Pigtail Tube Drainage as a Safe and Effective Alternative to Traditional Chest Tube Thoracostomy in Adults with Spontaneous Pneumothoraces: A Systematic Review

Ann M. Phillips
Pacific University

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Abstract

Background: Primary spontaneous pneumothorax occurs in young, healthy populations, usually males, in the absence of lung disease. Secondary spontaneous pneumothorax occurs in older adults who have underlying lung disease such as COPD, emphysema, or a malignant growth. The estimated incidence of spontaneous pneumothorax is 7.4 to 18 per 100,000 for males and 1.2 to 6 per 100,000 in females. Traditionally pneumothoraces have been treated with chest tube(s) but some have shown clinical success with small pigtail tube drainage. Relevant evidence was evaluated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) tool developed by the GRADE Working Group.

Method: An exhaustive search of available medical literature was performed using MEDLINE, Google Scholar, EBM multifile, and CINAHL using “pigtail” “adult” and “pneumothorax” individually and in combination. This search focused on articles published since 1999 pertaining to chest tube thoracostomy versus pigtail tube drainage.

Results: Four articles meeting the search criteria were included in the review. These studies evaluated length of hospital stay, time to extubation, total cost, and success rates. Two studies showed a decrease in length of hospital stay as well as decreased time to extubation. One study demonstrated a decrease in total cost and 3 studies reported success rates as acceptable for pigtail tube drainage prior to chest tube thoracostomy.

Conclusion: Pigtail tube drainage is a safe and effective alternative to chest tube thoracostomy in adults with spontaneous pneumothoraces. More studies are required as these articles were given a GRADE of low.

Keywords: Pneumothorax, adult, chest tube, pigtail
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Pigtail Tube Drainage as a Safe and Effective Alternative to Traditional Chest Tube Thoracostomy in Adults with Spontaneous Pneumothoraces: A Systematic Review

Ann Phillips

Pacific University School of Physician Assistant Studies

May, 2011

Faculty Advisor: Jim Ferguson
Clinical Graduate Project Instructors: Torry Cobb, DHSc, MPH, PA-C & Annjanette Sommers MS, PAC
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TABLE OF CONTENTS

INTRODUCTION ............................................................................................................. 5
  Background .................................................................................................................. 5
  Purpose of the Study ................................................................................................. 7
METHOD .......................................................................................................................... 7
RESULTS ........................................................................................................................ 8
DISCUSSION............................................................................................................... 14
  Study Limitations .................................................................................................... 15
  Grading the Evidence .............................................................................................. 16
REFERENCES .............................................................................................................. 19
APPENDICES ................................................................................................................ 20
  A. Table 1: GRADE ............................................................................................... 21
  B. Table 2: Summary of Reviewed Literature ......................................................... 22
INTRODUCTION

Background

A pneumothorax or “collapsed lung” is a life threatening condition caused by air accumulation between the lung and chest wall. It may spontaneously occur in younger healthy people (age 18-40), usually males, who smoke and have a thin build. It may also happen in older individuals (age 60+) secondary to underlying lung diseases such as COPD, emphysema, and malignant growth (Tsai et al., 2006). The estimated incidence is 7.4 to 18 per 100,000 for males and 1.2 to 6 per 100,000 in females (Noppen, 2010).

Traditionally pneumothoraces have been managed with large-bore chest tubes, usually 16 French (F) or larger. The issue of using a smaller chest tube, or pigtail tube drain, has recently been raised as a less traumatic and painful alternative to traditional treatment. Anatomically, the size of the average adult intercostal space is approximately 8.9 +/- 1.4mm (Gammie et al., 1999). Commonly used chest tubes such as the 24F and 32F are 8.0mm and 10.7mm, respectively. In comparison, an 8.3F pigtail tube is only 2.8mm in size (Gammie et al., 1999).

