Comparison of Pigtail Catheter to Chest Tube for Drainage of Parapneumonic Effusion in Children

比較豬尾巴及胸管於引流兒童肺炎性積水

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ABSTRACT

Background: The use of thoracostomy tube for drainage of parapneumonic effusion is an important therapeutic measure. In this study, we compared the effectiveness and complications between chest tube and pigtail catheter thoracostomy for drainage of parapneumonic pleural effusion in children.

Methods: We retrospectively reviewed the medical records of children with parapneumonic effusion during the period of July 2001 through December 2003. Patients who received thoracostomy with either chest tube or pigtail catheter were enrolled into this study. Medical records such as age, sex, clinical presentation, subsequent therapies, hospital stay, laboratory data and complications were collected and compared between these two methods of intervention.

Results: A total of 32 patients (17 males and 15 females, range, 2-17 years, mean 14 years old) were enrolled into the study. Twenty patients were treated with traditional chest tubes, while 12 patients were treated with pigtail catheters. In the chest tube group, drainage failure occurred in one patient and pneumothorax occurred in 2 patients. In the pigtail catheter group, drainage failure occurred in 2 patients but no case was complicated with pneumothorax. There were no significant differences in either drainage days or hospitalization days between the chest tube group and pigtail catheter group (6.0 ± 2.6 vs 5.9 ± 3.8, $p = 0.66$; 12.5 ± 5.6 vs 17.3 ± 8.5, $p = 0.13$).

Conclusion: The effectiveness and complications of the pigtail catheter were comparable to those of the chest tubes.

Key words: pigtail catheter; chest tube; drainage; parapneumonic effusion

1. Introduction

Parapneumonic effusion, a complication of pneumonia, used to be drained off by large-bore chest tubes. However, this procedure requires making an incision on the skin and dissecting the intercostal muscle bluntly before the chest tube can be inserted into the pleural space. This invasive procedure is therefore associated with potential complications like hemothorax, pneumothorax, organ perforation, diaphragm laceration, empyema, pulmonary edema and Horner's syndrome.[1-3] Recently, the use of pigtail catheter (flexible and small-bore) by a Seldinger technique has emerged as an effective alternative for thoracostomy and pleural drainage.[4-8] Because of its less-traumatic procedure, this method creates less pain and smaller scar during and after the placements, and possibly fewer procedure-associated complications. The purpose of this study was to compare the efficacy, safety and complications between the uses of chest tubes and pigtail catheters for thoracostomy and pleural drainage in children with paraneumonic pleural effusion.

2. Materials and Methods

2.1. Study population

We retrospectively reviewed our cases of parapneumonic effusion that received thoracostomy interventions by either chest tube method or pigtail catheter method when admitted to the pediatric department of China Medical University Hospital, Taiwan, during the period of July 1, 2001 through Dec. 31, 2003. All cases were under 18 years of age. The indication to drain the pleural fluid was based on its abnormal contents as recommended by Colice et al., which included glucose <40 mg/dL, pH <7.20, protein > 5 g/dL, lactate dehydrogenase >1000 IU/L, grossly purulent appearance, or positive Gram stain.[9] The pleural fluid pH was measured by the the pH meter of SUNTEX SP-2200 with a lowest limit of 6.80. The severity of the pleural effusion was judged by Light's classification.[10] However, those patients ascribed to empyema initially or who had been intubated with tracheal tubes were excluded from this study.

Before thoracostomy, all patients were studied by chest ultrasonogram to define precisely the location and thickness of the pleural effusion. The patients were sedated with intravenous midazolam and ketamine, and the puncture site, usually in the mid-axillary line of the 4^{th} to 5^{th} intercostal space, was prepared with lidocaine infusion.

In the group of chest tube thoracostomy (straight tubes, 7-12 F, Sherwood Medical, St. Louis, MO), the skin was dissected and a trocar-needle-tube combination set was inserted vertically into the chest cage to an assumed depth. When the pleural fluid was aspirated by syringe smoothly, the trochar was removed, and the chest tube was then pushed in over the needle to a premeasured distance or until a resistance was met. The tube was then sutured and fixed on the skin, as well as connected to a suction bottle by 10 cm H_2O negative pressure.

