Neonatal Subcutaneous Emphysema Secondary to Chest Tube Placement Using the Trocar Technique: A Case Report

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Abstract

Subcutaneous emphysema (SE) is a type of air leak in which air accumulates within the subcutaneous layer of the skin underneath the dermal layers. The accumulation of air can be seen on imaging in relevant body areas such as the abdomen, chest, face, or neck. During physical examination, crepitus, the sensation or sound of crackling upon palpation, is the most common associated finding. Various causes for SE exist with one such cause being thoracostomy, or chest tube placement. Chest tube placement is invasive and as such can result in complications. The trocar technique particularly has been associated with greater complications compared to other techniques. At this time, much of the knowledge regarding subcutaneous emphysema related to chest tube placement is in the adult population. Here we present a case of subcutaneous emphysema in a neonate occurring after placement of chest tube using the trocar technique. We hope to bring awareness to this complication in neonates and add to the growing body of knowledge regarding this topic.

Categories: Pediatrics, Radiology, Pulmonology

Keywords: neonatal intensive care unit (nicu), thoracostomy tube, pneumothorax, pigtail, trocar, chest tube, neonate, subcutaneous emphysema

Introduction

Subcutaneous emphysema (SE) refers to a type of air leak in which there is presence of air within the subcutaneous layer of the skin [1]. SE occurs when gas or air accumulates and seeps under the skin, where normally no gas should be present. Subcutaneous refers to the subcutaneous tissue, and emphysema refers to trapped air pockets. Since the air generally comes from the chest cavity, subcutaneous emphysema usually occurs around the upper torso, such as on the chest, neck, face, axillae and arms, where it is able to travel with little resistance along the loose connective tissue within the superficial fascia. In most cases, the air leak manifests as visible distension or bloating in the chest, abdomen, neck or face. The most common notable finding is crepitus, a characteristic sound and sensation of crackling upon palpation of the affected areas [1]. Common causes of subcutaneous emphysema include tissue infections, blunt or penetrating trauma, intubation, and iatrogenic [2]. In hospitalized patients, SE commonly occurs because of pneumothorax or pneumomediastinum [2]. Imaging such as chest x-ray (CXR) and chest computed tomography (CT) scan can aid in diagnosis. On CXR, intermittent areas of radiolucency often appear as areas of fluffiness on the exterior borders of the thoracic walls. More specifically, there can be striations of gas along the pectoralis major, a finding known as the ginkgo leaf sign [1]. CT scans will show gas in the subcutaneous layer, demonstrated as dark pockets. Although CXRs are often the most immediate diagnostic tool, CT may be more sensitive in determining the source of injury [1].

While the presentation of SE has been well documented in the adult population with signs and management clearly defined, it is a rarely documented occurrence in the neonatal population [3]. In neonates, subcutaneous emphysema occurrence is associated with pneumothoraces or pneumomediastina, either as secondary presentations or consequence of treatment for these conditions [3]. Both pneumothoraces and pneumomediastina are often treated conservatively. However, thoracostomy, or chest tube placement, is a commonly utilized procedure when conservative management fails or is not appropriate for treatment. Other indications for chest tube placement include removal of abnormal fluid accumulation. Examples of these include pleural effusions, hemothoraces, empyemas, and chylothoraces [4].

When chest drainage is required, options for tube placement include traditional chest tube placement using a trocar with dissection or using a pigtail catheter. As the name suggests, the trocar technique utilizes a rigid tip trocar to insert the chest tube through the outside tissue and intercostal muscle layers and into the pleural cavity. While all methods are invasive and thus can result in technical and/or infectious complications, studies have shown that the trocar technique carries higher risk of complications and often leads to more intrathoracic or extrathoracic injuries compared to other methods [4]. However, almost all these cases have been documented in the adult population with little data regarding neonates. Here we present a case of subcutaneous emphysema in a neonate occurring after placement of chest tube using the trocar technique.
Case Presentation

A late term, 41+1 weeks appropriate for gestational age (AGA) male newborn delivered via cesarean section due to arrest of cervical dilation and failure to progress to a 22-year-old gravida 1 para 1 with adequate prenatal care (PNC). Mother was rubella equivocal and group B Streptococcus (GBS) positive with adequate treatment, all other serologies were negative. The membrane was ruptured artificially about 9 hours prior to delivery with clear amniotic fluid. APGAR scores were 8/8 and the newborn exam showed a normal neonate in no acute cardiopulmonary distress.

Approximately 4 hours after birth, the neonate began to desaturate in the nursery with oxygen saturations ranging from 85-92% with a difference in pre- and post-ductal saturations of about 3-5 points. During episodes of crying, desaturation was more prominent with levels reaching 70s but otherwise stable vitals. On the physical exam, the neonate was pale, capillary refill time was about 4-5 seconds, and heart sounds were faint on the left and more pronounced on the right.