Traditional large-bore chest tube placement is performed by preparing the site in a sterile fashion, using local anesthetic, and making an incision approximately 1 inch long with a scalpel. After the initial incision is made, additional local anesthetic is injected into the tissue in the line of the intended pathway of the tube. A tunnel is made using a blunt dissection technique until the chest cavity is reached and confirmed by the sound of rushing air. A finger sweep
is usually performed which means placing a finger in the tunnel to confirm the presence of lung tissue and verify that the tunnel is within the chest wall. Once the provider is certain of placement, a tube is inserted into the tunnel and secured with sutures. The tube is then connected to either water seal or suction, based on provider preference.

Pigtail tube placement is slightly different and causes less trauma to the area. The skin is prepared in the same sterile fashion as large-bore tube placement and local anesthetic is injected. Instead of making an incision and bluntly dissecting to the rib, a sharp hollow needle called a trochar is used to puncture the chest cavity. After penetration, a guide wire is inserted and the trochar removed. With the guide wire in place, a cannula or catheter is placed over the guide wire into the cavity and the guide wire is then removed. The catheter is secured to the skin with sutures and attached to, either a one way Heimlich valve or suction, similar to the large-bore tube. This may be performed with or without radiologic guidance (Central Venous Catheterization, 2008).

Poiseuille’s law describes the underlying physiologic reason for initially using a large bore tube. “At a constant driving pressure, the flow rate of liquid through a capillary tube is directly proportional to the fourth power of the radius of the tube and inversely proportional to the length and viscosity of the tube” (Poiseuille’s Law, 2011, page 1). By definition this should mean comparing a large diameter tube to a small diameter tube of the same length at a constant pressure, or the same amount of applied suction, the flow rate varies only based on the radius of the tube. The key to this equation, however, is the term liquid.
Traditional methods of draining air from the lung refer to this equation but the object in this case is air, not fluid. The aim of this study is to disprove the common misunderstanding that Poiseuille’s Law is occurring in the case of pneumothorax, perhaps because of gases being involved, and that a pigtail tube may be just as effective as large-bore chest tube thoracostomy (Fysh, 2010). It is widely accepted that a practitioner should employ the least invasive, effective treatment possible. A pigtail tube catheter as a safe and effective alternative to traditional large-bore chest tubes is an excellent example of this principle in practice.

Purpose of the Study

The purpose of this paper is to perform a systematic review of the literature on the use of pigtail tube drains for spontaneous pneumothoraces in adults using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) tool developed by the GRADE Working Group.

METHOD

An extensive review of the literature was conducted using MEDLINE, Google Scholar, EBM multifile, and CINHAL accessed through the Pacific University Library system. The keywords “chest tube” “pigtail” “adult” and “pneumothorax” were searched individually and in combination. The initial results included 945 articles. Limitations of the search results included the English language, human subjects, articles published since 1999, and exclusion of
duplicates and letters to the editor. This resulted in four articles that met the criteria of the systematic review and were included in the final analysis.

RESULTS

All four studies included in this review were observational with no randomized controlled trials. Three of the four studies were retrospective while one was prospective in nature. In total there were 320 patients included in the four trials ranging from 41 patients in the smallest group and 102 patients in the largest study group. Two studies occurred in China, one in France, and one in the United States. Refer to Appendix B, Table 2: Summary of Reviewed Literature for a summary of the population, intervention, comparison, and outcome of each study.

