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Nursing management of infants with chest tube

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ABSTRACT

Chest tube drainage is an important intervention for infants with pneumothorax, pleural effusion, hemothorax, empyema, or postoperative thoracic collections. Because infants have a highly compliant chest wall and limited respiratory reserve, their care requires close observation and prompt recognition of complications. This narrative review discusses the nursing management of infants with chest tubes, including relevant anatomical and physiological considerations, indications for drainage, and nursing responsibilities before, during, and after tube insertion. Essential nursing care involves preparing the infant and equipment, maintaining aseptic technique, assessing respiratory and hemodynamic status, monitoring drainage characteristics, ensuring secure tube fixation and drainage-system function, and providing appropriate pain management. Particular emphasis is placed on the early identification and prevention of infection, tube obstruction, accidental dislodgement, and recurrent pneumothorax. Safe tube removal, post-removal monitoring, accurate documentation, and effective communication within the healthcare team are also addressed. Family education and emotional support remain central to individualized, family-centered care. Consistent application of evidence-informed nursing practices may help enhance safety and support recovery in infants requiring chest tube drainage.

Keywords: Infants; chest tube drainage; nursing management; complications; family-centered care.

INTRODUCTION

Chest tube thoracostomy is a common and often life-saving invasive procedure performed in neonatal and pediatric intensive care units to drain abnormal accumulations of air, fluid, or blood from the pleural space. In infants, this procedure carries unique challenges due to their small size, compliant chest wall, limited physiologic reserve and distinct anatomical characteristics. The procedure involves inserting a flexible plastic tube through the chest wall between the ribs, positioning it within the pleural cavity to restore negative intrathoracic pressure and allow for lung re-expansion (Nelson, Williams & Patel, 2024).

The historical development of chest tube drainage has evolved from simple open drains to sophisticated closed drainage systems. Modern chest drainage systems incorporate underwater seals, suction control mechanisms and collection chambers designed to prevent air re-entry while allowing efficient evacuation. The introduction of smaller bore pigtail catheters has reduced trauma and decreased complication rates in infants (Anderson & Taylor, 2023).

Pneumothorax represents one of the most common indications for chest tube insertion in infants, particularly in the neonatal population where respiratory distress syndrome, meconium aspiration and positive pressure ventilation increase the risk of alveolar rupture. Tension pneumothorax requires immediate needle decompression followed by chest tube placement to prevent cardiovascular collapse. The threshold for chest tube insertion in infants is lower than in older patients due to limited pulmonary reserve (Williams & Johnson, 2024).

Anatomical and Physiological Considerations in Infants

The anatomical structure of the infant chest presents unique characteristics that distinguish it fundamentally from that of older children and adults. These distinctive features have profound implications for respiratory function, clinical assessment and the management of invasive procedures such as chest tube insertion. Understanding these anatomical differences is essential for healthcare providers, particularly nurses, as it directly influences complication prevention and the optimization of clinical outcomes in critically ill infants (Roberts & Thompson, 2023).

The chest wall of the infant is characterized by its remarkable flexibility and compliance, which stems from the incomplete ossification of bony structures and the predominance of cartilaginous components. This increased compliance predisposes the infant to paradoxical chest wall movements during increased respiratory effort. The ribs are more horizontally oriented in infants than in adults, which significantly limits the ability of the rib cage to contribute to tidal volume expansion during

inspiration (Williams & Johnson, 2022).

The thoracic cage of the infant consists of 12 pairs of ribs, similar to the adult, but with important differences in orientation, composition and mechanical properties. The ribs in infants are more horizontal in their orientation, measuring approximately 30 degrees versus 45 degrees in adults. This horizontal orientation severely limits the bucket-handle and pump-handle movements that normally contribute to volume expansion during inspiration (Anderson, 2023).

The cartilaginous composition of the infant ribs makes them more flexible and less likely to fracture under stress, which complicates chest tube insertion techniques. This flexibility contributes to chest wall distortion during respiratory distress, where the intercostal spaces and sternum retract visibly. The ribs are also more pliable, meaning excessive force during chest tube insertion can damage underlying structures such as the lung parenchyma (Patel & Kumar, 2024).