Single film CXR showed a small, right-sided pneumothorax, a depressed left hemidiaphragm, a right-sided shift of mediastinum, and a developing left-sided tension pneumothorax. A repeat 4-view CXR showed moderate sized right pneumothorax, mild right basilar opacity suggestive of atelectasis, and a large left-sided pneumothorax that had worsened since initial imaging with signs of tension pneumothorax. Echocardiogram revealed a patent foramen ovale and small patent ductus arteriosus but was otherwise normal. The neonate was transferred to the neonatal intensive care unit (NICU) and placed on 1L high flow nasal cannula (HFNC).

In the NICU, a 10 French Trocar thoracostomy was performed at the left midline. The tube was placed on continuous suction with bursts of air and serosanguineous fluid. Post-procedural CXR confirmed proper chest tube placement and slightly increased right sided pneumothorax (Figures 1, 2). At this time, breath sounds were noted to be decreased in the left upper area.
FIGURE 1: Chest x-ray at day 1 of life documenting the presence of large left sided tension pneumothorax after chest tube placement. There is a moderate-sized right pneumothorax which is partially obscured by the mediastinal shift.
FIGURE 2: Chest x-ray on day of life 1 after left chest tube placement without signs of subcutaneous emphysema.

Approximately 10 hours later, repeat 2-view CXR showed signs of left sided subcutaneous soft tissue emphysema on the left chest wall (Figure 3). Up to this point, the neonate had intermittent tachypnea with respirations in the 60s-80s and mild retractions but was otherwise stable with oxygen saturations ranging from 91-100% on 1L HFNC with fraction of inspired oxygen (FiO2) of 21-40%. Complete blood count (CBC), comprehensive metabolic panel (CMP), and capillary blood glucose (CBG) were all within normal limits.
FIGURE 3: Chest x-ray on day of life 1 showing initial left sided subcutaneous emphysema.

On his second day, the neonate presented with respiratory distress most likely secondary to spontaneous pneumothoraces and transient tachypnea of the newborn (TTN). Repeat CXR showed left sided subcutaneous emphysema, decrease in size of pneumomediastinum, and small bilateral pneumothoraces. Chest tube suction was turned off and the neonate was weaned off HFNC to room air.

On his third day, repeat CXR showed small right and left basilar pneumothoraces unchanged from before and increase in size of the left sided subcutaneous emphysema on the chest wall. The emphysema was found to be larger and tracking to the upper chest and abdomen anteriorly and posteriorly (Figure 4). At this time, the neonate’s respiratory distress was resolving with mild retractions and stable oxygen saturations of 92-100% on room air.
Repeat CXR on day 4 showed a decrease in size of the left pneumothorax while the right remained unchanged. The large subcutaneous emphysema was noted to be slightly decreasing. The chest tube was removed as the patient was clinically improving. Repeat CXR on day 5 showed that the subcutaneous emphysema was still present on the left chest wall and upper abdomen and unchanged from prior imaging. On exam, significant crepitations along the entire chest, back, and abdomen were still appreciated. However, no respiratory distress or increased work of breathing were noted, and the neonate was still deemed clinically stable.

On day 6, repeat CXR showed that the bilateral pneumothoraces were fully resolved (Figures 5, 6). Subcutaneous emphysema was still present in imaging and crepitations were appreciated on exam as before. The neonate was otherwise stable with no signs of distress. At this time, the neonate was discharged home with plans for outpatient follow up with their pediatrician.
FIGURE 5: Chest x-ray on day of life 6 showing resolution of pneumothoraces bilaterally with continued presence of left sided subcutaneous emphysema.
FIGURE 6: Chest x-Ray on day 6 of life documenting resolution of pneumothorax. A large amount of subcutaneous air overlies the left chest and upper abdomen. There are mild bilateral infiltrations. No obvious pneumothorax is identified.

