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Research Article

Is Clamp Test Necessary in the Management of Spontaneous Pneumothorax?

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Abstract

Background: Spontaneous pneumothorax is a common condition. Although benign, it can be life-threatening. The main complication is recurrence noted in 20 - 60% of cases. The management of primary and secondary spontaneous pneumothorax remains controversial and many treatment options are available to the clinician, with thoracic drainage remaining the most common therapeutic modality.

Objective of the Study: To study the indication and the interest of the chest tube clamp test in the management of pneumothorax.

Methods: A survey of the practices allowed to carry out a mapping of the management of the drained patient with the concerned services reinforced and followed by a comparative prospective study on the spontaneous pneumothorax admitted to the pneumology service of Marrakech. Variables analyzed included; demographics, duration of chest tube drainage, number and size of pneumothorax recurrences, required interventions, hospital stay, morbidity and mortality.

Results: A total of 44 patients (90% male, mean age 45 years) was included in the study. In the PS group without clamping, there were fewer relapses, with a smaller mean pneumothorax size ($p = 0.01$) and fewer interventions were required ($p = 0.042$) with a shorter hospital stay ($p = 0.04$) compared with the clamp group. In the clamp group, pneumothorax recurrences tended to be greater ($p = 0.04$), a larger mean pneumothorax size and ultimately more interventions eventually required. Three cases involved patients with idiopathic spontaneous pneumothorax, while thirteen cases were secondary: emphysema bulla (6 cases), tubercular cavern (3 cases), neoplastic (2 cases) and one case each of PID and Histiocytosis X. No deaths were reported.

Conclusion: The clamp test is useless before the removal of the chest tube in the management of spontaneous pneumothorax in terms of recurrent pneumothorax.

Keywords: *Clamping; Chest Tubes; Spontaneous Pneumothorax*

Introduction

A pneumothorax is defined by the abnormal presence of air in the pleural cavity. A pneumothorax is said to be "spontaneous" when there is no precipitating factor of traumatic origin (penetrating thoracic wound, closed thoracic trauma, pleural breach by costal fracture) or of iatrogenic origin (subclavian catheterization, transparietal pulmonary puncture, trans bronchial biopsy, pleural puncture). Among spontaneous pneumothoraxes, a distinction is made between primary spontaneous pneumothoraxes (PSP) - formerly "idiopathic spontaneous pneumothorax" of the young subject - which occur in the absence of obvious underlying chronic respiratory disease, and secondary spontaneous pneumothoraxes (PSS) which reveal or punctuate the evolution of an underlying chronic respiratory disease [1].

Spontaneous pneumothorax is a common condition. Although benign, it can be life-threatening. The main complication is recurrence, which occurs in 20 - 60% of cases. The management of primary and secondary spontaneous pneumothorax remains controversial and many treatment options are available to the clinician, with thoracic drainage remaining the most common therapeutic modality.

Descriptions of pleural space drainage procedures date back to the time of Hippocrates. Despite the different techniques and devices used throughout history, the basic principles have not changed. Today, chest drainage remains among the most commonly performed procedures from the bedside to the operating room, from life-saving emergencies to postoperative chest drainage in elective surgery [2].

The feared complication following chest tube removal is recurrence of a previously resolved pneumothorax. A recurrent pneumothorax may be associated with premature chest tube removal (i.e. before complete lung re-expansion), occult air leakage, or air entering the pleural space during removal [3].

Removal of chest tubes with or without clamping should take into account the underlying lung disease, the presence or absence of a bronchopleural fistula, the history of pneumothorax, and the severity of the initial episode.

Once a chest tube has been inserted, the most appropriate time to remove it is usually a matter of discussion, as there is no strong evidence to develop evidence-based guidelines. Typically, chest tube removal policies are driven by personal preference and experience, influencing quite variable lengths of stay for the same procedures [4].

Chest tube insertion has its own morbidity, with published rates ranging from 9% to 25%. For example, misplaced chest tubes can lead to repeated attempts at placement, as well as pulmonary, vascular, and intraperitoneal injury. Similarly, published rates of recurrent pneumothorax after chest tube removal range from 2% to 24%, and reinsertion rates range from 1% to 6% [4].

Overall, the clamped chest tube provides a more definitive assessment of persistent occult air leaks and avoids premature removal, and it did not appear to have any adverse effects on patient safety. Further improvements in the clamping procedure may be needed, as some patients still require redrawing despite the absence of pneumothorax after a 6-hour clamping trial. Given these data, a prospective study with clamping is warranted to evaluate whether or not such a system can increase the rate of chest tube removal and decrease length of stay while maintaining patient safety.