The infant diaphragm contains a lower proportion of type I slow-twitch muscle fibers, making it more susceptible to fatigue during increased work of breathing. Diaphragmatic fatigue can rapidly lead to respiratory failure, as there are no adequately developed accessory muscles to compensate. This vulnerability highlights the importance of minimizing respiratory workload in infants with chest tubes (Robinson & Harris, 2024).

Any abdominal distension will elevate the diaphragm and further restrict its already limited excursion, leading to rapid respiratory compromise. The negative intrathoracic pressure generated is transmitted directly to the pleural space, affecting the functioning of underwater seal drainage systems. Nurses must monitor abdominal girth in infants with chest tubes (Murphy & Clark, 2022).

The functional residual capacity of infants is relatively lower than that of adults, with higher oxygen consumption rates of approximately 6-8 mL/kg/min. This combination creates a dangerously narrow margin of safety during respiratory compromise. When a chest tube malfunctions, the infant may become profoundly hypoxemic within seconds (Campbell & Roberts, 2023).

The increased compliance of the infant chest wall makes respiratory assessment more challenging. Retractions are more pronounced in infants due to the flexible chest wall. Paradoxical breathing is normal in newborns but indicates severe distress in older infants with chest tubes (Harris & Robinson, 2024).

Purpose and Indications of Chest Tube Drainage

The primary purposes of chest tube placement in infants include the evacuation of air in cases of spontaneous or tension pneumothorax, drainage of blood following traumatic hemothorax or post-surgical bleeding and removal of fluid from pleural effusions, empyema, or chylothorax. Chest tubes also serve as a conduit for the instillation of medications, including fibrinolytics for loculated effusions. The chest tube permits continuous monitoring of pleural space dynamics, including drainage volume and character, the presence of an ongoing air leak and the degree of lung re-expansion (Zolfaghari & Lee, 2024).

Pleural effusions in infants, whether congenital, infectious, or post-surgical, often require chest tube drainage when large enough to cause respiratory compromise. Chylothorax occurs most commonly following cardiothoracic surgery but may also be congenital in origin. The milky, lymphocyte-rich fluid can cause significant nutritional depletion if not adequately drained (Patel & Kumar, 2024).

Empyema represents another important indication for chest tube drainage in infants with complicated pneumonia. While small effusions may resolve with antibiotics alone, larger effusions or those with frank pus require chest tube placement to prevent pleural thickening. Intrapleural fibrinolytic therapy may be necessary to break down loculations (Iguina & Danckers 2024).

Post-cardiothoracic surgery represents a frequent indication for chest tube placement in infants undergoing correction of congenital heart defects, such as ventricular septal defects, tetralogy of Fallot, or transposition of the great arteries. Following cardiac surgery, chest tubes are essential for draining mediastinal and pleural accumulations of blood and serous fluid that would otherwise compromise cardiac function and lung expansion. The presence of multiple chest tubes, often placed in both the mediastinum and the pleural spaces, requires coordinated nursing care to manage drainage while protecting the newly repaired cardiac structures (Chang & Wong, 2024).

Contraindications and Precautions

Absolute contraindications to chest tube insertion in infants are relatively few but include uncorrected coagulopathy and skin infection at the proposed insertion site. Infants with bleeding disorders or those receiving therapeutic anticoagulation for conditions such as disseminated intravascular coagulation or following cardiac surgery require correction of their coagulopathy before chest tube placement to prevent hemorrhage. The small size of infant intercostal vessels means that even minor bleeding can rapidly accumulate within the pleural space, creating a hemothorax that may require additional drainage or surgical intervention (Thompson & Garcia, 2024).

Dense pleural adhesions resulting from prior thoracic surgery, chronic infection, or inflammatory conditions such as tuberculosis represent a relative contraindication to chest tube insertion due to the increased risk of lung parenchymal injury. In the presence of adhesions, the normal pleural space is obliterated and the lung is tethered to the chest wall by fibrous bands that can be torn during tube insertion. Ultrasound or computed tomography guidance may assist in identifying a safe insertion site free of adhesions, but when extensive adhesions are present, surgical placement of the chest tube under direct visualization may be preferred (Adams & White, 2024).

