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CASE REPORT

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Pulmonary Interstitial Emphysema in Live Birth Determination: Radiographic and Gross Pathologic Features

ABSTRACT: Pulmonary interstitial emphysema (PIE) has previously been reported as a useful finding in the determination of live birth in cases where the birth and death were not attended. Herein, we present the radiographic and gross pathologic features of PIE in such a case. In this instance, in addition to parenchymal interstitial emphysema, there were subpleural air collections and a pneumothorax.

KEYWORDS: forensic science, pulmonary interstitial emphysema, asphyxia, live birth, infant death

Pulmonary interstitial emphysema (PIE) develops due to the accumulation of extra-alveolar gas secondary to alveolar wall rupture into the interlobular pulmonary vascular sheaths. A pressure gradient develops between the alveoli and the vascular sheath. The escaped air then extends along the planes of least resistance. Distal extension of the gas to the subpleural space may result in a subpleural gas collection or pneumothorax. Extension of the gas proximally leads to pneumomediastinum, with possible pneumothorax as well.

The most common precipitator is positive-pressure ventilation. We report on a newborn baby whose birth and death were not witnessed by medical personnel. Injuries present on the face and chest were interpreted as inflicted injuries. Radiographic and autopsy findings confirmed PIE manifested as subpleural blebs and a pneumothorax, indicative of live birth.

Case Report

The body of an approximately 38-week gestation (by weight and measurements) newborn was found discarded adjacent to a garbage pail outside a private residence. The infant was wrapped in a bloodstained blanket. On interviewing the residents of the building, it was determined that the mother was a 19-year-old primigravida who asserted that she did not know she was pregnant and upon going to the bathroom the baby fell out onto the floor. She stated that it was dead and did not breathe, and she denied any attempts at resuscitation. She then wrapped the baby in a blanket and discarded it.

The body was that of a 2.35 kg female baby with a normal umbilical cord and placenta still attached. There was no maceration, autolysis, or putrefaction. Her crown–heel and foot lengths were 47.0 and 7.5 cm, respectively. There were bilateral palpebral conjunctival petechiae, in addition to subscleral hemorrhage of the left eye. There were multiple abrasions and contusions of the nose and mouth (Fig. 1). Pre-autopsy radiographs showed a large col-

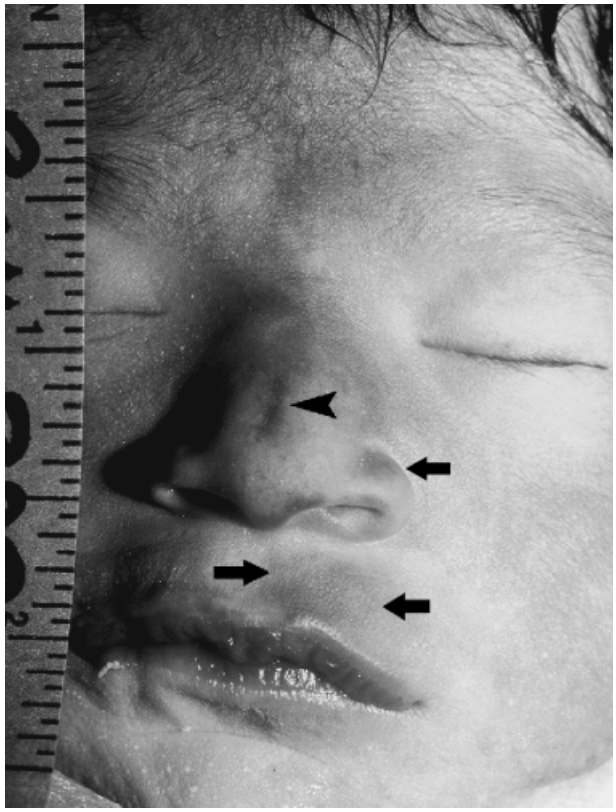

FIG. 1—*Baby's face showing multiple blunt trauma injuries, most notably an abrasion of the nose (arrowhead) and contusions of the nose and lip (arrows). Scale in inches.*

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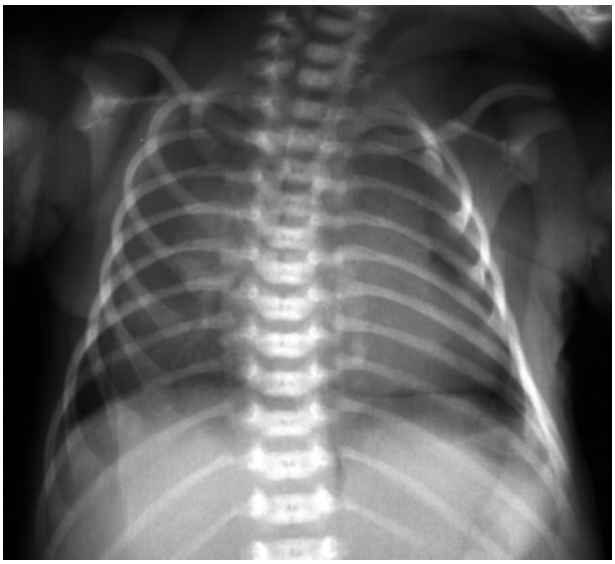

FIG. 2—*Frontal image of the chest demonstrates small air collection at the right lung base laterally and left pneumothorax.*

lection of air surrounding most of the left lung, compatible with pneumothorax (Fig. 2). There was a second much smaller collection at the right lateral costophrenic angle consistent with a subpleural bleb. Gas was present in the distribution of the stomach, better demonstrated on the oblique image (Fig. 3).