The first study reviewed was performed by Gammie et al. (1999) and titled The Pigtail Catheter for Pleural Drainage: A Less Invasive Alternative to Tube Thoracostomy. The authors retrospectively reviewed 109 consecutive pigtail catheter placements in 86 patients to determine efficacy of the smaller drain. Placement was performed at the bedside under local anesthetic in the absence of radiologic guidance with suction applied immediately after insertion. Placement was confirmed by pre and post procedure radiographs with success defined as “freedom from a second intervention (repeat pigtail placement, tube thoracostomy, or operation) within 72 hours after removal of the pigtail catheter” (Gammie, 1999, p. 59).
The patients’ mean age was 56.3 years with a range from 16 years to 80 years. There were 36 males and 50 females included. There were a variety of etiologies generating the pneumothoraces including central line related (10 patients), trauma (9 patients), spontaneous (7 patients), and postoperative (6 patients), totaling 32 patients with pneumothoraces (Gammie, 1999). During the study there were 5 patients who failed pigtail catheter treatment. Patient one had a persistent pneumothorax which resolved with placement of a large-bore chest tube. Patient two had a continuing air leak, failed the 2\textsuperscript{nd} pigtail catheter, had two large-bore chest tubes placed, and died of Acute Respiratory Distress Syndrome (ARDS). Patient three also had a continuing air leak which resolved in 19 days after placement of 3 large-bore chest tubes. Patient four had a recurrent pneumothorax on day 4 when the pigtail catheter side holes migrated outside the thorax that resolved with placement of a large-bore chest tube. Patient five had bilateral pneumothoraces, the left sided pigtail was successful while the right side failed and eventually resolved with placement of a large-bore chest tube (Gammie, 1999).

Based on these results, Gammie et al. (1999) recommend the use of the 8.3F pigtail catheter as the method of choice for draining pneumothoraces. They report no associated complications from the insertion in their 109 consecutive cases, 32 of which were for pneumothoraces (Gammie, 1999).

The next study reviewed was performed by Liu, C., Hang, L., Chen, W., Hsia, T., & Hsu, W. (2003) and is titled Pigtail Tube Drainage in the Treatment of Spontaneous Pneumothorax. The authors retrospectively reviewed 102 patient
charts of 79 males and 23 females. Of the 102 patients, 52 were treated with the conventional large-bore chest tubes while 50 patients were treated with pigtail tube placement. They excluded patients who were diagnosed with congenital, traumatic, current lung disease, or tuberculosis.

Patients who were treated with pigtail tube placement underwent a chest echo for guidance before placement of the 8F or 10F pigtail tube under local anesthesia (Liu, 2003). The catheter was then connected to a one-way Heimlich flutter valve for drainage without applied suction. Management of the pneumothorax was achieved by repeated chest x-ray (CXR) to determine size and if the treatment was effective. According to Liu et al. (2003, p. 242) the “timing of the follow-up CXR, and the decision-making regarding extubation and discharge [of the large-bore chest tube], were similar to the pigtail group”.

The clinical endpoints in this study were time to extubation of the pigtail or large-bore chest tube in days, the evacuation rate in percentage per hour, the length of hospital stay, and the total cost (Liu, 2003). All endpoints measured, were superior in the pigtail group with the exception of a slightly slower evacuation rate. When comparing the same endpoints between a right and left sided pneumothorax and a first versus recurrent pneumothorax the results were also superior in the pigtail tube group, however, none of these endpoints were statistically significant (Liu, 2003).

Liu et al. (2003, p. 244) found “no significant difference between the chest tube and the pigtail as an initial treatment for spontaneous pneumothorax” and further “recommend that pigtail tube drainage be considered as the initial
treatment of choice in patients with spontaneous pneumothorax”. With this recommendation they do suggest that a large randomized trial be performed to evaluate the clinical application of the technique used (Liu, 2003).

In the next study reviewed, pigtail tube drainage was included as a primary treatment for spontaneous pneumothorax. Marquette et al. (2006) published a clinical pilot study to propose stepwise management of spontaneous pneumothoraces. In their article, *Simplified stepwise management of primary spontaneous pneumothorax: a pilot study*, Marquette et al. (2006) enrolled 41 consecutive patients for a prospective case series. Patients were eligible for inclusion if they had complaints of breathlessness or chest pain with any size pneumothorax, or if according to the ACCP definition the pneumothorax was “large”. They were excluded from the study if they had any history of pneumothorax or underlying lung disease (Marquette, 2006). There were 37 males and four females enrolled with an average age of 26, ranged 17 to 40 years. Thirty six of the 41 enrolled admitted smoking with an average of 8.1 pack years.