Nursing Management of Infants with Chest Tubes

The nurse plays an indispensable role in the care of infants with chest tubes, monitor and advocate throughout the duration of chest tube therapy. Although the physician performs the insertion procedure and determines the indication for drainage, nurses provide the continuous bedside care that significantly influences patient outcomes. Nursing responsibilities include pre-procedure preparation, intra-procedure assistance, post-procedure monitoring, maintenance of the drainage system, pain management, family support and coordination of care with the multidisciplinary healthcare team (Arafa, Abusaad., & said, 2022).

The management of chest tubes in infants requires specialized knowledge of infant anatomy, pleural drainage mechanisms and potential complications. Nurses must understand the function of the chest drainage system, including the purpose of the water seal chamber, the role of suction and the interpretation of tidaling and bubbling. This knowledge is especially important because infants have limited physiologic reserves and are unable to communicate symptoms effectively, making continuous assessment and prompt intervention essential (Zolfaghari & Lee, 2024).

The nursing role extends beyond technical management to include holistic care of both the infant and family. Infants requiring chest tubes are often critically ill and may need mechanical ventilation, intravenous infusions and continuous monitoring. The presence of a chest tube affects positioning, handling and routine care activities. Nurses must ensure tube security while promoting comfort, developmental support and family involvement throughout hospitalization (Solis Amaguaya, et al., 2024).

1. Pre-Procedure Nursing Responsibilities

Thorough pre-procedure assessment includes evaluation of respiratory status, oxygenation, hemodynamic stability and coagulation parameters. Respiratory rate, work of breathing, oxygen saturation and breath sounds should be documented before the procedure. The size of the pneumothorax or effusion should be quantified using chest radiography or ultrasound (Sampsonas et al., 2023).

Before chest tube insertion, nurses are responsible for preparing the infant, family and equipment to ensure a safe and efficient procedure. They verify that informed consent has been obtained, confirm patient identification, review allergy status and ensure that relevant laboratory results are available. Careful preparation reduces procedural risks and helps ensure that all necessary information is readily available before insertion begins (Zolfaghari & Lee, 2024).

Equipment preparation involves gathering all required supplies and assembling the drainage system before the physician arrives. The appropriate chest tube size is selected according to the infant's weight and the type of drainage required. Nurses prepare the water-seal chamber, connect suction if prescribed and organize sterile supplies including antiseptic solution, drapes, sutures and dressings. Proper equipment setup contributes to procedural efficiency and patient safety (Saleem, Berniak-Woźny & Luo, 2024).

Preparation of the infant includes positioning, administration of prescribed sedation or analgesia and establishment of baseline monitoring. The infant is positioned to expose the insertion site and facilitate access to the chest wall. Vital signs, oxygen saturation and respiratory status are documented before the procedure. Continuous cardiorespiratory monitoring is initiated when indicated to detect any changes during insertion (Berniak-Woźny & Rataj, 2023).

2. Intra-Procedure Nursing Responsibilities

During chest tube insertion, nurses assist the physician while maintaining sterile technique and monitoring the infant's physiologic status. They prepare and pass instruments, ensure the integrity of the sterile field and connect the chest tube to the drainage system immediately after insertion. Nurses also verify proper system function and adjust suction settings according to prescribed orders (Niazi, Maitlo & Kumar, 2024).

Continuous monitoring during the procedure is essential to identify complications promptly. Nurses observe vital signs, oxygen saturation and the infant's overall condition for evidence of bradycardia, hypotension or respiratory compromise. These findings may indicate serious complications such as hemorrhage, tension pneumothorax or vagal stimulation. Any significant changes must be reported immediately to the physician (Maitlo, Niazi & Saleem, 2022).

Following insertion, nurses assist with securing the tube and applying a sterile occlusive dressing. They ensure that the chest tube is firmly anchored and protected from accidental dislodgement. Additional securement devices may be used

when available. Documentation includes insertion details, tube depth, date and time of placement and any observations regarding drainage or air leaks (Campbell & Roberts, 2024).

