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TITLE: Chest tube management after surgery for pneumothorax

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Key Points: management of chest tubes after lung resection; Suction vs. no suction; regulated suction; management of chest tube after surgery for pneumothorax; regulated suction and recurrence

Synopsis:

There is scant evidence on the management of chest tubes after surgery for pneumothorax. Most of the current knowledge is extrapolated from studies performed on lung cancer patients.

We reviewed the existing literature on this subject with particular focus on the effect of suction and no suction on the duration of air leak after lung resection and surgery for pneumothorax.

Moreover, we discussed the role of regulated suction, which seems to provide some benefit in reducing pneumothorax recurrence after bullectomy and pleurodesis.

Finally we provided a personal view on the management of chest tubes after surgery for pneumothorax.

1. Management of chest tubes after lung resection

A. Suction vs. no suction

There are relative pros and cons in using suction versus no suction. Theoretically, suction promotes pleura-pleural apposition favoring the sealing of air leak and certainly favoring the drainage of large air leaks. However, suction has also been shown to increase the flow through the chest tube proportional to the level of suction applied (1) and it is assumed that this increased airflow increases the duration of drainage. Further, the use of suction has also historically, been associated with reduced patient mobilization, particularly if wall suction is used. On the other hand, the so called “no suction” or “alternate suction” approaches have been shown to be effective in some circumstances to reduce the duration of air leak (2,3,4), presumably by decreasing the air flow, whilst also favoring mobilization (since the patient is not attached to the wall suction). Nonetheless, the absence of suction makes this approach ineffective in case of medium to large air leaks (particularly in the presence of a large pneumothorax) (2) and to be associated with an increased risk of other complications (particularly pneumonia and arrhythmia) (5).

Table 1 summary of the findings of the randomized trials published on suction versus no suction in lung resection patients.

As evident from the table, these trials yielded mixed results. Some authors found a benefit by using “water seal” (2,3,7), others did not find any difference between the two modalities (5,6).

The lack of objective data for more sensitive measurement of air leak severity has prevented the standardization of studies, and even test and control groups within studies, resulting in a lack of accurate quantification and reproducibility.

B. Regulated Suction

Some new electronic chest drainage systems are now able to measure the pleural pressure. There is scant evidence on the role of pleural pressure on the healing of the lung parenchyma after surgery and duration of air leak.

A recent paper has shown that the difference between minimum pressure and maximum pressure calculated from measurements taken during the 6^{th} postoperative hour following lobectomy was associated with the duration of air leak and the risk of a prolonged air leak (8).

More than half of patients with an airflow greater than 50 ml/min and a differential pressure greater than 10 cmH2O developed an air leak longer than 3 days.

There seems to be therefore the potential to influence the duration of air leak by altering the intrapleural pressure.

New digital drainage systems have the capability to deliver a regulated suction, which is a suction variable according to the feedback received from the pressure measurements in order to maintain the preset level of negative pressure. In other words these machines work to maintain a stable intrapleural pressure regardless the volume of air leak, minimizing the oscillations around the preset value.

Modern chest drain devices, which are able to apply regulated suction to maintain the pre-set intrapleural pressure, represent the ideal instruments to reliably assess the effect of different level of negative pressures on the duration of air leak (9).

They may overcome the main limitation of previous trials using traditional devices and comparing suction versus no suction: the impossibility to control whether the preset level of suction was indeed maintained inside the chest.

In this regards, a recent randomized study assessed the effect of different levels of pleural pressure on the duration of air leak under controlled conditions by using a regulated chest drainage system (10).

One hundred patients submitted to pulmonary lobectomy were randomized to receive two different types of chest drainage management: Group 1, regulated individualized suction mode, with different pressure levels depending on the type of lobectomy and ranging from -11 cm H2O to -20 cm H2O based on a previous investigation (11); group 2, regulated seal mode (-2 cm H2O). At this low level of suction the system used worked only to compensate the occurrence of values more positive than -2 cm H2O in case of air leak. Otherwise, it worked passively as a regulated, no suction device. The average air leak duration and the number of patients with prolonged air leak were similar between the groups, showing that regulated seal is as effective and safe as regulated suction in managing chest tubes following lobectomy.

More investigations are warranted to further clarify the role of intrapleural pressure on the recovery of lung parenchyma after surgery.

2. Management of chest tubes after surgery for pneumothorax

A. Suction vs. no suction

There is really scant evidence regarding the management of chest tubes after surgery for PSP. Whilst there seems to be consensus on the preferred surgical approach, videoassisted thoracic surgery (VATS), to perform bullectomy and pleurodesis, there are few studies investigating the effect of different drainage modalities on the occurrence of pneumothorax recurrence, which is the main outcome in these patients.

Recent guidelines do not recommend the systematic use of suction in all patients treated for PSP but only in those who show failed lung re-expansion after drainage (12,13).

It has been shown that the presence of a residual pleural space after surgery may be one of the factors associated with increased risk of recurrence (14).