This trial was developed on the premise that if a recurrent pneumothorax or tension pneumothorax developed within the planned 6-hour clamping window, it was possible to simply loosen the drain rather than place a new chest tube. There is significant debate regarding chest tube clamping.

An American College of Chest Physicians (ACCP) consensus statement, however, noted that although 41% of its group would not clamp a chest tube under any circumstances, the remaining 59% would consider a clamp test and radiograph before removing a chest tube [5]. Given the existence of this debate and the potential to minimize the need for chest tube replacement in cases of recurrent pneumothorax, we felt that a study within our department and our own data was warranted.

Patients and Methods

Study objective:

- To determine the value of the clamp test in the management of pneumothorax: the rate of pneumothorax recurrence with or without clamping.
- Analyze the impact of the clamp test on the cost of care:
    - Length of hospital stay
    - The number of chest X-rays and radiation treatments undergone

- The need for and number of painkillers taken
- The number of interventions performed
- Morbidity and mortality.

Study methodology

Survey of practices

The study was restricted to those departments that were likely to be responsible for the installation and/or monitoring of drainage, identified by a minimum annual consumption of drainage systems.

The analysis of the practices has allowed us to carry out a mapping of the management of the drained patient with the concerned services. The audit was carried out by us with all the health professionals concerned (pulmonologists, thoracic surgeons, resuscitators and emergency and disaster physicians) at the regional and national level (during the national congress of the Moroccan Society of Pneumology). The collection grid was tested and validated before implementation. Its items cover the key stages of thoracic drainage, such as the main indications for its implementation, the clamping test and the removal of the drain. An analysis of the differences between the observed practice and the desired practice was carried out at a distance.

Prospective comparative study

On the basis of the results of the analysis of practices conducted in the services and the opinion of local experts, and after review of the literature and in particular international recommendations, we proposed to develop a comparative prospective study on the place of the clamping test in the management of pneumothorax, its interest in the identification of sub-clinical minimal air leaks, its impact on the cost of care and to determine its risks, in order to standardize practices and to improve the quality of the care provided.

Patient selection

Inclusion criteria: Patients included in the study were:

- All patients hospitalized in the pneumology department of ARRAZI Hospital, CHU Mohammed VI, during the study period for a secondary or primary spontaneous pneumothorax requiring thoracic drainage.

Exclusion criteria:

- Traumatic or iatrogenic pneumothorax
- Pneumothorax not requiring thoracic drainage
- Patient refusal.

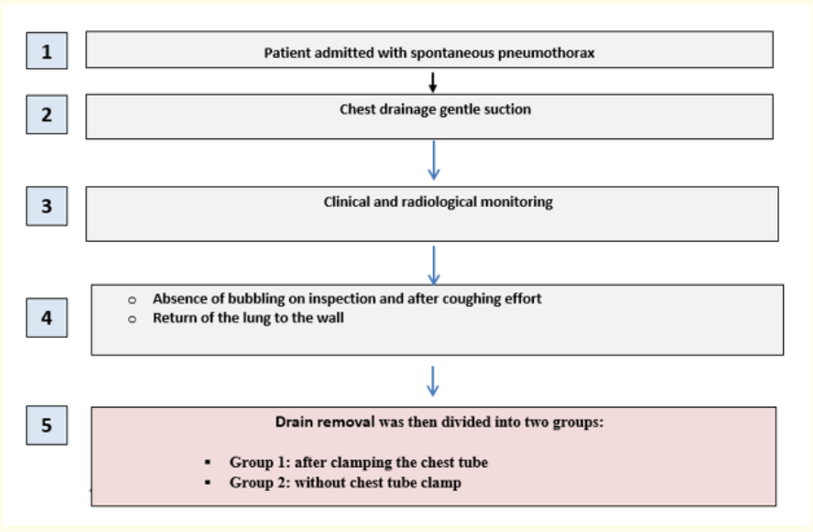


Figure 1

Statistical analysis of data: Qualitative data were expressed as numbers and percentages, and quantitative data as mean values ± standard deviation and medians with extreme values. The rate of correct answers was also compared question by question. A «p-value» < 0.05 was considered significant.

Ethical considerations: Patient consent was obtained prior to inclusion in the work and prior to performing chest drainage.

Clinical data collection was conducted with respect to patient anonymity and confidentiality.

