Review Article

Review Article:

Pigtail Catheters in Pleural Diseases

Dr. Pallavi Periwal[1], Dr. Arjun Khanna*, Dr. Kartik Deshmukh[2],
Dr. Ankit Kumar Sinha[3], Dr. Kamal Kishore Pandey[4], Dr. Deepak Talwar[5]

1. Consultant Pulmonologist, Aanch Hospital, Jaipur, India.
2. MBA Candidate, Duke Fuqua Business School, North Carolina, USA
3, 4. Consultant Pulmonologist, Yashoda Superspeciality Hospital, Kaushambi, UP
5. Director and Chairman, Metro Centre for Respiratory Diseases, Noida, Sector 11, UP

***Corresponding Author: Dr. Arjun Khanna,** Consultant Pulmonologist, Yashoda Superspeciality Hospital, Kaushambi, UP.

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Introduction

The pleural cavity is the space between the visceral pleura which covers the lung, and the parietal pleura which covers the chest wall, diaphragm, and mediastinum. **(**1**)** In normal conditions, the pressure inside the pleural cavity is negative (less than the atmospheric pressure), and this helps prevents the lungs from collapsing. The pleural cavity is lubricated by the pleural fluid, the amount of which is governed by a delicate balance of pleural fluid formation and removal.

Tube thoracostomy (with >20 Fr tube) has been the standard of care for evacuation of air(pneumothorax) or fluid (pleural effusion) from the pleural space. **(**2**)** However, there is considerable evidence suggesting that tube thoracostomy using large-bore chest drains (LBCD) is associated with significant pain, morbidity, and complications. Small-bore chest drains known as pigtail catheters (PC) were previously used in paediatric patients and have significantly less complication risk as compared to LBCD. Hence many pulmonologists are shifting from the traditional practice of using LBCD for chest drainage to insertion of PC under radiological guidance for various pleural diseases in adult patients. **(**3**)**

Pigtail Catheters

Pigtail catheters are small-bore indwelling flexible chest drains made of polyvinyl chloride **(**4**)**. PCs have been named so because of the curvature of the catheter after the rigid insert is removed. The curve prevents the dislodgement of the drain in the pleural cavity. The size of a chest tube refers to its outer diameter and is given in 'French' (F), with 3 F corresponding to 1 mm **(**5**)**. The usual outer diameter of PCs is between 8F to 20F, which is significantly smaller than the diameter of an LBCD (more than 20F). The inner diameter of PCs may vary according to the thickness of the wall and hence changes as per the manufacturer. As with other chest tubes, the drainage of air and fluid through PC is governed by the physics of the Fanning equation and Poiseuille's law respectively.

Indications

Primary spontaneous pneumothorax
Secondary spontaneous pneumothorax
Traumatic pneumothorax
Iatrogenic pneumothorax
Tension pneumothorax after initial needle drainage
Hemopneumothorax
Parapneumonic effusion
Simple non loculated empyema
Malignant and Para-malignant pleural effusion
Symptomatic transudative pleural effusion
Post-surgical thoracic drainage (after open cardiac/thoracic surgery)

Table 1: Indications of Pigtail Catheter Drainage (PCD)

There are many indications for the placement of PCs in pleural diseases. **(**6**) (Table 1)** PCs can be used for draining both pneumothoraces and pleural effusions of multiple aetiologies. For most transudative and some exudative pleural effusions, PCs are a suitable alternative to LBCD. There have been several studies establishing the role of PC in primary, secondary spontaneous, and traumatic pneumothoraces (mentioned under the section of Pneumothorax).

Contraindications

INR>1.5
Platelet count <50,000/UL
Antiplatelet therapy

Table 2: Relative Contraindications of PC

PC insertion has to be considered in the context of the overall condition of the patient, after a risk vs benefit assessment. **(**7**)** In emergency procedures, there are no contraindications, such as in a patient with tension pneumothorax. For elective and semi-elective PC placement, coagulopathy, bleeding diathesis, and anticoagulation therapy are relative contraindications **(Table 2)**; the relative contraindications are similar to one associated with LBCD insertion. **(**6**)** Consideration should be given to the normalization of coagulation parameters before commencing with the procedure in such cases. **(**7**)** Coagulation abnormalities pose a lesser threat with PC drainage, as compared to LBCD, as the latter would be inherently associated with more tissue dissection. Many patients who are candidates for PC are on antiplatelet drugs. The simultaneous administration of these drugs is a relative contraindication, and the risk of bleeding must be individualized pre-procedure.