Internally, there was hemorrhage of the base of the tongue. There was a 1.5 cm area of hemorrhage in the area of the anterior left first and second intercostal spaces. On opening the thoracic cavity, several subpleural blebs were noted, mostly on the diaphragmatic surfaces of the lower lobes (Fig. 4). It is important to note that these blebs can deflate shortly after exposure; therefore, documentation of the gross findings must be obtained promptly. In addition there was a 1.5 cm contusion of the anterior wall of the left ventricle and anterior portion of the interventricular septum.

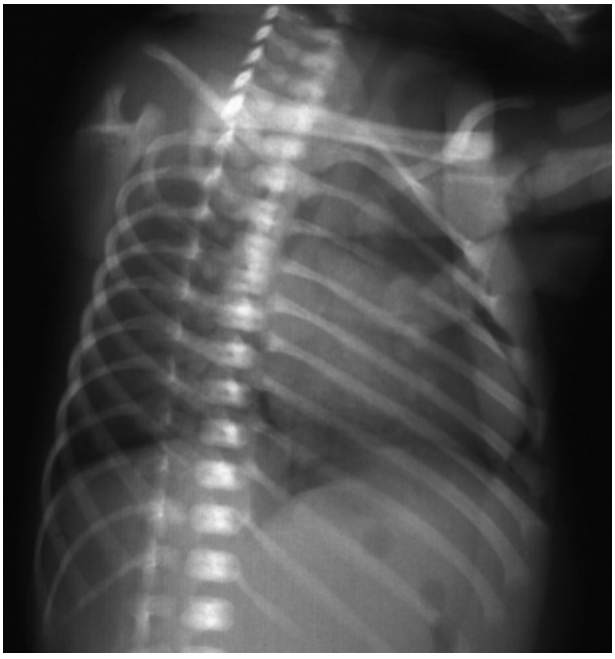

FIG. 3—*Left posterior oblique image, better demonstrating the left-sided pneumothorax and bubbles of gas in the distribution of the stomach.*

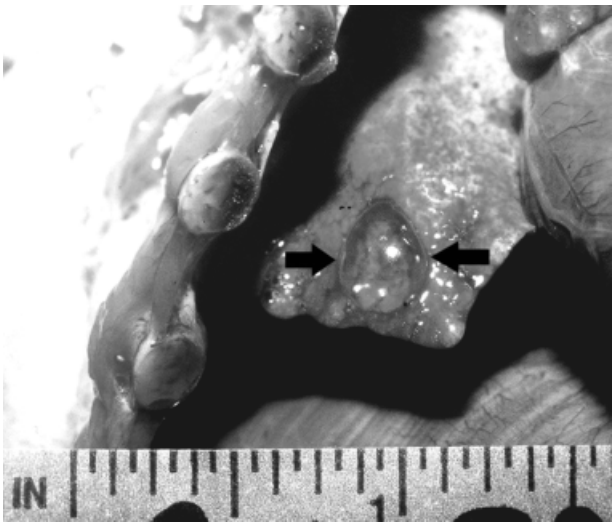

FIG. 4—*Autopsy photograph showing a sub-pleural gas-filled bleb of the right lower lobe (arrows). The cut ends of the right ribs are on the left and a portion of the right ventricle is seen, upper right. Scale in inches.*

There were no pulmonary congenital anomalies, inspissated secretions, or foreign objects in the airways. The lungs were buoyant in water. Prior to removing the gastrointestinal tract, the esophagus and duodenum were cross-clamped. The stomach was then opened under water and gas bubbles escaped from the lumen. Histologically, the lungs showed pockets of gas in the interlobular perivascular spaces, with extension to the visceral subpleural space where the pleura was elevated (Fig. 5).

The cause of death was attributed to smothering and compression of the neck and chest. When confronted with the autopsy findings, the mother's only admission was to wrapping up the baby and not seeking help. She subsequently pleaded guilty to criminally negligent homicide and was sentenced to 1 year in prison, to be followed by deportation to her country of origin.