Results

Practical survey

The overall response rate was 74.5% (82/110), the majority of responders were pulmonologists 73% followed by both thoracic surgeons and resuscitators 5% then 2% for emergency physicians, almost half of them practicing in university hospitals, the average frequency of thoracic drainage was 3 times/month, the most encountered incidents during thoracic drainage were dominated by subcutaneous emphysema. The average optimal duration of drainage was 5 to 7 days in 45% of cases.

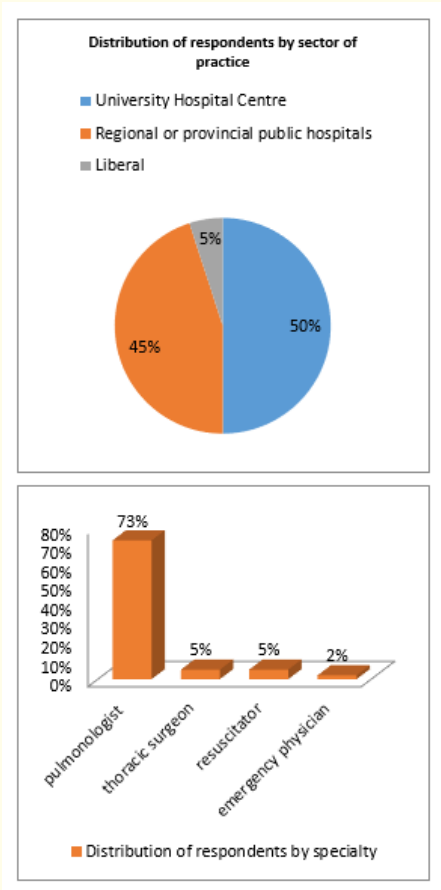


Figure 2

The notion of the chest tube clamping test allowed us to divide the responders into two groups; G1: for clamping (n = 72) and G2 against clamping (n=10): according to the specialty, the pneumologists were 54 for VS 6 against, i.e. a p = 0.32.

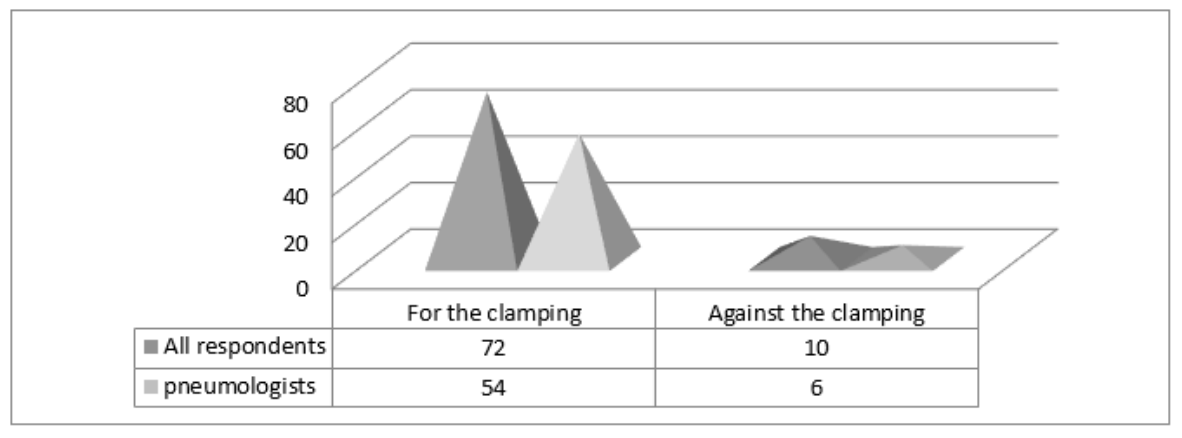


Figure 3

The elements taken into consideration to indicate or not a clamping of the drain were: the presence of a sub-adjacent pulmonary pathology (G1:35 VS G2 5 that is to say a p = 0,003), the absence of a sub-adjacent pulmonary pathology (G1:31 VS G2 5 that is to say a p = 0,0007) and the recurrence of the pneumothorax (G1 : 40 VS G2 : 0 that is to say a p = 0,009 a very significant difference).