Preparation

Sterile gown, gloves and drapes
Antiseptic skin preparation (betadine or chlorhexidine)
Syringes (10 and 5 mL) and needles
Local anaesthetic (details discussed in text)
Scalpel (size 11 blade)
Sterile gauzes and dressings
Artery and needle holding forceps
Pigtail catheter with guide wire and dilators
Closed drainage system, tubing and sterile water for the underwater seal system
Silk sutures and scissors

Table 3: Recommended equipment for PC insertion

A thorough history and clinical examination should be performed for every patient. One must ensure that a recent chest radiograph is available. **(**6**)** A thoracic ultrasound must be used for imaging in every patient as recommended by the international guidelines. This guides the appropriate placement of a PC and helps minimize the complications. **(**6,7**)** Strict aseptic precautions should be observed throughout the procedure. All types of equipment required should be available and checked before the procedure is commenced. **(Table 3). (**6,7**)** Whenever possible, the patient should be informed of the risks, and informed consent should be taken.

Patient Position

The patient should be in a supine or semi-recumbent position. The ipsilateral hand should be raised to rest behind the head to optimize exposure of the 'triangle of safety'. **(**7**)** The triangle is bordered anteriorly by the lateral edge of the pectoralis major, laterally by the lateral edge of latissimus dorsi, inferiorly by the line of the fifth intercostal space, and superiorly by the base of the axilla **(**6**).** With a loculated pleural effusion or pneumothorax, the site of insertion is dictated by the site of locule, which is ideally determined by pre-procedural imaging **(**6**)**. Ultrasound-guided PC insertion is preferred over CT guided procedure because of real-time visualization of the advancing needle with the US, ease of use, availability, cost, and portability. USG guided PC insertion can be performed in hemodynamically unstable patients at the bedside as well. CT guided PC insertion may be required for multi-loculated pleural effusions/empyema.

Anaesthesia

After cleaning and draping the skin, a local anesthetic (lidocaine, up to 3 mg/kg) is usually infiltrated into the skin and then progressively deeper through to subcutaneous tissue, intercostal muscles, periosteum along the upper border of a rib and parietal pleura. **(**6,7,8**)**. The volume given is considered to be more important than the dose to aid the spread of the effective anesthetic area and therefore a dilute preparation (1% rather than 2%) is preferable **(**6**)**. In anxious patients, mild intravenous sedation may be used under proper supervision.

Insertion Technique

PC is inserted by the modified Seldinger technique. The aim should be to place the tip of the PC apically to drain air and basally for fluid. The site of PC insertion is confirmed once pleural contents (air or fluid) are aspirated in the needle. A guidewire is passed through the needle. The needle is then withdrawn leaving the guidewire in place. A small incision is made in the skin and subcutaneous tissue. Using a twisting motion, the dilator is passed gently over the guidewire. **(**9**)** The PC is passed over the guidewire, ensuring that the last side hole is within the pleural space.**(**8**)** The guidewire is then removed, leaving the PC in place **(**9**)**. PC is then clamped and connected to the tubing and drainage system. To hold the PC in place, it is sutured to the skin and chest wall. **(**9**)** A chest radiograph must be obtained after the procedure to check the placement of the tube.

Management of Pigtail Catheters

All patients with small-bore catheters in situ must be monitored daily for the functioning of the PC, the amount of drain, signs of wound infection, and air leak. The initial drain ideally must not be greater than 1.5 litres in the first hour, and the PC may be clamped if a higher volume of the effusion is expected to be drained. **(**6**)** The clamp is released to slowly allow the rest of the fluid to drain. **(**6**)** In patients with a persistent air leak, the PC must not be clamped.

Removal

The criteria for the removal of the PC is the same as that of an LBCD. The most important criteria are the reversal of the indication for insertion. In the case of pleural effusions, the PC is removed when the drain is less than 200ml/day **(**6,8**)**. In pneumothorax, the PC is removed once the lung has completely expanded and there is no air leak or the PC has stopped functioning. **(**6,8**)** The PC is removed in a swift motion, and breath-holding is not mandatory, as there is no difference in the rate of pneumothorax on drain removal in inspiration or expiration. **(**10**)** The incision is sutured and dressing is done.