In the group of pigtail catheter thoracostomy (soft, curled and multi-hole catheters, 7-12 F, manufactured by PBN Medicals Denmark or 14-16 F, by Create Medic Co., Ltd), a modified Seldinger technique was used. The pleural fluid was first test-aspirated by a small angiocatheter (16 or 18 gauge, catheter-over-needle). The soft angiocatheter was then smoothly advanced to its full length and the needle was removed. Thereupon, a soft-tip, J-shaped guidewire was inserted into the angiocatheter for an adequate length, usually > 10 cm. Holding the guide wire on the chest wall, the angiocatheter was removed and a stiff dilator was then forwarded over the wire to enlarge the entry route. After removal of the dilator, a pigtail catheter could then be advanced freely over the guidewire into the pleural space. The guide-wire was removed and the pigtail catheter was securely tapped or sutured on the chest wall and then connected to the suction bottle. The positions of the tubes or catheters were then confirmed by chest X-ray.

Success of intervention was defined as evacuation of fluid smoothly (confirmed by chest X-ray) and no other intervention being required. Failure of intervention was defined as persistence or increasing of fluid requiring an additional drainage tube or catheter or even a surgical thoracotomy.

Several variables were compared between these two groups with thoracostomy, including demographic data, bore size of chest tubes or pigtail catheters, drainage days, hospitalization days, complications and any necessary rescue interventions. The possible thoracostomy-related complications including pneumothorax, hemothorax, hepatic perforation, subcutaneous hematoma and kinking or dislodgement of tubes or catheters were identified and recorded.

2.2. Statistical analysis

Continuous variables were expressed in mean ± SD and compared by Student's *t*-test. Chi-square test or Fisher's exact test were used to compare the categorized data. The SPSS package (SPSS, Inc., Chicago. Illinois, USA), version 11, was used for analyses and p value <0.05 was considered statistically significant to reject the null hypothesis.

3. Results

A total of 32 patients (17 males and 15 females, age: 2-17 years, mean 6.4-years-old) were enrolled into this study. Twenty-one chest tubes were placed in 20 patients and 14 pigtail catheters were place in 12 patients (Table 1). There were no significant differences between the traditional chest tube group and pigtail catheter group in patient demographics except the size of the catheter and tube (Table 2).

In the chest tube group, failure to drain happened in one patient who later required surgical decortication because of disease progression to empyema on the twelfth hospital day. One patient received bilateral chest tube drainage because he had severe pneumonia with bilateral parapnuemonic effusion. Two patients also were intervened with intrapleural urokinase irrigation, in addition to the chest tube drainage. The only complication was pneumothorax in 2 patients. The average number of drainage days was 6.0 ± 2.6.

In the pigtail catheter group, failure to drain occurred in 2 patients. One patient needed another chest tube for drainage because of delayed resolution and development of a thick empyema on the third days later. One patient had bilateral parapnuemonic effusion and received bilateral pigtail catheter drainage of both lungs initially. However, one more pigtail catheter had to be inserted on the left side because of persistent effusion. Two patients also received intrapleural urokinase therapy in addition to the pigtail catheter drainage. None needed further surgical intervention, and there were no other complications. The average number of drainage days was 5.9 ± 3.8.

Only 6 patients (18.8%) had culture-proved bacterial pathogens, and bacteria were found in the Gram stain results of pleural fluid in one of the patients. The pathogens were

Sreptococcus pneumoniae in 5 patients and *Staphylococcus aureus* in 1 patient. The sensitivity of penicillin for *Streptococcus pneumoniae* was rated sensitive in 2 patients, intermediate in 2 patients, and resistant in 1 patient.

Four patients in the chest tube group complained of wound pain which could be easily managed with oral medication of acetaminophen. No intravenous narcotic agent was used in either group.

4. Discussion

Pigtail catheter drainage method appears easier to perform, has fewer procedures, is less traumatic, has less ambulatory limitation and is better tolerated by patients than the chest tube thoracostomy. Many previous studies have compared the efficacy of drainage of pneumothorax between these two methods,[2,11,13] however, as yet, not for parapnuemonic effusion. Our study showed that the pigtail method was as effective and even safer than the conventional chest tube method in draining pleural effusion.