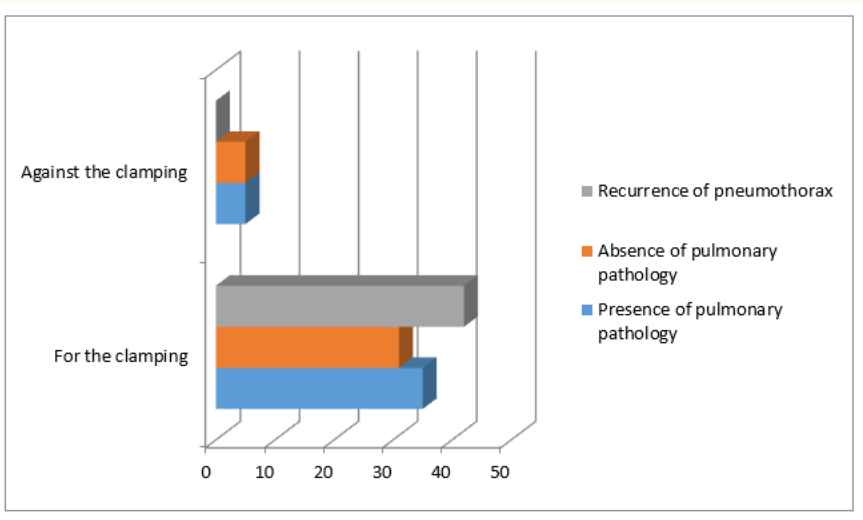


Figure 4

The ideal duration of clamping was 48 hours in 43% of cases. In case of detachment after clamping, 72% of those questioned were in favour of declamping and 27% in favour of another drainage, preferably anterior. 77% of those who responded had resorted to clamping after the recurrence.

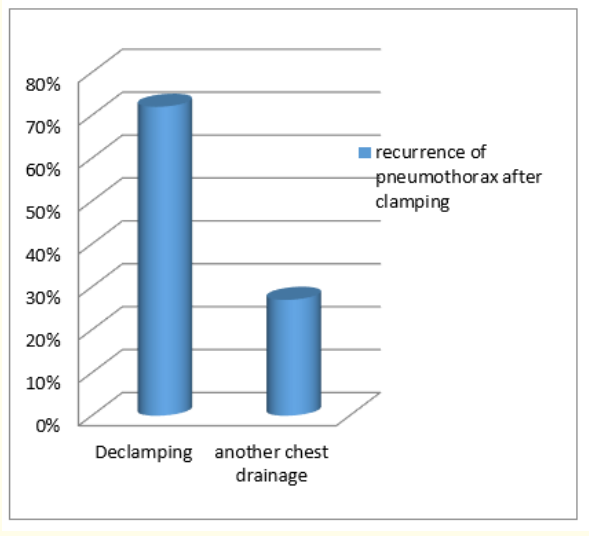


Figure 5

The control chest X-ray was indicated in 100% of the cases G1 VS 2% G2, according to the responders the removal of the chest tube depends on several conditions in particular: the return of the lung to the wall (90%), absence of bubbling (51%) and clinical improvement (19.5%).

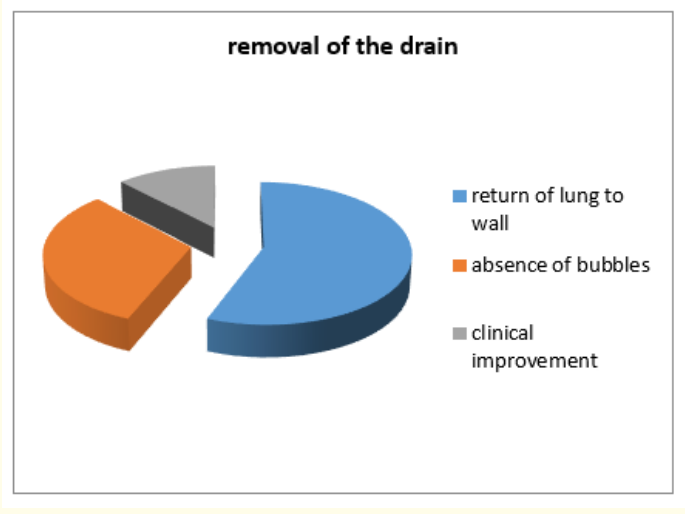


Figure 6

According to our practitioners, a national consensus regarding the chest tube clamping test should be established.

Prospective study

General characteristics

The study population included forty-four patients (22 in each group). No subjects were dropped or lost at any time during the study.

The mean age for the entire patient sample was 46 years. The minimum age was 18 years and the maximum age of the subject was 74 years.

There were 44 (90%) male patients, while 4 (9%) were female, with a male/female ratio of 11:1.