Complications

Common complications
PC related: malposition/ dislodgement or kinking/ blockage
Pain
Infection- wound / intrapleural
Bleeding (usually minimal)
Rare complications
Visceral injury- Lung/Diaphragm/Heart/Liver/Spleen
Pneumothorax
Re-expansion pulmonary edema Major bleeding

Table 4: Complications of PC insertion

The most common complications linked to small-bore catheters are blockade, dislodgement, malposition, and kinking.**(**11**)(Table 4)** Other complications are procedure-related such as pain, bleeding and infection.**(**6**)** Infection of the surrounding wound can occur if proper asepsis is not maintained during the procedure.**(**8**)** Infection of the pleural space and empyema can occur if the PC is not handled with care and retrograde movement of bacteria occurs through the tube. Insertional complications, dry taps, and procedure failure are less common these days due to the use of ultrasound. **(**6**)** Life-threatening organ injury is a rare complication of PC insertion as the technique does not require blunt dissection, and the small-bore tube minimizes the risk of injury. **(**11**)**

Comparison with Large Bore Chest Drains

PC is easier to insert as compared to LBCD. Compared to the LBCD, PC insertion is better tolerated due to lesser pain and lesser perceived invasion **(**11**)**. Since PC is more flexible, it facilitates easy ambulation. **(**12**)** It causes significantly fewer complications, is minimally invasive and the scar left behind is also smaller.**(**11**)** The advantages and comparison of PC and LBCD have been compared in specific disease conditions that are mentioned in the text below.

Comparison of PC with LBCD In Specific Conditions Pneumothorax

Pneumothoraces of various etiologies have classically been drained using large bore drainage tubes. Sargent and Turner first reported the use of a small-bore catheter for draining pneumothoraces, by using a 9-french Teflon catheter by the trocar technique in 20 iatrogenic pneumothorax patients after percutaneous needle aspiration in 1970.**(**13**)** Later, 16 French catheters were reported to have a success rate of 80-95 % in iatrogenic pneumothorax.**(**14,15,16**)** The use of PC has been successfully reported not only in iatrogenic but also in spontaneous pneumothoraces. Park et al. reported that the use of 8-french catheter use did not present differences in clinical efficacy when compared to LBCD insertion in primary spontaneous pneumothorax (PSP), and was more comfortable for patients with reduced need for intravenous analgesics. **(**17**)** It was reported by Liu et al. that the insertion of fluoroscopy-guided pigtail catheter in spontaneous pneumothorax treatment did not present differences in tube indwelling period, air-reduction rate, and hospital stay when compared with conventional LBCD.**(**18**)** It was also associated with decreased activity restriction and had lesser overall complication rates when compared with LBCD.**(**18,19**)** In 2017, Riber et al demonstrated that the duration of hospitalization was reduced when PC was used as compared to the previous studies which had shown a hospital stay comparable to patients with LBCD.**(**20**)**

PC drainage appears to be a safe and promising technique in the treatment of the first episode of secondary spontaneous pneumothorax (SSP) and traumatic pneumothoraces. **(**21,22**)**

Bauman et al, studied 496 trauma patients with hemothorax/ hemopneumothorax, over 7 years and concluded that PCs had similar outcomes to LBCDs in terms of failure rate, tube insertion-related complications, and the initial drainage output from PCs was not inferior to that of LBCDs **(**23**)**.

Chang et al, in their meta-analysis comparing PCs and LBCD as the initial treatment of pneumothorax, reported that for spontaneous pneumothorax, the drainage duration and hospital stay are shorter in the PC group. They also reported, for SSP, the complication rate is significantly lower in the PC group. Collectively, the results of the meta-analysis suggest that the PC drainage may be considered as the initial treatment option for both PSP and SSP. **(**24**)**

A study done on the utility of PCs in the management of mechanically ventilated patients with pneumothoraces showed that drainage using PCs is relatively effective in iatrogenic

pneumothoraces but less promising in barotraumas associated pneumothoraces occurring in patients with ARDS on high PEEP.(25) In conclusion, patients with large air leaks or barotraumas / ARDS associated pneumothorax require an LBCD, rest can easily and perhaps, more safely be managed with PCs.

There are a few limitations with the use of PCs in pneumothorax. Negative suction and talc pleurodesis cannot be performed with PCs in pneumothorax. Hence, a likelihood or future need for the negative suction and talc pleurodesis should be assessed before the placement of PCs.

