



## Stage of Respiration During Removal of Intercostal Catheters: A Review of Physiology and Literature

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### Abstract

Insertion of an Intercostal Catheter (ICC) is an accepted treatment for a pneumothorax (primary, secondary, traumatic or iatrogenic), haemothorax, pleural effusion or post thoracic surgery. Reinsertion of an ICC is the most common complication of removal, primarily due to recurrence of a pneumothorax. There are many guidelines for when to remove an ICC and criteria that must be met to reduce incidence of recurrent pneumothorax. However there is a significant lack of discussion regarding the exact procedure to remove an ICC, with specific focus on the stage of breathing required.

**Keywords:** Traumatic pneumothorax; Intrapleural pressure; H<sub>2</sub>O; Thoracic intrapleural pressure

### Introduction

During normal respiration, the pleural space is a closed system with a pressure that is negative, relative to the surrounding atmosphere. This negative pressure is maintained by the mechanical properties of the lung tissue, the chest wall, tensile forces of pleural fluid and lung surfactant [1,2]. The thoracic intrapleural pressure in a healthy upright lung at relaxed end-expiration lies between -3 cm H<sub>2</sub>O at the lung bases and -8 cm H<sub>2</sub>O at the apices. The mean intrapleural pressure is approximately -5 cm H<sub>2</sub>O. During normal physiological tidal breathing the mean intrapleural pressure is reduced further to -8 cm H<sub>2</sub>O at end-inspiration [2].

Thus, when removing an ICC, the clinician should aim for a minimal pressure gradient. Physiologically, this would mean that during forced expiration, enhanced by a Valsalva manoeuvre, the gradient would be decreased or possibly raise the intrapleural pressure above that of the atmosphere [3]. However, this places the patient in a position to draw a larger breath in, thus rapidly changing the pressure gradient and allowing for great entrainment of air into the pleural cavity.

This article aims to discuss the physiological basis for when to remove an ICC and review the current literature surrounding this topic.

### Literature Review

Articles were sourced from MEDLINE search using PubMed using search terms of "Tube thoracostomy removal", "Intercostal catheter removal" and "Chest Tube removal". Each search term was then used with "stage of respiration" added.

Articles were excluded on basis of relevance to topic, if they were a designed protocol or guideline, if primary outcomes were focussed on the equipment used or if the primary outcome did not assess the removal technique. Guidelines were sourced from Google Scholar and PubMed.

### Results and Discussion

143 articles were found using the above search method. Only 3

articles were deemed suitable based on the criteria. Cerfolio et al. published a randomised control trial in 2012 in which they attempted to determine the best technique for removal of an ICC post lung resection. This study found that of the 179 patients randomized to have their chest tube removed on full inspiration, 58 (32%) had a larger or new pneumothorax after chest tube removal and 5 (3%) required intervention or delayed discharge. Of the 163 patients randomized to have their chest tube removed on full expiration, 32 (19%) had a larger or new pneumothorax after chest tube removal [4]. Due to the results, this study was discontinued early and remains underpowered to provide significant statistical evidence.

Bell et al. conducted a similar study on 102 ICCs in 69 patients with traumatic pneumothorax requiring ICC insertion. Patients were randomised to removal at end inspiration or end expiration. Of 52 ICC removals at end inspiration, there were 4 incidences of recurrence. In 50 removals at end expiration, there were 3 incidences of recurrence [5]. This study found the stage of respiration to be equivocal.

Thitvaraporn et al. performed a randomised control trial in 2017 assessing whether the addition of a Valsalva manoeuvre reduced the rate of recurrence of pneumothorax. A party balloon was used as an adjunct to help patients perform an effective Valsalva. This study contained 48 patients, divided into 4 groups; Group A: classic inspired, group B: classic expired, group C: balloon-inspired; and group D: balloon-expired. Recurrence rates in Groups A and B were 15.4 and 16.8 respectively, compared to 0% in Groups C and D3. These results are limited by very small sample size and correlate to an incidence of only 2 patients in each group. While Valsalva manoeuvre may be of benefit, there is no difference between stages of respiration.

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None of these studies were able to demonstrate significance between stage of respiration on removal.

Guidelines on ICC removal reviewed were from the British Thoracic Society [6], the NHS [7], Nursing Standard [8], the Royal Children's Hospital [9] and The Agency for Clinical innovation [10]. Of the 5 guidelines reviewed, 4 recommended removal on exhalation, with or without Valsalva. Only the ACI guideline made no mention of stage of respiration, instead focussing on pinching the skin to seal off the tract [10]. Of note is that 4 of the reviewed guidelines all based their recommendations on the British Thoracic Society Guideline from 2016. In this guideline, no evidence is given to support their recommendation, nor is there any discussion of the underlying physiology.

## Conclusion

Removal of a chest drain is a common practice in any hospital. It has been a common and long held belief that removal on expiration, possibly with a Valsalva manoeuvre, is the safest and most effective method. However, this places the patient in a position to inhale rapidly and entrain air. There is currently no definitive evidence to provide a strong recommendation for the most effect method, however current guidelines that strongly recommend one method over the other should be regarded with caution.

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