Active smoking was observed in 32 patients (72%) with an average consumption of 50.5 packs per year, cannabis use in 15 patients (34%) and occupational exposure was identified in 16 patients (36.3%), predominantly to silica.

The two groups were equal in size and nearly comparable in terms of clinical characteristics of patients (Table 1).

Study population (N = 44)	The average	Group 1: with drain clamp (N = 22)	Group 2: without clamping (N = 22)
Age	46 years old	43 years old	46 years old
Type	44 M / 4 F	21H / 1F	19 H / 3F
Intoxication	Active smoking (72%)	17	15
	Cannabis use (34%)	7	8
	occasional exposure (36%)	10	6
Etiology pneumothorax	Blebs (13.6%)	0	6
	Emphysema bulla (67%)	18	11
	Tubercular cave (9%)	2	2
	Neoplastic (6.8%)	1	2
	Other (4.5%)	1	1

Table 1

The comparison of the frequency of recurrent pneumothorax in the two groups was found to be statistically significant, the p-value was 0.04 (Table 2).

Frequency of recurrent pneumothorax	Group 1	Group 2	The p-value
Yes	7 (31%)	2 (9%)	0.04
No	15 (68%)	20 (90%)	

Table 2

Seven out of twenty-two patients (31%) in group 1 developed recurrent pneumothorax requiring clamp release, while in group 2, two out of twenty-two patients (9%) required a second chest tube placement due to the development of recurrent pneumothorax.

Recurrent pneumothorax	Group 1 (N = 22)	Group 2 (N = 22)	The p-value
Frequency	7 (31%)	2 (9%)	0.04
Size	Partial 1 (5%)	Partial 0	0.31
	Total 6 (27%) of which 3 are live	Total 2 (9%)	0.011
Interventional gesture	Declamping: 7 (31%)	Thoracic redrainage: 2 (9%)	0.042
	Another chest drain, preferably anterior: 3 (13.6%)		

Table 3

Analgesic consumption was assessed by the use of different levels of analgesics during the hospital stay. There was no significant difference in pain assessment. On the other hand, there was a significant difference in the consumption of analgesics in group 1 (with clamping of the thoracic drain) compared to group 2 (p = 0.041) according to the choice of treatment.

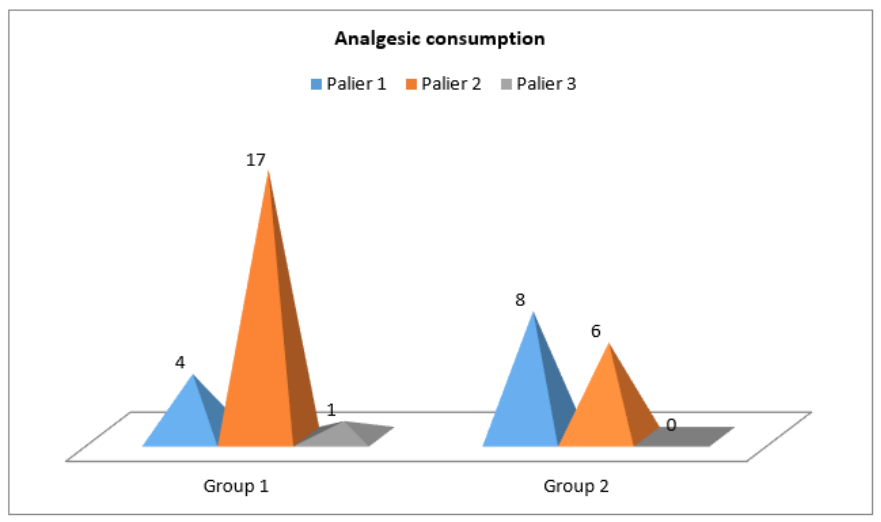


Figure 7

A single chest x-ray exposes the patient to about 0.1 mSv. The risk of low-level radiation exposure is not easily calculated from these studies. Because radiation exposure from all sources can add up and radiation can, in fact, increase the risk of cancer, imaging tests using radiation should only be done for a good reason.

Cumulative irradiation identified by the average number of chest X-rays performed was more marked in group 1 with an average of 8 compared to 4 for group 2.