Discussion

Tube thoracostomy is one of the most common thoracic procedures performed in operating rooms, emergency rooms, and intensive care units to remove fluid or air from the pleural space. The tubes can vary in size, particularly width, and there are different methods for inserting the tube. In neonates, methods for insertion include the use of a trocar or with a pigtail catheter via the Seldinger technique. When placing a tube using a trocar, the drain and trocar are inserted using excessive force \[5\]. In comparison, a pigtail catheter via the Seldinger technique involves a smaller bore tube with a guidewire and tract dilators, usually with ultrasound guidance \[4, 6\]. As an invasive procedure, any method of tube placement carries a substantial risk for complications. Broadly, complications fall into two categories - infectious or technical \[4, 7\]. More specifically, technical complications can be due to insertion, position, removal, or malfunction of the tube \[4, 7\]. Compared to the pigtail catheter, the use of a trocar is believed to be associated with a higher complication rate due to the rigid nature of the trocar and the excess force required \[4, 5, 6, 7\]. The most reported complication by trocar is insertional complications with injury to intrathoracic and/or extrathoracic organs \[4\]. In adults, Mohan et al concluded that the trocar technique should be avoided and instead blunt dissection with digital exploration, another insertion method, should be utilized \[8\]. A separate study by Dural et al concluded that a modified technique combining trocar use with digital exploration resulted in less complications than a purely trocar approach \[5\]. In neonates, a retrospective study comparing pigtail catheter insertion via the modified Seldinger technique to trocar thoracostomy found that trocar technique resulted in longer procedure times. However, there was no statistically significant difference in length of chest tube stay, hospital stay, or complication rate \[9\]. Tube malposition/malfunction was the most common complication but without any significant difference between the two groups and neither group reported development of infection, laceration, hemothorax, subcutaneous emphysema, or need for surgical intervention \[9\]. While pigtail catheters are generally considered safer than insertion with trocars, a separate neonatal study suggested that complications from pigtail catheters, mainly lung perforation in the upper lobes, is more common than believed \[10\].
Subcutaneous emphysema (SE) has a variety of etiologies and can occur spontaneously, often as a sequela of infections, trauma, mechanical ventilation, or as complications from surgical/procedural interventions such as chest tube insertions [1]. In cases of trauma or procedural complications, the development of SE is thought to be due to injury to the parietal pleura which allows for air passage into the pleural and subcutaneous tissues [1]. A study that followed cases of SE over 10 years demonstrated that the mean age of patients with subcutaneous emphysema was 55 +/- 14.85, with a 71% of cases being male [1]. However, SE in neonates is a rare complication, most frequently occurring secondary to pneumothoraces and pneumomediatina [11]. The incidence of pneumothorax in neonates is found to be 1% in term neonates, and 6-10% in preterm neonates [12]. A pneumomediatinum is, like the word itself suggests, air trapped in the mediastinal area [1, 13] and was similarly found to have a 2.3% incidence in term neonates, 2% in preterm neonates, and 1% in neonates born via cesarean section [14]. Spontaneous pneumothorax can result in SE via the 'Macklin Effect' where alveolar rupture is followed by air leaking into the loose connective tissue that surrounds the pulmonary vasculature. From there it tracks along the broncho-vascular sheath and is therein free to continue along fascial planes [15]. Although our patient had a spontaneous pneumothorax, signs of subacute emphysema only began to develop about 10 hours after tube thoracostomy using the trocar technique. This is suggestive that for our patient, subcutaneous emphysema was most likely a result of the placement of the chest tube rather than the original spontaneous pneumothorax.

In patients with chest tubes, regardless of insertion technique, subcutaneous emphysema can occur when the parietal pleura is breached which then creates a pathway for air to directly enter the surrounding tissue. With the drain now in place, it is hypothesized that SE continues to develop due to the volume of air passing from the parietal pleura to the subcutaneous tissue exceeding the amount of air being removed from the pleural cavity via the drain [15].

For some patients such as ours, rapid treatment is often preferred and necessary. Neonates have a flexible chest wall, frail lung tissue, and vital structures in proximity. Since they have little compensatory lung reserve, in cases where they develop a pneumothorax, it can rapidly devolve into a serious situation [9]. For that reason, it’s imperative that those in the neonatal intensive care unit (NICU) be prepared to diagnose and rapidly treat air leaks to avoid morbidity and mortality [9]. It is for that reason perhaps that the trocar technique is still used in NICU patients. However, this advantage does not outweigh the high rate of complications associated with this technique, especially for already vulnerable patients such as neonates. In the case of our patient, the use of trocar technique most likely directly led to the development of subcutaneous emphysema. SE is usually self-limited and nonfatal but is not without its risks [1]. The expansion of air into the subcutaneous tissues can interrupt proper lung expansions which prevents patients from reaching appropriate tidal volumes. This can result in oxygen desaturations, respiratory distress, and even cardiac arrest [1].

Management of subcutaneous emphysema starts with treatment of the underlying cause, which generally leads to gradual resolution of the emphysema. For mild cases, observation is indicated as it is typically self-limiting and resolves in 10 days or less if the cause is treated [1]. In more severe cases, high concentration oxygen (high FiO2) is generally recommended. Oxygen replaces nitrogen in the pneumothorax and allows for gaseous diffusion and resolution of the pneumothorax and SE [1]. In the case of our patient, despite still having clinical signs of huge crepitus as result of subcutaneous emphysema, the patient remained clinically stable and showed no signs of respiratory distress. This complication resolved spontaneously with respiratory and symptomatic management. Subcutaneous emphysema, in rare cases, progresses to a life-threatening condition and subcutaneous emphysema due to mechanical ventilation may induce ventilatory failure. In our index case the SE was resolving without treatment at time the infant was discharged home, thus following the pattern of most SE which is typically self-limiting.

While data regarding risks and benefits is readily available for the adult population, data from the neonatal world tends to be scarce. We reported a case of a late term neonate who underwent chest tube placement via the use of a trocar that resulted in subcutaneous emphysema to enrich the literature on this topic.

**Conclusions**

Chest tube placement is one of the procedures done in the Neonatal Intensive Care Unit (NICU). Subcutaneous emphysema is a rare complication of pneumothorax or chest tube placement. Increase awareness of neonatal procedures leading to complications is highlighted in this case report. Since some complications can be life threatening, our hope is that neonatologists would take all the complications of procedures into consideration and report any of those to enrich the data coming from the neonatology world.

**Additional Information**

**Disclosures**

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