Simple Pleural Effusions and Empyema

PC is an effective way of draining simple, unlocated pleural effusions. (26) Loculated tubercular pleural effusions treated with PC drainage and streptokinase irrigation have shown better short- and long-term outcomes, as evidenced by greater pleural fluid removal, rapid resolution of pleural effusions, less occurrence of residual pleural thickening and improved lung function during the 12-months follow-up. (27) Lin et al reported no statistically significant difference in terms of severity of parapneumonic effusion, drainage days, hospital days, failure to drain, wound pain, and overall complications between children with PC and LBCDs.(28) Pierrepoint et al showed that, as compared to the conventional stiff drains, PC insertion in patients with simple parapneumonic effusions was associated with a significantly decreased period of the drain in situ, time to becoming afebrile, time to improve, and overall procedure to discharge time.(29)

Grodzin and Balk demonstrated that the use of a small indwelling pleural catheter was more cost-effective when used in place of a closed tube thoracostomy for drainage of large-volume pleural effusions. (30) The PC may have utility for exudative (stage I, American Thoracic Society) empyemas, although there is limited experience treating this entity with small-bore catheter drainage. Stage II (fibrinopurulent) and stage III (organized) empyemas require more invasive management with conventional LBCDs. (26) Pierrepointet aland Horsleyet suggested that PCs may be used initially in treating pleural empyema if there was no ultrasound evidence of loculation. (29,31) PC may be an effective and safe alternative for draining simple pleural effusions as compared to the more invasive LBCD. This has now been demonstrated in multiple studies and patients with large volume transudative pleural effusions, have been treated successfully with PC. Very often patients with cardiac, renal, and liver diseases present with symptomatic large volume transudative effusions.

These effusions tend to refill quickly and many times, need to be drained for symptomatic relief. In these patients, many physicians would shy away from putting an LBCD for the high risk of bleeding, either due to primary underlying disease or concomitant blood thinner therapy. In these patients PC based drainage seems to be an attractive option for large volume pleural fluid drainage. This has not been systematically studied in any large randomized studies.

Malignant Pleural Effusions

Malignant pleural effusion (MPE) is a common clinical problem associated with debilitating breathlessness in patients with poor performance status and short life expectancy. **(**32**)** Treatment options for MPE are determined by factors such as symptoms and performance status of the patient, the primary tumor type and its response to systemic therapy, and degree of lung re-expansion following pleural fluid evacuation **(**33**)**. MPEs are often most effectively managed by complete drainage of the effusion and instillation of a sclerosant for pleurodesis which prevents the recurrence of the effusion. **(**32**)**.

British Thoracic Society guidelines recommend small-bore chest tubes as the initial choice for effusion drainage and pleurodesis using a sclerosing agent in MPEs **(**33**)**. Recurrence at 4 weeks was reported to be similar between conventional LBCD and PCs. Literature suggests that small-bore chest tubes have comparable success rates to larger-bore chest tubes in these patients **(**34,37**)**. The duration of hospital stay was not significantly different whether LBCD or small-bore tubes were used **(**34,35,37**)**. PCs can be an excellent alternative for palliation in these patients, with no compromise in pleurodesis performance. **(**31**)** Many patients with advanced malignancies have a very low general condition. In these patients, PC insertion would be less traumatic and more gentle as compared to LBCD.

The Pleurx catheter system which has been recommended in patients with MPE is not readily available in our country and is expensive. PC based drainage of MPE in place of the Pleurx drainage system seems, to be a plausible option in many Indian patients with MPE. **Table 5** enlists the advantages and disadvantages of both PC and IPC in malignant pleural effusion **(**38**)**.

	Advantages	Disadvantages
Pigtail catheter (PC)	East to insert, similar to Large bore chest drain insertion	No cuff present at the distal end. Often dislodges if is not sutured securely.
	Low cost	No one-way valve present. Need to keep the PC connected to the bag always.
	Catheter tract metastasis, peri-catheter leakage, catheter fracture on removal is not common	Needs to be monitored by a healthcare worker
Indwelling pleural catheter (IPC)	The polyester cuff in the tunnelled portion of the catheter promotes tissue fibrosis and avoids inadvertent catheter dislodgement.	The insertion technique requires tunnelling, has a learning curve.
	One-way valve permits ambulatory drainage of fluid, the catheter can be 'opened' and connected to drainage devices when needed	Expensive
	Drainage can be done by the patient, depending on the rate of fluid re-accumulation and dyspnea.	Catheter tract metastasis, peri-catheter leakage, catheter fracture on removal is common

Table 5: Advantages and disadvantages of PC and IPC insertion in Malignant pleural effusions.

Conclusion

Overall, it can be concluded that PCs are a simple, effective, and easy alternative to LBCD for managing most pleural effusions and pneumothoraces. Patient compliance is higher, pain score is lower and the complications are minimal when the PCs are inserted under image guidance. More studies are required to ascertain the role of PCs in empyemas, loculated pleural effusions and pneumothoraces, large air leaks, and barotraumas / ARDS associated pneumothoraces. PCs might replace the conventional LBCD in the years to come in certain predefined situations.

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