After verbal informed consent was obtained, each patient followed the same stepwise approach to drainage. After the pigtail tube was inserted via the Seldinger technique without radiologic guidance, it was connected to a Heimlich valve with a three-way stopcock. If the patient complained of dyspnea, the attending physician made the decision to connect the valve to -10 to -20 cmH₂O suction or to simply leave the Heimlich valve as it was when initially connected. If at any time the patient complained of dyspnea, the pigtail tube was immediately
connected to suction by the nursing staff. If the lung failed to expand after 48 hours, the pigtail tube was disconnected from the Heimlich valve, replaced with a water seal device, and suction applied at the same -10 to -20 cmH₂O as the dyspnea group. After resolution of the pneumothorax confirmed by CXR, the tube was left to water seal for 24 hours then discontinued. If these techniques proved unsuccessful and the pneumothorax persisted longer than 2 days, the attending surgeon then considered video-assisted thoracic surgery (VATS) (Marquette, 2006).

The outcome of this study was measured by the 24 hour and 1 week success rates determined by complete or near-complete resolution of the pneumothorax (Marquette, 2006). They also looked at the actuarial 1 year recurrence rate measuring the time to ipsilateral recurrence (Marquette, 2006). No patients were lost to follow up providing an actuarial 1 year recurrence rate of 24 percent at a mean of 321 days. Secondary endpoints included “6 and 48 hour success rates; safety; patient discomfort, as assessed by the need for pain relief medications; patient comfort, as assessed by ambulatory status; ability to take a shower; and length of stay” (Marquette, 2006, p. 472).

Marquette et al. (2006, p. 474) recommend a “one system, two-steps approach” starting with a pigtail catheter connected to a Heimlich valve and adding suction in 48 hours if the pneumothorax is unresolved. They also advise that “a small caliber catheter attached to a Heimlich valve kit could be safely proposed as the first and single treatment in primary spontaneous pneumothorax” (Marquette, 2006, p. 475). In addition to their primary endpoints
of resolution of pneumothorax, they also emphasize the ability of the patient to ambulate during their hospital stay leading to a more rapid discharge.

The success seen in the “one system, two steps approach” (Marquette, 2006) was also validated in the study published by Tsai et al. (2006) evaluating the traditional large-bore catheter versus the smaller pigtail catheter in Pigtail catheters vs large-bore chest tubes for management of secondary spontaneous pneumothoraces in adults. A retrospective chart review comprised of 91 patients was performed excluding patients who were younger than 18 years and patients experiencing mechanical ventilation-related barotraumas or pyopneumothorax. Patients included in the study were symptomatic with a confirmed diagnosis of secondary spontaneous pneumothorax, initially treated with either the large-bore or pigtail catheter, and had sufficient follow-up chest x-rays. The mean age was 60 years and there were 76 males and 15 females included in the study with more patients in the pigtail catheter group (69 patients) than the chest tube group (22 patients). Patient demographics were similar with the exception of smoking, 55 patients in the pigtail group were smokers whereas only 15 patients in the chest tube group admitted smoking. (Tsai, 2006).

Those in the pigtail catheter group were treated with a 10F to 14F sized tube using the modified Seldinger technique utilizing chest echo for guidance before initiation of the procedure (Tsai, 2006). The catheter was connected to a Heimlich flutter valve without suction and left in place until complete inflation of the lung was achieved. Chest x-rays at 8, 24, and 48 hours evaluated the continued need for tube drainage. In the large-bore chest tube group sized 20F
to 28F, the drain was connected to water seal or slight aspiration after insertion (0 to -5 cmH₂O).