In the study of Roberts et al, pigtail catheters were simple to place in critically ill pediatric patients, and were highly effective in drainage of pleural serous and chylous effusion, somewhat less efficacious in drainage of hemothorax or pneumothorax, and less efficacious in drainage of empyema.[14] However, in Liang et al's study of pigtail catheter drainage in adults who were admitted in the ICU, the success rate reached 100% when used to treat traumatic hemothorax, but only 42% when used to treat empyemas (42%). Most authors suggest that patients with empyemas should initially be managed with large chest tubes and intrapleural thrombolytic therapy, even if a decortication or lobectomy is required.[4,10,14] Nevertheless, from a view of easiness, safety, less trauma and better cosmetic result, Pierrepoint et al and Horsley et al suggested that pigtail catheter could be used initially in treating pleural empyema, if there was no ultrasound evidence of loculations.[7,15] Two patients in our study were found to be deteriorated by empyema. One was in the pigtail group and the other in the chest tube group. In our limited experience, if pleural effusion deteriorates into a state of empyema, the pigtail catheter drainage alone may be inadequate. Early urokinase irrigation or even surgical curettage and debridement on the fibrinopurulent pleura may be required.

In our study, there was no statistically significant difference in terms of severity of parapneumonic effusion, drainage days, hospital days, failure to drain, wound pain, and complication between the two groups. However, the size of tube or catheter was significantly smaller in the pigtail catheter group, which may be one reason for its fewer traumas, smaller residual scars and less discomfort to the pediatric patients.[12,15,16] In our study, four patients in the chest tube group and none in the pigtail group complained of wound pain. Because of the small sample size in this study, the difference did not show statistically significant. This less-pain advantage of pigtail catheters could be due to its smaller tube size required compared to the chest tube group, as well as its softer texture.

The drainage effects depend strongly on the pathogens of the pleural effusion, which can also determine their subsequent therapies and prognosis. For example, pleural effusions in case of mycoplasma pneumonia are usually in small amount and may be resolved spontaneously, [17] while most cases of complicated pneumococcal pneumonia present with a large amount of sticky pleural effusion and need to be adequately drained or even surgical evacuated by a video-assisted thoracoscopy (VATS) procedure. In this study, we have tried very hard to find the pathogens from the pleural fluid cultures; however, the positive cultures were very low. Furthermore, during the period of this study, urine pneumoccoccal antigen test was not yet available in this hospital and mycoplasma antibody titers were only done in a few patients.

The complications associated with pigtail drainage look similar to those of chest tube drainage, including hemothorax, pneumothorax, liver perforation and tubal dislodgement, kinking or disconnection.[7,8,14] Liang et al reported that the complication rate of using pigtail catheters in adults was 8%,[8] while that for children in the series of Roberts et al was about 5%.[14] Complications can be reduced to a minimum by strict attention to anatomic landmarks with transthoracic ultrasound, both before and after the procedure.[14] Gammine et al advised inserting the pigtail catheter in a “safe zone”, above the sixth intercostal space, to avoid subdiaphragmatic catheter placement.[18] A latest survey of intercostal chest drain in the United Kingdom showed that Seldinger chest drain insertion was associated with significant complications, even organ puncture and death, and may not necessarily safer than conventional thoracostomy chest tube drain.[19] We believe that those severe complications of inadvertent organ punctures can be avoided by using ‘modified Seldinger method’, as we did in our study, which employs a soft angiocatheter and a J-tip guide wire rather than a hard puncture needle and a straight guide wire. Once the pleural fluid has been aspirated through the tip of an angiocathter, the fine needle can be removed and simultaneously, the soft catheter can be advanced as far as possible without a fear of puncturing anything. Thereupon, if a J-tip guide wire is used to insert into the soft catheter without any risk. Afterwards, the soft catheter is removed and a skin dilator over the guide wire can be safely advanced to enlarge the skin hole to facilitate the final entry of the pigtail catheter. We agree that a good education and training program for all junior operators regarding this procedure is very crucial to reduce the complications to minimum.

In this study, we placed pigtail catheters in the 4th-6th intercostal space of the mid-axillary line for most patients, and none suffered subdiaphragmatic catheter placement. On the contrary, pneumothorax occurred in two patients of the chest tube group.

