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# –8 cm H<sub>2</sub>O, the new paradigm in chest drain management following thoracoscopic lung resection?

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## Key words

chest drain, intrapleural pressure, video assisted thoracoscopic surgery.

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## Abstract

**Background:** Chest drain suction of –20 cm H<sub>2</sub>O has been used universally after lung resection. After introducing new guidelines, –8 cm H<sub>2</sub>O was used routinely for all non-pneumonectomy, thoracoscopic lung resections. We conducted a review to determine outcomes and safety.

**Methods:** After introduction of the guidelines data were collected in the study institutions' thoracic surgical database and subsequently analysed.

**Results:** A total of 155 patients underwent thoracoscopic lung resection. Mean patient age was 61.5 ± 13.6 years. Video-assisted thoracoscopic surgery was performed in 92.2% (144/155) of patients and robotically-assisted thoracoscopic surgery was performed in 7.8% (12/155) of patients. Lobectomy was performed in 56.8% (88/155) of patients, segmentectomy was performed in 11.6% (18/155) of patients and wedge resection was performed in 31.6% (49/155) of patients.

Median ICC duration time was 1 day (IQR 1–3). Median length of stay was 3 days (IQR 2–6). For patients undergoing lobectomy median ICC time was 2 days (IQR 1–4.5) and median length of stay was 3.5 days (IQR 2–7), for segmentectomy median ICC time was 1 day (IQR 1–5) and median length of stay was 2 days (IQR 1–5) and for wedge resection median ICC time was 1 day (IQR 1–1) and median admission time was 2 days (IQR 1–4).

**Conclusion:** A suction level –8 cm H<sub>2</sub>O is safe to use for thoracoscopic lung resections from day 0 post-operatively. A dedicated, prospective study comparing levels of suction should be performed.

## Introduction

Whilst there have been numerous developments in Thoracic Surgery and post-operative care over the years, some things have remained stable. Intercostal catheters connected to some form of drain with a one-way valve have remained unchanged. Since the 1940s chest drains have almost universally been set to –20 cm H<sub>2</sub>O of suction,<sup>1</sup> despite numerous scientific developments that have shown normal intra-pleural pressure to be between 0 and –8 cm H<sub>2</sub>O.<sup>2,3</sup> Numerous studies have been performed to assess difference between higher and lower levels of suction post lung resection.<sup>4–6</sup> Whilst providing recommendations against the routine use of suction post-resection, current guidelines do not currently provide any clarity on what levels of suction – if any – should be used.<sup>7</sup> Air leak has traditionally been the most common barrier to chest drain

removal. Chest drain fluid output has been the area of the greatest area of evolution in chest drain management. Traditionally a fluid output of <300 mL/day would be the allowable volume for chest drain removal – given the estimated maximal pleural fluid absorption of 350 mL/day.<sup>3</sup> More recent recommendations have further increased this to <5 mL/kg/day.<sup>8</sup>

There is mounting evidence, which suggests higher levels of suction increase air leak duration and fluid volume production.<sup>4,6</sup> This in turn may result in prolonged hospital admission.

Based on the work of Mesa-Guzman and colleagues,<sup>9</sup> our institution changed its post-operative management criteria for all patients undergoing Video-Assisted or Robotic-Assisted Thoracoscopic Surgery (VATS or RATS) non-pneumonectomy lung resection. We conducted a review of the last 155 patients managed with a digital chest drain set at –8 cm H<sub>2</sub>O of suction.

## Methods

### Ethics

Human Research ethics was attained via study institution's Research Governance Unit (HREC LNR/17/MH/121).

### Patients

The new criteria for management of intercostal catheters (ICC) was instituted from September 2019. Our institutional thoracic surgery database was analysed and all patients who underwent non-pneumectomy pulmonary resection from September 2019 – January 2021 were included. The patients and public were not involved in the design, conduct and reporting of the research.

### Definitions

Re-insertion of an ICC was defined as the re-insertion of an ICC during the initial admission after the initial ICC that was placed at the time of surgery was removed. Thoracoscopic surgery was defined as surgery with any number of ports without rib spreading. Wedge resection was defined as non-anatomical sub-lobar lung resection. Segmentectomy was as an anatomical sub-lobar lung resection. Regulated suction was defined as providing a variable level of suction to maintain a set level of intra-pleural pressure. Fixed suction was defined as a continuous level of suction.<sup>2</sup> A prolonged air leak was defined as an air leak that lasted longer than 7 days.