Treatment outcomes of the study included success rate, extubation length in days, hospital stay in days, and 6 month recurrence rate (Tsai, 2006). The pigtail catheter group and the chest tube group were similar although none of the outcomes reached statistical significance. Tsai et al. (2006, p. 799) stated “we recommend that pigtail tube drainage be considered as the initial treatment of choice in patients with the first episode of secondary spontaneous pneumothorax in adults”.

DISCUSSION

The primary purpose of this review was to evaluate existing literature to determine whether pigtail tube catheters are a safe and effective alternative to traditional large-bore chest tube thoracostomy. Although there have been many studies on pneumothoraces, none have been randomized controlled trials or studies with a high grade of evidence. As one would expect, conducting a controlled trial for a patient with spontaneous pneumothorax is a difficult task. It would, in fact, be unethical to deny a patient treatment with either pigtail or large-bore drainage as they could suffer irreversible harm and even death. This collection of studies employs vastly different research methods and comparisons although they seemed to end with similar conclusions. All studies recommend pigtail tube drainage as the first line of treatment in spontaneous pneumothoraces as well as further study in this area, particularly randomized controlled trials.
Study Limitations

All studies except one were restricted by their retrospective nature. Liu et al. (2003) had a reasonable control comparison and patients with similar demographics; however, they failed to inquire about the smoking habits of participants which could make a drastic difference in recovery after insertion of either catheter. Another limitation of this study was the use of a chest echo for guidance prior to the pigtail catheter insertion. This method has the clear advantage of performing the procedure with guidance as opposed to conventional, essentially blind, insertion of the large-bore catheter. Nonetheless, Liu et al. (2003) showed favorable outcomes in time to extubation, length of hospital stay, and total cost.

Tsai et al. (2006) was the only study to include the smoking habits of their patients. While they accounted for this confounding variable, they failed to account for the significant difference in the higher number of males to females and the increased percentage of patients treated with pigtail tube drainage versus traditional chest tubes. The incidence of pigtail tube treatment was as a result of success in their clinical experience with the pigtail drain. Since this was a retrospective trial, the figures correspond to that clinical success with a higher number of patients treated with the pigtail tube catheter.

The inherent flaw of the case series performed by Gammie et al. (1999) is the lack of comparison group. This case series only follows consecutive placement of pigtail catheters consequently providing no information about large-bore chest tube placement. In addition, they were interested in both pleural
drainage and pneumothorax; therefore, the number of patients evaluated with only pneumothorax was quite small at 32 patients. This was the only study that also included other causes of pneumothorax in addition to spontaneous pneumothoraces such as trauma, central line related, and post operative pneumothoraces. Despite the study flaws they were able to exquisitely detail the failures of the pigtail drain in patients with pneumothorax and provide insight as to where treatment might be ameliorated.

Marquette et al. (2006) were the first to describe a stepwise approach to the management of spontaneous pneumothorax. This was the only prospective study included in the review but as this was an approach to management, not comparison between groups, there was no control group included. This study also had a small sample size at only 41 patients with a greater than 9:1 male to female ratio. This prospective trial allows bias as patients were enrolled on a volunteer basis.

Grading the Evidence

Evidence based medicine is the cornerstone to our success as providers and helps ensure the safety of our patients. Medicine changes and new advances are made daily requiring constant reevaluation of our current practices. During this review, the Grading of Recommendations Assessment, Development and Evaluation (GRADE) tool developed by the GRADE Working Group was utilized to evaluate the studies included. The following is a definition of quality according to the GRADE Working Group:
- “High quality – Further research is very unlikely to change our confidence in the estimate of effect, Moderate quality – Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate, Low quality – Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate, Very low quality – Any estimate of effect is very uncertain” (Guyatt, G., 2008, p. 926).

Tsai et al. (2006) and Liu et al. (2003) both measured length of hospital stay as well as time to extubation. Both these studies started with a grade of low as they were retrospective case series and neither were upgraded based on the GRADE Working Group. Although the study by Tsai et al. (2006) mentioned smoking as a confounding factor, it was not accounted for in the study and did not raise the grade of evidence.

