or hand.

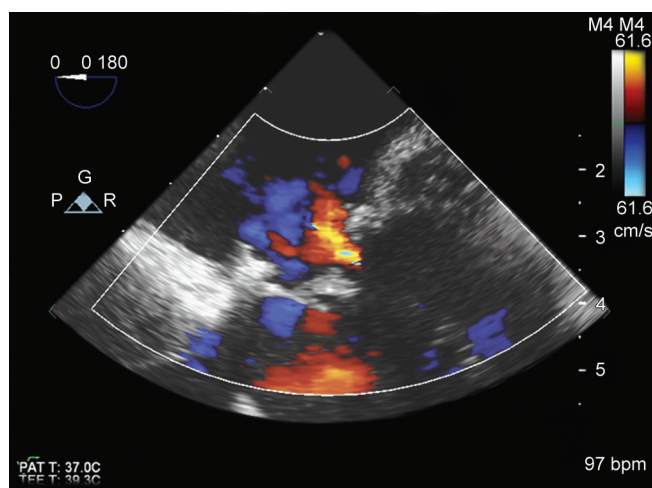
In 1992, the first thymectomy via a VATS approach was reported.<sup>2</sup> Interest in less invasive approaches for thymectomy was spurred by the desire to decrease postoperative pain, speed recovery, and shorten postoperative length of stay. This approach is generally reported to require single-lung ventilation and CO<sub>2</sub> insufflation.<sup>3-5</sup> Isolation of the ipsilateral lung aids exposure of the operative site while CO<sub>2</sub> insufflation at 10 to 12 mm Hg helps to compress the lung as well as aid in the dissection of anterior mediastinal connective tissue.<sup>3</sup> This technique has proven effective in reducing the postoperative length of stay, with one study reporting a reduction from an average of 4.3 to 2.3 days and another study reporting a reduction from an average of 4.3 to 2.4 days.<sup>3,6</sup> Despite the noted benefits of CO<sub>2</sub> insufflation for these procedures, it is not absolutely necessary and VATS for other indications is commonly performed without the use of CO<sub>2</sub>.



**Fig. 5:** Continuous-wave Doppler tracing of the tricuspid regurgitant jet showing estimation of pulmonary artery systolic pressure



**Fig. 6:** Midesophageal long-axis view after mitral annuloplasty showing only trace residual regurgitation



**Fig. 7:** Midesophageal four-chamber view after mitral annuloplasty showing trace residual regurgitation



Although VATS thymectomy has proven advantages, the hemodynamic management of patients during this approach can be significantly more challenging than during sternotomy. For any approach, the concern for compression of mediastinal structures from the thymoma itself after supine positioning or after administration of neuromuscular blocking drugs must be appreciated. However, CO<sub>2</sub> insufflation during a VATS approach creates another source of mediastinal compression as seen in our patient. Upon initiation of CO<sub>2</sub> insufflation in the right hemithorax at a pressure of 10 mm Hg, significant compression of the right atrium and right ventricle were immediately seen on TEE with hypotension and elevated CVP. Even after cessation of CO<sub>2</sub> insufflation and a gradual resumption to a lower pressure of 6 to 8 mm Hg, continued compression of the right side of the heart was seen with hypotension requiring vasopressor support. Single-lung ventilation may have allowed visualization of the anterior mediastinal structures without the use of CO<sub>2</sub> insufflation, however double-lung ventilation was utilized at the surgeon's request as this was his usual practice. In their review, Plummer et al describe complications associated with VATS procedures. These include rare events such as direct damage to the heart and massive hemorrhage from injury of thoracic vascular structures, and more common occurrences such as nerve injury from improper patient positioning, hypoxia due to single-lung ventilation, and hypotension from CO<sub>2</sub> insufflation.<sup>7</sup> The hypotension exhibited by this patient may have been exacerbated by relative dehydration due to an overnight preoperative fast. Very importantly, volume loading to treat reduced venous return and hypotension was relatively contraindicated in this patient. Although IV fluid administration is the standard temporizing measure for dealing with obstructive shock, this technique was not used due to concerns of worsening the patient's left ventricular dilation and severe mitral regurgitation.

During the procedure, subcutaneous emphysema developed and the patient developed severe hypercapnia. However, there were no echocardiographic signs of

pulmonary hypertension including no right ventricular strain, no increase in the patient's mild tricuspid regurgitation, and the pulmonary artery systolic pressure did not increase above preoperative values. As we had not placed a pulmonary artery catheter, TEE allowed monitoring of right ventricular function and estimation of pulmonary artery pressures during hypercapnia to rule out pulmonary artery hypertension with RV failure as the cause of systemic hypotension.

## CONCLUSION

This report describes the TEE changes that occur during CO<sub>2</sub> insufflation of the right hemithorax during VATS thymectomy and correlates them with their hemodynamic consequences. Insufflation of CO<sub>2</sub> creates right atrial and right ventricular compression with obstructive shock physiology. Although not seen in our patient, hypercapnia has the potential to increase pulmonary vascular resistance with resultant RV strain. Transesophageal echocardiography provides the ability to monitor these changes and the effects of therapeutic interventions.

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