### Statistical analysis

Data were sourced from hospital medical records and lung cancer databases. Statistical analysis was performed with STATA version 15 (Stata Corp, College Station, TX, USA). Unless otherwise stated, continuous data were summarized as mean  $\pm$  SD.

### Endpoints

The primary endpoint was ICC duration time. Secondary endpoints were length of stay and re-insertion of an ICC for any reason.

### Chest drain management protocol

Management of chest drains for all non-pneumectomy VATS and RATS lung resections were standardized for all thoracic surgical patients at our institution. All patients had a single ICC inserted at the time of surgery; however, the size of the ICC was surgeon dependant. The drains were all secured to the skin with a 0 silk stitch, however, a dissolvable 3–0 V-Loc™ (Medtronic, USA) stitch was used around the ICC as a purse string. Digital chest drains (Thopaz™, Medela AG, Switzerland) were used for all patients. A chest radiograph (CXR) was performed for all patients in the recovery room of the operating theatres to confirm drain position and lung re-expansion. All chest drains were set to a pressure of  $-8$  cm H<sub>2</sub>O. The chest drain was assessed at the morning ward round every day at 0700 and a decision would be made at the time to retain the drains or remove them. Air leak criteria for drain

removal was  $>6$  h of  $<20$  mL/min of air leak with three single allowable spikes of air leak  $>20$  mL/min (as measured every 10 min by the digital drain). Fluid criteria for drain removal was any volume of non-chylous fluid. If there was a chyle leak or a suspected chyle leak the ICC was retained.

## Results

A total of 155 patients underwent thoracoscopic lung resection from September 2019 to February 2021. Mean patient age was  $61.5 \pm 13.6$  years. A total of 51.0% (79/155) of patients were female. Video assisted thoracoscopic surgery (VATS) was performed in 92.2% (144/155) of patients and robotically assisted thoracoscopic surgery (RATS) was performed in 7.8% (12/155) of patients. Lobectomy was performed in 56.8% (88/155) of patients, segmentectomy was performed in 11.6% (18/155) of patients and wedge resection was performed in 31.6% (49/155) of patients.

Median ICC duration time was 1 day (IQR 1–3 days) for all patients. Median length of stay was 3 days (IQR 2–6 days) for all patients. For patients undergoing lobectomy median ICC time was 2 days (IQR 1–4.5 days) and median length of stay was 3.5 days (IQR 2–7 days). For patients undergoing segmentectomy median ICC time was 1 day (IQR 1–5 days) and median length of stay was 2 days (IQR 1–5 days). For patients undergoing wedge resection median ICC time was 1 day (IQR 1–1 day) and median admission time was 2 days (IQR 1–4 days).

The complication rate was 12.9% (20/155). There were no hospital mortalities. The rate of ICC re-insertion for pneumothorax was 1.3% (2/155). There were no ICC re-insertions for pleural effusions. A prolonged air leak was observed in 5.2% (8/155) of patients with 1.3% (2/155) requiring re-operation. A chylothorax was observed in 2.6% (4/155) of patients with 0.7% (1/155) requiring a re-operation for it.

## Discussion

With the introduction of digital chest drains for Thoracic Surgery at our institution there was a concerted effort among the three surgeons (later expanded to four half-way through the study period) to standardize ICC management. The greatest advantage the digital drains provided over the traditional underwater seal drains was the ability to regulate suction<sup>2</sup> and the ability to continuously monitor air leak.

To our knowledge, we are the first group to publish the use  $-8$  cm H<sub>2</sub>O of suction as routine for all lung resections from post-operative day 0. Holbeck and colleagues,<sup>4</sup> performed a randomized trial comparing  $-2$  cm H<sub>2</sub>O to  $-10$  cm H<sub>2</sub>O in patients undergoing VATS lobectomy. They found that the lower suction group had shorter ICC time, shorter air leak times and less pleural fluid production without subsequent changes in morbidity. We chose  $-8$  cm H<sub>2</sub>O of suction to correspond to normal maximal intra-pleural pressures at the end of inspiration.<sup>3</sup> This number was chosen for the balance of having sufficient negative pressure to allow the lung to fully expand whilst allowing air and fluid evacuation from the pleural cavity without subsequent exacerbations of air leak, given the evidence that suggests a greater incidence in pneumothorax in patients with underwater seal compared to chest tube suction.<sup>10</sup> Given the trend in the literature