In a series of more than 400 patients operated on for primary or secondary spontaneous pneumothorax, Gaunt and coll. found an incidence of residual apical space after chest tube removal of 30%. Residual apical space was associated with 1 day longer duration of chest tube and 1 day longer hospital stay compared to those without residual apical space. More importantly, a residual apical space was the only factor associated with recurrence of pneumothorax after logistic regression analysis. Patients with a residual apical space at discharge had an incidence of recurrence of 11.6% vs. 4.4% of those without it ($p=0.005$).

One possible hypothesis to explain the association between residual pleural

space and recurrence of pneumothorax may be the failed pleurodesis due to lack of pleura-pleura apposition.

The concept of applying suction to promote parietal to visceral pleura apposition and favoring the sealing of air leak by promoting pleurodesis is the same discussed in several studies comparing suction versus no suction after lobectomy.

Indeed, Varela and coll. (15) have shown that applying suction to chest drainage after uncomplicated upper lobectomy is capable to reduce the differential pleural pressure (difference between inspiratory and expiratory pressure values). This is likely explained by a reduction in volume of the residual apical pleural space, allowing for a decreased inspiratory pressure to achieve lung expansion.

Under this point of view it appears logic to apply some level of negative pressure to the chest tube after bullectomy and pleurodesis operation for PSP.

A recent meta-analysis has shown no clear difference between suction and no suction in terms of air leak duration, chest tube duration and hospital stay with very low level of evidence quality. The only endpoint with a moderate level of quality evidence was the reduction in the incidence of residual pneumothorax when suction is applied after lung resection (16).

To the best of our knowledge however there is only one study that compared suction versus no suction after bullectomy and pleurectomy for PSP.

Ayed and coll (17) randomized 100 patients to either suction (-20 cmH2O) or no suction after VATS bullectomy and pleurodesis. They found that patients managed with chest tube connected to suction had a 1 day longer chest tube

duration and hospital stay and higher incidence of prolonged air leak compared to those wit chest tube managed without suction. In particular those with suction had a prolonged air leak incidence of 14% vs. 2% in those without suction (p=0.03). The authors reported only 2 recurrences of pneumothorax, a too small number to perform a reliable comparison between suction and no suction.

B. Regulated suction and recurrence

There is only one study evaluating the effect of the application of a regulating suction device in the management of chest tubes after bullectomy and pleurodesis for PSP (18). This was a retrospective analysis including 174 consecutive patients operated on for PSP by uniportal VATS and submitted to bullectomy and mechanical pleurodesis in two centers. Patients chest tubes were managed either by applying external wall suction for 48 hours or by using an electronic chest drainage system capable to deliver a regulated suction (variable suction to maintain a pre-determined level of intrapleural pressure). To minimize selection bias the authors used propensity score case matching analysis and compared two matched groups of 68 patients. They found that the incidence of 1-year recurrence rate was more than three fold higher in the group managed with traditional suction compared to the one managed with regulated suction (14% vs. 4.4%, p=0.04).

Moreover, the incidence of air leak duration, chest tube duration and hospital stay was similar between the two groups.

Although a causal relationship cannot be proven with a retrospective analysis, we can speculate that the application of a regulated suction capable to stabilize the intrapleural pressure favors pleura-pleura apposition enhancing

pleurodesis. This can in turn lead to a reduction of pneumothorax recurrences.

Although this hypothesis is intriguing further studies with clinical-pathological models are warranted to better define the role of intrapleural pressure with the effect of pleurodesis.

C. Final considerations

From what we have discussed above, it appears clear that the current evidence on the management of chest tubes after surgery for PSP is scarce.

Current clinical practice is mostly based on personal experience and background or extrapolated from the literature on lung cancer surgery.

The authors' personal preference in the management of chest tubes after minimally invasive surgery for PSP is the following:

One 24-28 French single tube is used. Regulated suction is applied at a level of -20 cmH2O for 48 hours to promote lung expansion and pleural juxtaposition favoring pleurodesis. If no air leak is present after 48 hours the tube is removed following a chest X ray to rule out the presence of a residual pleural space. Conversely, if an air leak is still present after 48 hours, the regulated suction is reduced from -20 cmH2O to -8 cmH2O to reduce the volume of air leak. In patients with a persistent air leak (reported as 8% of the total in the literature) a trial with a portable device (Heimlich valve) can also be attempted after few days of drainage with suction at -8 cmH2O, in preparation for discharge. However, one should always keep in mind that the presence of a residual pleural space should be minimized to reduce the risk of recurrence.

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Table 1: Summary of randomized trials comparing suction versus no suction after lung resection surgery

Author	**Algorithm**	**n. pts**	**Favor no suction**	**Benefit**
Cerfolio RJ 2001[2]	no suction on POD2	33	yes	Larger air leak seal by POD3
Marshall B 2002[3]	no suction on ward arrival	68	yes	Shorter air leak duration
Brunelli A 2004[5]	no suction on POD1	145	no	No diff in air leak duration, increased trend of compl
Brunelli A 2005[4]	Alternate suction	94	yes to AS	Shorter tube duration, LOS, less PAL vs. full time no suction
Alphonso N 2005[6]	Immediate no suction	234	no	No difference
Gocyk W 2016[7]	No suction on POD1	254	yes	Shorter chest tube duration and reduced incidence of prolonged air leak in no suction pts