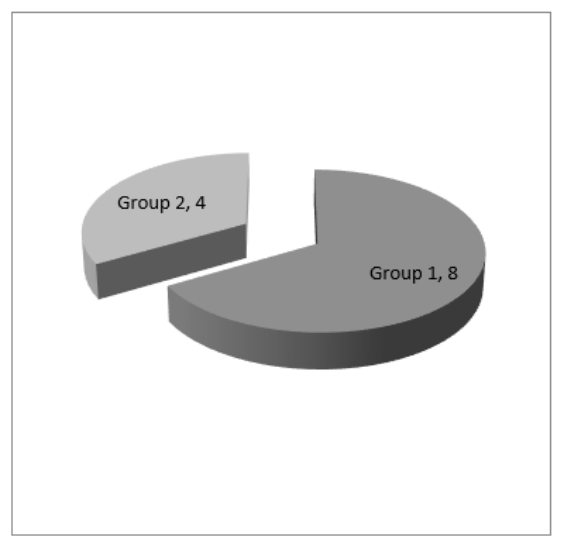
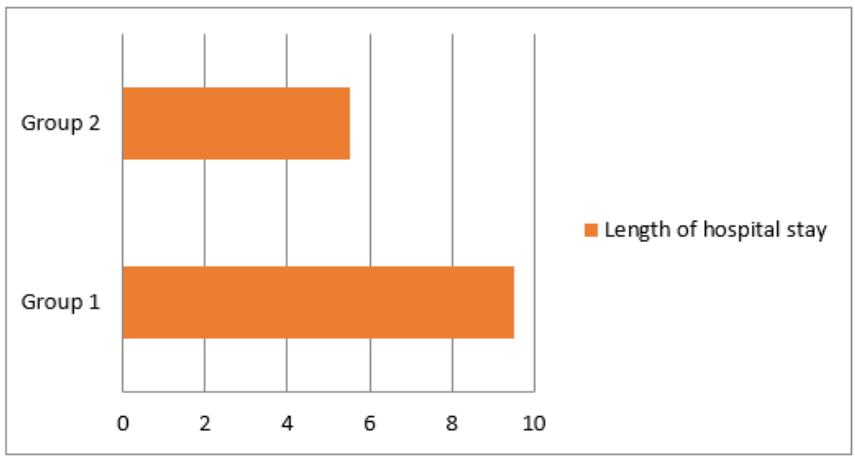


Figure 8

The average length of hospital stay was observed to be longer in group 1 (with chest tube clamp) with an average of 9.5 days compared to 5.5 days for group 2 (without clamp).



Length of hospitalization	Group 1	Group 2	p
	9,5	5,5	<0.04

Figure 9

No deaths or other complications were described during our study.

Discussion

In a tension pneumothorax, air continues to leak into the pleural space until the pleural pressure increases to the point that it compresses the veins and interferes with right heart venous filling. With a functional chest tube in place, either on water seal or suction, such a complication cannot develop. However, when the chest tube is clamped, there is no escape route for air and the positive pressure necessary to produce tension physiology can develop.

Therefore, before removing a chest tube placed for a pneumothorax, it is important to ensure that any air leakage (from the lung into the pleural space) has stopped. This is usually checked over a period of hours or days by placing the chest tube in a bucket of water, seeing no air bubbles through the bucket of water, and obtaining a chest x-ray that shows the lung is still inflated (at the wall). At this point, some remove the chest tube and monitor the patient. However, some experts argue that a safer approach is to clamp the chest tube and closely monitor for recurrence of the pneumothorax. That way, if the pneumothorax recurs, one can simply unclamp the chest tube and avoid having to place another one.

There are few guidelines and even fewer trials on when and how to safely remove a chest tube. The British Thoracic Society recommends that chest tubes not be clamped before removal (grade B evidence), arguing that there is no significant difference in chest tube reinsertion rates when comparing chest tube removal with and without clamping trials. In contrast, the Belgian Respiratory Society recommends a few hours of clamping followed by a chest x-ray when there is doubt about the safety of removal (grade D evidence). The American College of Chest Physicians convened a group of experienced clinicians to make their recommendations; 53% of the group would never clamp a chest tube before removal, while 47% would. Regardless, the majority of the group (62%) in this report would obtain a repeat chest radiograph 5 to 12 hours after chest tube removal [5-9].

Literature studies	For the clamping test	Against the clamp test
ACCP consenus DELPHI [5]	47%	53%
BTS consenus [6]	0%	100%
Baumann and Strange [9]	67%	27%
Our series	87%	12%

Table 4

In the absence of consistent clinical guidelines on chest tube removal, it is not surprising to find variability in practice among clinicians. The article by Huggins John., *et al*. (to Up To Date) on this topic acknowledges the lack of data and recommends a clamping trial if there is any doubt about the tightness of an air leak (or for all patients on positive pressure ventilation, which increases the likelihood and risk of an air leak). During a clamp test, closely monitored for clinical signs of air accumulation, such as hemodynamic instability or respiratory difficulty, is recommended [10].