However, two potential disadvantages might be associated with pigtail catheter drainage: first, large-caliber tubes may be required to drain some very viscous fluid, and second, pigtail catheters may be kinked by squeezed angles or clogged by turbid fluid with a lot of debris. These disadvantages can result in drainage failure. Under these circumstances, use of intrapleural urokinase irrigation, insertion of two pigtail catheters at different foci or even surgical intervention with VATS for curettage and decortication may be required. When chest tube is preferred in following procedures, the original pigtail catheter can serve as a safety route for chest tube entry.[20]

This retrospective study enrolled only 32 admitted patients of one hospital during a period of 3 years. The selection of either pig-tail catheter or chest tube for pleural drainage was at the discretion of the primary care physician, so our recommendation from this study is flawed by its non-randomized allocation of the intervention methods to these two groups of cases. Also, many detailed past histories and medication histories are not accessible from a retrospective perspective. Further prospective and randomized study to follow a well-designed protocol will be warranted to elucidate these unsolved issues.

In conclusion, the pigtail catheter drainage of parapneumonic effusion achieved comparable effectiveness to that of the conventional chest tube thoracostomy. Therefore, we recommend that pigtail catheter maybe used as the initial treatment mode in draining the parapneumonic effusions of pediatric patients, and a large-bore chest tube can be reserved for those cases with very viscous pleural fluid.

References

1. Bertino RE, Wesbey GE, Johnson R. Horner syndrome occurring as a complication of chest tube placement. *Radiology* 1987;99:745.
2. Miller KS, Sahn SA. Chest tubes: indications, technique management and complications. *Chest* 1987;91:258-64.
3. Iberti TJ, Stern PM. Chest tube thoracostomy. *Crit Care Chest* 1992;8:879-95.
4. Fuhrman BP, Landrum BG, Ferrara TB, et al. Pleural drainage using modified pigtail catheters. *Crit Care Med* 1986;14:575-6.
5. Lawless S, Orr R, Killian A, Egar M, Fuhrman B. New pigtail catheter for pleural drainage in pediatric patients. *Crit Care Med* 1989;17:173-5.
6. Lai YF, Chao TY, Wang YH, Lin AS. Pigtail drainage in the treatment of tuberculous pleural effusions: a randomized study. *Thorax* 2003;58:149-51.
7. Horsley A, Jones L, White J, Henry M. Efficacy and complications of small-bore, wire-guided chest drains. *Chest* 2006;130:1857-63.
8. Liang SJ, Tu CY, Chen HJ, et al. Application of ultrasound-guided pigtail catheter for drainage of pleural effusions in the ICU. *Intensive Care Med* 2009,35:350-4.
9. Colice GL, Curtis A, Deslauriers J, et al. Medical and surgical treatment of parapneumonic effusions: an evidence-based guideline. *Chest* 2000;118:1158-71.
10. Light RW. A new classification of parapneumonic effusions and empyema. *Chest* 1995;108:299-301.
11. Liu CM, Hang LW, Chen WK, Hsia TC, Hsu WH. Pigtail tube drainage in the treatment of spontaneous pneumothorax. *Am J Emerg Med* 2003;21:241-44.
12. Dull KE, Fleisher GR. Pigtail catheters versus large-bore chest tubes for

pneumothoraces in children treated in the emergency department. *Pediatr Emerg Care* 2002;18:265-7.

13. Tsai WK, Chen W, Lee JC, et al. Pigtail catheters vs large-bore chest tubes for management of secondary spontaneous pneumothoraces in adults. *Am J Emerg Med* 2006;24:795-800
14. Roberts JS, Bratton SL, Brogan TV. Efficacy and complications of percutaneous pigtail catheters for thoracostomy in pediatric patients. *Chest* 1998;114:1116-21.
15. Pierrepoint MJ, Evans A, Morris SJ, Harrison SK, Doull JI. Pigtail catheter drain in the treatment of empyema thoracis. *Arch Dis Child* 2002;87:331-32.
16. Clementsen P, Evald T, Grode G, Hansen M, Krag Jacobsen G, Faurschou P. Treatment of malignant pleural effusion: pleurodesis using a small percutaneous catheter: a prospective randomized study. *Respir Med* 1999;92:593-6.
17. John SD, Ramanathan J, Swischuk LE. Spectrum of clinical and radiographic findings in pediatric mycoplasma pneumonia. *Radiographics* 2001;21:121-31.
18. Gammine JS, Banks MC, Fuhrman CR, et al. The pigtail catheter for pleural drainage: a less invasive alternative to tube thoracostomy. *JSLS* 1999;3:57-61.
19. Maskell NA, Medford A, Fleeson FV. Seldinger chest drain insertion: simpler but not necessarily safer. *Thorax* 2010;65:5-6.
20. Westcott JL. Percutaneous catheter drainage of pleural effusion and empyema. *AJR* 1985;144:1189-93.