**Table 1** Comparison of VATS lobectomy among multiple cohorts

|                       | Holbeck <i>et al.</i>  | Yaftian <i>et al.</i>  | Holbeck <i>et al.</i>   | Bjerregaard <i>et al.</i> | Pompili <i>et al.</i>   | Pompili <i>et al.</i>   |
|-----------------------|------------------------|------------------------|-------------------------|---------------------------|-------------------------|-------------------------|
| Number of patients    | 111                    | 88                     | 111                     | 622                       | 196                     | 196                     |
| Level of suction      | −2 cm H <sub>2</sub> O | −8 cm H <sub>2</sub> O | −10 cm H <sub>2</sub> O | −10 cm H <sub>2</sub> O   | −20 cm H <sub>2</sub> O | −20 cm H <sub>2</sub> O |
| Drain type            | Digital                | Digital                | Digital                 | Both                      | Digital                 | Analogue                |
| ICC duration (days)   | 1.1                    | 2                      | 2                       | 2                         | 3.6                     | 4.7                     |
| Length of stay (days) | 2                      | 3.5                    | 3                       | 4                         | 4.6                     | 5.6                     |

towards reduced levels of suction,<sup>11</sup> the next major avenue of research for us would be to compare lower levels of suction to our current data. Of specific interest was whether there was a change in ICC duration, length of stay or morbidity.

The decision was made to base the standardized protocol for ICC removal on the work performed by Mesa-Guzman and colleagues<sup>9</sup> at The Royal Brompton Hospital. They performed an analysis of increasingly permissive criteria for air leak and fluid output. They found that ICCs could be safely removed with an air leak of <20 mL/min over 6 hours, regardless of non-chylous fluid. We based our management criteria on this.

Among our cohort of 155 patients, only 2 (1.3%) required a re-insertion of an ICC. Both were for pneumothorax and both patients met the Mesa-Guzman criteria<sup>9</sup> for drain tube removal. Both patients were noted to have pneumothoraces and subcutaneous emphysema on their initial post-removal CXR. The decision to insert a drain was made when a subsequent CXR showed expansion of the pneumothorax. The rates of ICC re-insertion among this cohort were comparable to other published series as well as data from our own institution.<sup>4,12</sup> A pilot safety study performed at the introduction of digital chest drains in thoracic surgery at our institution demonstrated an ICC re-insertion rate of 3.2% (2/62) (one for pleural effusion and one for pneumothorax). All drains were set to a suction of −20 cm H<sub>2</sub>O during this trial period.<sup>12</sup>

When comparing our data to other published series, the primary and secondary outcomes are comparable. Bjerregaard and colleagues published a series of over 600 VATS lobectomies that were managed with digital chest drain suction set to −10 cm H<sub>2</sub>O. They had a median drain time of 2 days, median length of stay of 4 days and 4.8% incidence of chest drain re-insertion.<sup>13</sup> Pompili and colleagues performed a randomized control trial comparing digital to analogue chest drains in patients undergoing lobectomy and segmentectomy. In their digital chest drain group the suction was set to −20 cm H<sub>2</sub>O on post-operative day 0 and then set to −8 cm H<sub>2</sub>O from post-operative day 1. In the digital drain group they found a mean ICC time of 3.6 days and mean length of stay of 4.6 days.<sup>14</sup> A comparison of ICC duration and length of stay among patients undergoing lobectomy among the various described cohorts of patients with various levels of suction can be found in Table 1.<sup>4,13,14</sup> Whilst a formal comparative analysis has not been performed, there appears to be a trend towards decreased ICC duration and length of stay with lower suction.

## Conclusions

A suction level −8 cm H<sub>2</sub>O appears safe to use for thoracoscopic lung resections from day 0 post-operatively. Lower levels of

suction may result in reduced ICC duration and length of stay. A dedicated, prospective study comparing levels of suction should be performed.

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## Conflict of interest

None declared.

## Author contributions

**Phillip Antippa:** Conceptualization; investigation; methodology; writing – review and editing. **Nima Yaftian:** Conceptualization; data curation; formal analysis; investigation; methodology; writing – original draft. **Isabelle Ferrari:** Data curation. **Benjamin Dunne:** Conceptualization; methodology; writing – review and editing.

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