Based on experience and evaluation of the literature according to Lekshmi Santhosh and colleagues recommends initiating a clamp trial only after the chest tube has been off (i.e. sealed with water) for a period of time without recurrence of the pneumothorax. We also recommend that the clamp on the chest tube be secured outside of the bedding in view of the medical team. In addition, if there is any sign of tachypnea or hemodynamic instability, the chest tube should be loosened immediately, even before ordering a repeat chest x-ray or initiating a rapid response team. Responsibility for ordering the chest radiograph and following up on its results should be clearly delineated to avoid assumptions and gaps in communication [4].

Factors contributing to the error in this case include the lack of clear guidelines for chest tube removal, such as assigning responsibility for monitoring the patient and obtaining and verifying the follow-up chest radiograph. In such situations, checklists may be useful. Checklist-type protocols have been published to help guide nurses in the timing of chest tube removal. Funk and colleagues have described a chest tube care pathway that outlines an algorithm for safe chest tube removal, including the frequency of monitoring during a clamping trial.

Within hospitals, various stakeholders such as pulmonologists, intensivists, thoracic surgeons, interventional radiologists, and nurses should work together as a multidisciplinary team to develop a uniform chest tube management policy to avoid conflicting advice to primary care teams. Because physicians or nurses may remove chest drains, guidelines should clearly state who has this responsibility [11-14].

Clamping a chest tube can be dangerous if there is bubbling, indicating a bronchopleural breach. A clamped chest tube is equivalent to no chest tube at all and is at risk of tension pneumothorax, if a recurrence occurs and a bronchopleural breach exists. In case of cessation of bubbling and complete re-expansion, the interest of clamping the drain before its removal has not been demonstrated. The technique for removal of a chest tube is not codified, but the active expiration of the patient (Valsalva maneuver) and the suctioning of the tube, in order to avoid the entry of air from the outside to the inside and to allow the aspiration of clots and fibrin during the extraction, are reported and of good sense.

Frequency of recurrent pneumothorax	Clamp test group	Group without clamp test
Geoffrey A., *et al*. [14]	13 (9,7%)	5 (4,6%)
Muhammad Rashee., *et al*. [15]	9 (10.0%)	4 (4.5%)
Tashfeen Imtiaz., *et al*. [16]	4 (0,15)	18 (0,67%)
Our series	7 (31%)	2 (9%)

Table 5

Published rates of recurrent pneumothorax vary from 2% to 24%, which in our study was 20%, which is considerably similar. This can be attributed to the adherence to standardized ablation method in which meticulous attention must be paid to avoid pneumothorax at the time of ablation, which emphasizes that the procedure of drain removal should have the same importance as the insertion procedure. However, careful attention should be paid to other factors that may play a role in preventing recurrent pneumothorax after ablation. These factors may include prompt removal, immediate occlusion of the drain insertion site, suturing the wound with a pre-positioned holding suture, and the role of an experienced hand in removing.

In terms of the literature, a frequently cited approach called the "clamp test" is described in a letter to the editor of the Annals of Thoracic Surgery as a way to manage patients with a prolonged air leak. But one of the best resources is a letter to the editor of Chest in which an author favors clamping and provides 8 references to support his position. In response, the author of the original article replies with 5 references that support not clamping the drain.

The discomfort caused by a clamp for 24h would be less than a second chest tube insertion after a relapse. If the chest tube did not work (no water column movement and no air leak) overnight, then it can be considered as well as a clamp, and it can be removed if the lung is fully dilated clinically and radiologically. A clamp for 12 to 24 hours before drain removal is one aspect of the authors' view of patience in the management of pneumothorax. How could a chest tube be dangerous in a patient with a possible tension pneumothorax? Once the chest tube is clamped and if the patient is suddenly short of breath, the only thing to do is to remove the clamp and carefully observe vital parameters. Indeed, in the case of a clamped chest tube, the patient and staff on duty should be asked what action to take

as soon as shortness of breath occurs. If symptoms of tension pneumothorax can occur after a clamp, why not when the chest tube is removed? This point needs to be clarified [17].