Discussion

When the remains of a discarded child are found, it is important to determine (beyond a reasonable doubt) whether or not the child was born alive. Whether or not there was an independent extrauterine existence (circulatory and respiratory), however brief. If

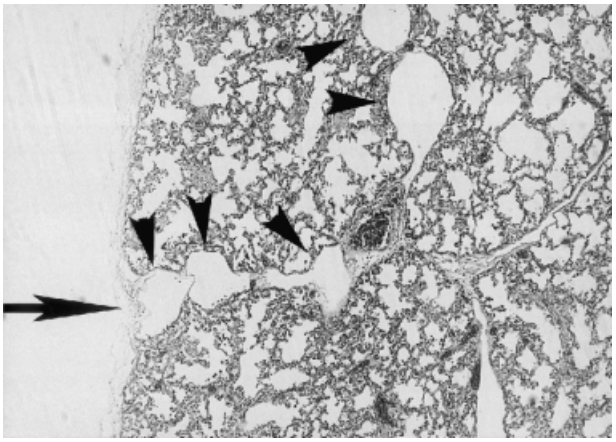

FIG. 5—*Hematoxylin–eosin-stained histologic section of lung (× 40). The alveoli are distended. Adjacent to the interlobular vessels are pockets of air, in a beaded pattern (arrowheads), extending to the pleural surface (arrow).*

the child was born alive and was developmentally capable of independent existence and its death resulted from violence or failure to provide the necessary care to the infant deliberately or by omission, the manner of death must be termed a homicide (1,2). The disposal of the infant's body also increases suspicion of infanticide. Occasionally, however, the death of the infant may be a result of natural causes (congenital abnormalities incompatible with life), and the body may have been disposed of to conceal the birth.

Traditionally, the criteria for determining live birth included the presence of air in the lungs, gastrointestinal tract, or middle ears, and also the presence of extrauterine materials in the stomach. Although the presence of air in the lungs, bowel, and the middle ears is valuable evidence of respiration, the limitations of these findings must be recognized. Attempted resuscitation by artificial respiration and postmortem gas formation due to decomposition may also result in the presence of gas in these areas. The presence of food in the stomach is absolute proof of live birth, given that swallowing is the only mechanism by which this occurs (2). Histologic evaluation of the umbilical cord stump (not useful in this case) for evidence of postnatal vital reaction may also be helpful in determining live birth.

Lavezzi et al. (3) were the first to use the presence of PIE as an indicator of live birth in newborn infants where the birth and death were unattended. Lavezzi et al. (4) in a later paper described 16 cases of "florid PIE" in liveborn infants. No manifestation of PIE was detected in 21 stillborn controls. They concluded that florid PIE is found only in liveborn infants. They defined florid PIE as the presence of markedly dilated interstitial spaces, often coalescing with subpleural dilated spaces, similar to those seen in our case. Since the fetus goes from a liquid to a gaseous environment at birth, PIE in a newborn is a lesion acquired outside the uterus. There is no mechanism for air entry into the lungs of an infant who is known to be stillborn (4). Gas may enter the airways by active inspiration (live birth) or forcibly during resuscitation.

In 1930, Joannides et al. (5) stated that the causes of interstitial emphysema in general included a sudden increase in the intrapulmonic air pressure resulting from physical straining (coughing, childbirth), or obstruction of the air passage by aspiration of a foreign material, which acts as a ball valve during unaided forceful respiration against the obstruction. Since the mechanism of breathing against an immovable object is a well-established cause of PIE, we agree with the conclusion of Lavezzi et al. (4) that suffocation is a competent explanation for PIE.

Joannides et al. (5) also recognized that PIE could complicate administration of general anesthesia in which the intrabronchial air pressure is increased as a result of positive pressure ventilation. Their proposed etiology of PIE was confirmed by Macklin and Macklin (6) in a landmark paper in 1944.

Prematurity and hyaline membrane disease, which decreases pulmonary compliance, also significantly increases the incidence of PIE in neonates (7,8). Other known risk factors for PIE include pulmonary anomalies and infection (pneumonia) (9). Only two infants have been described with spontaneous occurrence of localized PIE (10).

The typical radiographic appearance of PIE is that of linear interstitial air collections. Unlike air bronchograms, they do not branch and are usually subtle and disorganized. Subpleural air collections also may be a manifestation of PIE (11). They appear as thin-walled rounded lucencies on radiographs. Intrapulmonary gas-filled spaces, pneumomediastinum, and pneumothorax also may be seen. The differential diagnostic list includes pneumatocele, diaphragmatic hernia, congenital cystic adenomatoid malformation, lung abscesses, pre-existing bullae, cavitary infarcts, and loculated pneumothorax (12,13). Congenital lobar emphysema, air trapping due to foreign body, bronchiectasis, and idiopathic unilateral hyperlucent lung (Swyer–James) may have a similar appearance on plain film assessment. Precise differentiation among these entities relies upon the clinical presentation, and if necessary, computed tomography may be useful in the live infant.

The combination of radiographic and gross pathologic manifestations of PIE in this case are complementary and document the mechanics of air entry and the development of abnormal air collections in the newborn respiratory system. Careful evaluation of the radiographs is essential, as these gas collections are frequently inconspicuous. The mere presence of these collections indicates active air movement and some imposition of increased pressure. Therefore, in this and other similar settings, in the absence of resuscitative efforts, live birth can be proven with careful and expeditious documentation.

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