Tables

Table 1 Patient characteristics in chest tube and pigtail catheter group

Patient	Light's classification	Location	Size (F)	Duration (days)	Pleural culture	Hospital stay (days)	Failure to drain or complication
Chest tube Group							
1	3	L	12	5.2		8	
2	3	R	16	7.0		12	
3	3	L	12	3.0		11	
4	3	R	16	6.8		9	
5*	5	R	12	12.7	*S. Pneumoniae*	32	Failure to drain (decortication)
6	3	R	16	4.0	*S. aureus*	10	
7	3	R	16	4.0		10	
8	4	L	16	8.4	*S. Pneumoniae*	16	
9	4	L	16	10.0		15	Pneumothorax
10	3	R, L	16	3.0		13	
11	4	R	12	6.8		10	
12	4	R	12	6.8		16	
13	3	R	16	7.5		14	

14	3	R	16	3.8		7	
15	3	R	12	4.6		7	
16*	5	L	16	6.9		16	
17	4	L	12	8.0		16	
18	3	R	12	3.0		12	
19	3	R	9	6.0		10	Pneumothorax
20	3	L	16	3.0		6	
Pigtail catheter group							
1	3	R	8	2.0		9	
2*	4	R, L, L	8	6.0		27	Failure to drain on left side
3	3	R	6	3.9		14	
4	3	R	14	8.0		30	
5	3	R	10	5.0		10	
6	3	R	8	8.7		17	
7	3	R	14	5.0	*S. Pneumoniae*	11	
8	4	R	14	13.0	*S. Pneumoniae*	21	
9*	4	R	14	12.0	*S. Pneumoniae*	32	Failure to drain (additional

							chest tube)
10	3	L	14	1.0		10	
11	3	R	14	3.0		8	
12	4	R	12	3.0		18	

R = right; L = left, *patients who had been treated with intrapleural urokinase

Table 2 Comparison of pigtail catheter group and chest tube group

	Chest tube group	Pigtail catheter group	*p* value
Patient numbers/ (male: female)	20 (12:8)	12 (5:7)	
Age (yr)	7.1 ± 5.6	5.1 ± 2.7	0.195
Body weight (kg)	23.9 ± 15.3	19.0 ± 6.8	0.295
WBC count, per μL	13,944.2 ± 5,316.6	14,150.2 ± 4,064.7	0.909
C-reactive protein, mg/L	166.2 ± 99.0	214.4 ± 123.7	0.236
Pleural effusion			
pH	6.78 ± 1.3	7.1 ± 3.5	0.889
WBC count, per μL	2,178.1 ± 580.9	1,505.6 ± 1,170.8	0.551
Total protein, g/dL	3.9 ± 0.7	4.1 ± 0.9	0.701
Glucose, mg/dL	47.51± 23.3	62.4 ± 21.8	0.079
Lactate dehydrogenase, IU/L	3,690.2 ± 4,046.1	2,000.7 ± 2,542.3	0.150
Culture positive, Number. of patients	3	3	0.647
Size (F)	14.1 ± 2.3	11.3 ± 3.1	0.008*
Drainage days	6.0 ± 2.6	5.9 ± 3.8	0.895
Hospital days	12.5 ± 5.6	17.3 ± 8.5	0.066
Failure to drain	1	2	0.540
Wound pain	4	0	0.271
Complication	2	0	0.516

Data are presented as mean ± standard deviation. *$p<0.05$. WBC=white blood cells.