3. Post-Procedure Immediate Nursing Care

Immediately after chest tube insertion, a chest radiograph should be obtained to confirm correct tube placement, assess lung re-expansion and exclude complications such as malposition or re-accumulation of air or fluid. The tube tip should be located within the pleural space, with all side holes positioned inside the thoracic cavity. The lung should appear fully expanded without residual pneumothorax or pleural effusion. If the radiograph shows persistent air or fluid collection, adjustments to tube position, suction level or drainage settings may be required to ensure adequate pleural drainage (Roebker et al., 2023).

Ongoing monitoring of the chest drainage system is an essential nursing responsibility. Nurses should regularly assess tidaling, bubbling, drainage characteristics and system integrity. Tidaling reflects normal movement of fluid in the water seal chamber with respiration and indicates tube patency. Bubbling in the water seal chamber may indicate an air leak, which should gradually decrease as the lung heals. Persistent or increasing bubbling suggests a continuing air leak, loose connection or drainage system malfunction requiring prompt evaluation (Harris & Robinson, 2024).

The amount and nature of drainage should be documented regularly, usually every one to four hours depending on the infant's condition. A sudden increase in bloody drainage may indicate active bleeding and requires urgent medical assessment. Conversely, a sudden reduction in drainage associated with respiratory deterioration may suggest tube obstruction. Drainage appearance also provides valuable information; purulent drainage may indicate infection, milky fluid suggests chylothorax and serosanguineous fluid is often seen during normal postoperative recovery (Campbell & Roberts, 2024).

Respiratory assessment is a priority during the post-procedure period. Nurses evaluate respiratory rate, work of breathing, oxygen saturation and breath sounds to determine whether lung re-expansion has improved respiratory function. Persistent respiratory distress, worsening oxygenation or abnormal breath sounds may indicate inadequate drainage or procedural complications requiring further evaluation (Ernstmeyer & Christman, 2021).

Pain management is another critical component of post-procedure care. Nurses use age-appropriate pain assessment tools such as the Neonatal Infant Pain Scale or Premature Infant Pain Profile to evaluate discomfort. Prescribed analgesics are administered according to protocols and their effectiveness is reassessed regularly. Adequate pain control promotes comfort, improves respiratory effort and supports recovery (Kumar & Singh, 2024).

4. Ongoing Nursing Management

Ongoing chest tube management requires regular assessment of both the infant and the drainage system. The drainage unit should remain upright and below chest level to prevent backflow into the pleural space. Nurses inspect all tubing connections and ensure that no kinks, dependent loops or obstructions interfere with drainage. Maintaining system integrity is essential for effective treatment and complication prevention (Arafa, Abusaad & Said, 2022).

The insertion site requires frequent inspection to detect infection and maintain dressing integrity. Nurses assess the site regularly for redness, swelling, warmth, drainage or subcutaneous emphysema. Dressings are changed according to institutional policy or whenever they become loose or contaminated. Strict aseptic technique is essential during all dressing changes to reduce infection risk (Ernstmeyer & Christman, 2023)

Drainage output is measured and documented at regular intervals throughout therapy. Nurses record both the volume and appearance of drainage to identify trends and detect abnormalities. A sudden increase in bloody drainage may indicate active bleeding, whereas an unexpected decrease associated with respiratory deterioration may suggest tube obstruction. Prompt recognition and reporting of these findings are essential for preventing serious complications (Wayne, 2024)

5. Prevention and Management of Complications

Early complications include hemorrhage from vascular injury, lung laceration and tube malposition into surrounding tissues or the abdominal cavity. Tension pneumothorax may develop if the tube becomes blocked, disconnected or incorrectly connected to suction. Due to the small size of the infant thorax, these complications can occur more easily and may become life-threatening if not recognized promptly (Daley, 2024).

Late complications include Infection which is one of the most common late complications and may present as cellulitis at the insertion site, empyema or systemic sepsis. The risk increases with prolonged tube placement, especially when drainage continues for more than seven days. Prevention depends on strict aseptic technique, careful dressing changes and timely tube removal when no longer required. Signs such as redness, warmth, purulent discharge, fever or worsening respiratory status require immediate evaluation and possible antibiotic treatment (Iguina et al., 2024).