I appreciated the opportunity to read Dr. Gupta's comments on pneumothorax objected to the policy of removing the pleural drain without clamping it for a number of hours. In addition, he incorrectly suggested that we remove the drain immediately after drainage is stopped, without waiting 24h. To support his preference to clamp the drain, he cited several authors who favor clamping. However, this controversy cannot be resolved by a democratic referendum. The decision "to clamp or not to clamp" must be clinically based on experience, not on voting. There is no logic in clamping a drain that has not drained for several hours. When the drainage stops, the drain is left for 24 hours before removal. However, since a clamped drain is useless, it should be left unclamped. While pulmonologists and thoracic surgeons may favor clamping, there is no scientific evidence to support it [18].

The present study by Yan., *et al*. demonstrated that chest tube clamping can reduce the duration of chest tube drainage and shorten postoperative hospital stays (5.7 ± 1.8 vs. 6.4 ± 1.8 days) without causing adverse effects. This finding may be explained by Starling's revised law: absorption and lymphatic drainage increase with increasing interstitial hydrostatic pressure, which occurs when the chest tube is clamped [19]. This is in contradiction with the results of our study, which showed a longer hospital stay for the clamped group.

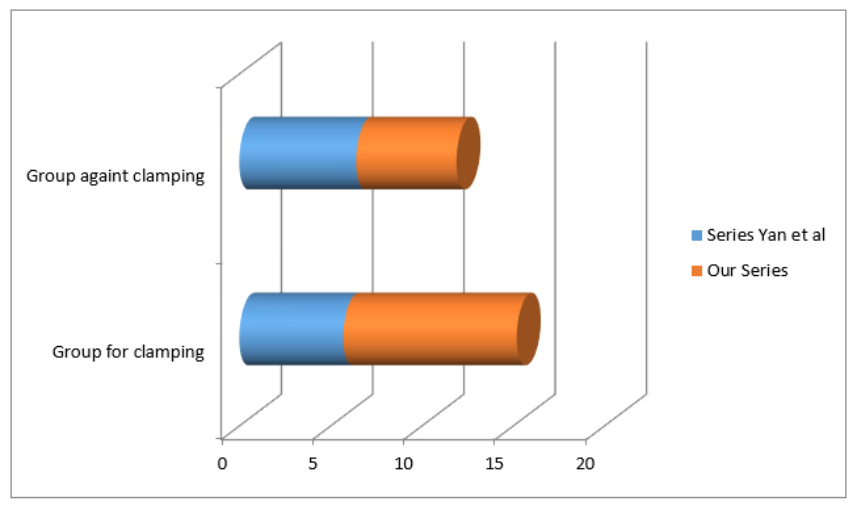


Figure 10

Chest tubes are removed when they reach their predefined therapeutic goals or when they become non-functional. In patients with pneumothorax or following thoracic surgery, a clamp test and chest x-ray prior to chest tube removal is not required to detect a recurrent pneumothorax, provided a digitally recorded drainage device shows that the patient is not leaking air. Acceptable airflow rates for chest tube removal are less than 20 ml/min for 8 to 12 hours when no suction is applied, or less than 40 ml/min for 6 hours, according to other authors.

There are no standardized guidelines and, especially for the assessment of air leaks, chest tube management is usually a matter of individual experience; therefore, disagreement between observers is common. Finally, an apparent air leak may be related to a pleural

space effect, and in this case, a clamp test should be performed to rule out small occult air leaks before removal. To date, few studies have been performed to evaluate the clinical impact of digital drainage systems. Previously published studies have shown that electronic drainage systems reduce interobserver variability, allowing earlier chest tube removal and reducing hospitalization time and costs. Brunelli., *et al*. indeed demonstrated a decrease in length of stay by 0.9 days (5.4 vs. 6.3 days) when comparing digital and traditional systems, allowing a decrease in postoperative costs of €476 per patient (€2391 vs. €2867). In addition, Cerfolio and Bryant showed a decrease in length of stay of 0.7 days (3.3 days vs. 4.0 days) comparing digital and traditional systems, with a mean day for chest tube removal of 3.1 vs. 3.9 in favor of the digital system. These studies highlight the potential clinical utility and impact of electronic drainage systems [20,21].

Conclusion

In the spontaneous pneumothorax with clamping group, there were more relapses with a larger mean pneumothorax size and more interventions eventually required, with a longer hospital stay compared with the group without clamping.

This study revealed that the unnecessary ritual of the pre-ablation clamp test should be avoided during chest tube removal in patients with spontaneous pneumothorax.

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