Three of the four studies reviewed included some version of success rate in their final outcome. All except Liu et al. (2003) measure how many patients went on to require more invasive treatment including but not limited to additional pigtail tube placement, chest tube placement, and VATS. The success rates for Gammie et al. (1999), Marquette et al. (2006), and Tsai et al. (2006) were 81%, 85%, and 72.5%, respectively. Again, this evidence was graded as low for the retrospective case series.

Finally, only Liu et al. (2003) reported the total cost outcome. Although the difference was not statistically significant at $25,110 for the pigtail group and
$27,343 for the chest tube group, it is clinically relevant data that should be considered.

Overall these four studies are given the grade of low. Although they had good intentions in regards to study endpoints, the designs of the studies were to blame. It is impossible to blind a patient to a particular tube thoracostomy treatment, as well as to include a control group for comparison. The author's recommendation is to perform a randomized cohort study, in the United States, to determine if this initial data is accurate and safe in our clinical practice. Considering pigtail tube placement as a first line treatment for spontaneous pneumothorax could decrease the physical trauma and pain associated with this necessary, life saving treatment.
REFERENCES


<table>
<thead>
<tr>
<th>Comparison</th>
<th>Outcome</th>
<th>Quantity and type of evidence</th>
<th>Findings</th>
<th>Starting grade</th>
<th>Decrease GRADE</th>
<th>Increase GRADE</th>
<th>Grade of Evidence for Outcome</th>
<th>Overall GRADE of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigtail Tube Catheters vs. Traditional Large-Bore Chest Tubes</td>
<td>Length of hospital stay</td>
<td>2 case series</td>
<td>Decreased length of hospital stay</td>
<td>Low</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Low</td>
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<tr>
<td></td>
<td>Time to extubation</td>
<td>2 case series</td>
<td>Decreased time to extubation</td>
<td>Low</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Success rate</td>
<td>3 case series</td>
<td>Acceptable success rates with pigtail cath</td>
<td>Low</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td>STUDY</td>
<td>POPULATION</td>
<td>INTERVENTION</td>
<td>COMPARISON</td>
<td>OUTCOME</td>
<td>COMMENTS</td>
<td></td>
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<tr>
<td>Gammie et al. (1999)</td>
<td>86 patients with spontaneous pneumothorax</td>
<td>8F pigtail catheter</td>
<td>Traditional chest tube thoracostomy</td>
<td>Freedom from a second intervention: repeat pigtail placement, tube thoracostomy, or operation</td>
<td>Pigtail catheters provide reliable, safe, and effective drainage of pneumothoraces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liu et al. (2003)</td>
<td>102 patients with spontaneous pneumothorax</td>
<td>8F to 10F pigtail tube</td>
<td>Traditional chest tube thoracostomy</td>
<td>Extubation time, mean hospital stay, evacuation rate, total cost</td>
<td>Pigtail tube drainage is as adequate as traditional chest tube drainage without ambulatory limitations and complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marquette et al. (2006)</td>
<td>41 patients with spontaneous pneumothorax</td>
<td>8.5F pigtail catheter prior to traditional chest tube insertion</td>
<td>None</td>
<td>1°: 24 hour and 1 week success rates, and actuarial 1 year recurrence rate. 2°: 6 hour and 48 hour success rates, safety, patient discomfort, patient comfort, ability to take a shower, and length of stay</td>
<td>The use of small caliber catheters could be safely proposed as the first and single treatment of primary spontaneous pneumothorax</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tsai et al. (2006)</td>
<td>91 patients with spontaneous pneumothorax</td>
<td>10F to 14F pigtail catheter</td>
<td>20F to 28F Large-bore chest tubes</td>
<td>Success rate, extubation in days, hospital stay in days, and 6 month recurrence rate</td>
<td>Recommend pigtail tube drainage to be considered as the initial treatment of choice in patients with first episode of secondary spontaneous pneumothorax in adults</td>
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