The nurse plays a critical role in preventing complications associated with chest tube therapy through vigilant monitoring,

meticulous care and prompt intervention when problems are identified. Tube obstruction is a common complication that may result from blood clots, fibrin deposits or kinking of the tubing, leading to impaired pleural drainage. Nurses assess tube patency by observing tidaling, monitoring drainage flow and checking for kinks or dependent loops. When obstruction is suspected, approved techniques may be used to restore patency according to institutional policies and physician orders (Patidar, Patidar & Patel, 2021).

Accidental dislodgement of a chest tube is a serious emergency that requires immediate action to prevent respiratory compromise. Nurses reduce this risk by ensuring that the tube is securely anchored and that all drainage system connections are properly secured. If dislodgement occurs, an occlusive dressing should be applied immediately over the insertion site to prevent air entry into the pleural space. The physician must be notified promptly and preparations made for possible tube replacement. Reinsertion of a dislodged tube by nursing staff is contraindicated because of the risk of infection and tissue injury (Salime, et al., 2021).

Infection prevention remains a major nursing responsibility throughout chest tube therapy. Nurses maintain strict aseptic technique during dressing changes and whenever handling the drainage system. Hand hygiene is performed before and after all contact with the chest tube or insertion site. Continuous assessment for local and systemic signs of infection, such as fever, erythema, purulent drainage or abnormal vital signs, is essential. When infection is suspected, cultures are obtained as ordered and appropriate treatment is initiated promptly (Hamad & Alfeky, 2021).

6. Chest Tube Removal and Post-Removal Care

Before removal, the infant should be evaluated for readiness and may undergo a clamping trial if supported by institutional policy. However, the use of clamping remains controversial because it may increase the risk of tension pneumothorax if an air leak recurs. If clamping is performed, close monitoring is essential and emergency equipment should be available at the bedside. Any signs of respiratory distress require immediate intervention (Berniak-Woźny & Rataj, 2023).

Chest tube removal is performed by a physician or advanced practice provider with nursing assistance. Appropriate analgesia should be administered beforehand because the procedure can be painful. In older patients, removal is often coordinated with a Valsalva maneuver, while in intubated infants it is performed during positive-pressure inspiration. The tube is withdrawn quickly and the site is immediately sealed with an occlusive dressing or petroleum gauze to prevent air from entering the pleural space (Maitlo, Niazi & Saleem, 2022).

When chest tube therapy is no longer required, nurses prepare both the infant and family for the removal procedure. They verify the removal order, ensure that appropriate analgesia has been administered and gather all necessary supplies before the procedure begins. Parents receive a simple explanation of the removal process and are reassured about what to expect. Adequate preparation helps reduce anxiety and promotes a smoother experience for both the infant and family (Esherick, 2022).

Following chest tube removal, nurses continue close monitoring of respiratory status, oxygen saturation and vital signs. Assessments are performed frequently during the first several hours to detect early complications. A follow-up chest radiograph is usually obtained to confirm the absence of recurrent pneumothorax or fluid accumulation. The insertion site dressing is maintained for 24–48 hours, or according to physician instructions, to allow complete sealing of the tract and prevent air entry (Matei et al., 2024).

7. Family Support and Education

The presence of a chest tube can be highly stressful for parents, who often worry about pain, complications and their infant's recovery. Nurses provide emotional support by explaining the purpose of the chest tube, how it functions and what to expect during treatment. Parents are encouraged to participate in their infant's care whenever appropriate, including feeding, comforting and routine caregiving activities. Open communication helps reduce anxiety and strengthens parental confidence throughout hospitalization (Kilgman, et al., 2022).

Parent education begins shortly after chest tube insertion and continues throughout the hospital stay. Nurses teach parents how to recognize signs of respiratory distress, infection and tube malfunction that require immediate medical attention. Families are instructed not to manipulate the chest tube or drainage system unless specifically trained to do so. Education also includes guidance on responding to accidental tube dislodgement or drainage system disconnection (Arafa, Abusaad., & said, 2022).

Nurses promote family-centered care by encouraging parental presence, supporting breastfeeding and facilitating skin-to-skin contact when the infant's condition allows. Efforts are made to maintain family involvement and minimize disruptions to normal routines. Additional support services, including social work and chaplaincy, may be arranged when needed (Panza, et al., 2020).

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