Review Article

The Radiological Manifestations of the Aberrant Air Surrounding the Pleura: In the Embryological View

Shih-Yi Lee,1,2 Chih-Hao Chen,2,3 Chin-Yin Sheu,2,4 Julie Hua Ying Tai,5 Sheng-Hsiung Yang,1,2 and Chao-Hsien Chen2,6

1 Division of Pulmonary and Critical Care Medicine, Mackay Memorial Hospital, Main Branch Hospital, Taipei 10449, Taiwan
2 Mackay Medicine, Nursing and Management College, Taipei 10449, Taiwan
3 Department of Thoracic Surgery, Mackay Memorial Hospital, Main Branch Hospital, Taipei 10449, Taiwan
4 Department of Diagnostic Radiology, Mackay Memorial Hospital, Main Branch Hospital, Taipei 10449, Taiwan
5 Semmelweis University, Budapest, Hungary
6 Division of Chest, Internal Medicine, Mackay Memorial Hospital, Main Branch Hospital, Taipei 10449, Taiwan

Correspondence should be addressed to Shih-Yi Lee, leesyi5538@yahoo.com.tw and Julie Hua Ying Tai, juliehuayingtai@gmail.com

Received 20 October 2011; Accepted 17 December 2011

Copyright © 2012 Shih-Yi Lee et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The radiological manifestations of the aberrant air surrounding the pleura are varied because of the air outlining the organs in and out of the visceral space. The continuity of the visceral space from the neck, mediastinum to the retroperitoneum is originated from embryological development, which is compatible with the findings through laboratory experiments, cadaveric anatomy, and thoracic computer tomography image. We reviewed the embryo development to understand the anatomy of body cavity, which can determine the radiological findings of pneumomediastinum and pneumothorax.

1. Introduction

During respiration, both lungs freely expand and collapse in the pleural space within the thoracic cavity. The pleural cavity, namely, is a space lined with pleura. The parietal pleura accompanied with ribs, muscles, and skin constitutes the thoracic wall. The visceral pleura covers the surface of both lungs (Figure 1).

The visceral pleura overlies both lungs in addition to the organs in the mediastinum [1] (Figure 2). It encloses a space, which is known as visceral cavity. The visceral cavity is continuous from the neck to upper abdomen (the level of T2 to L1). These anatomical relationships are established as early as embryo development and greatly influence the radiological signs of aberrant air surrounding the pleura, pneumothorax, and pneumomediastinum [2–4].

Embryo development occurs in the period of 3rd to 8th week of gestational age. The three layers of the germ disc (ectoderm, mesoderm, and endoderm) gives rise to specific tissues and organs [5]. The following cephalocaudal and lateral foldings of the germ disc establishes the primal spatial relationships of the fetus among different tissues and organs, including thoracic and abdominal cages, pleura and peritoneum, trachea, and intestine.

In this review, we will focus on the formation of the continuum of visceral space during embryo development and its relationships to the radiological signs of aberrant air surrounding the pleura.

2. The Body Cavity Formation

After fertilization of the human ovum, the zygote procedes to several stages of development: morula, blastocyst, implantation, bilaminar germ disc, trilaminar germ disc, embryonic period, and fetal period.

In the embryonic period, the lateral folding of the trilaminar germ disc forms the embryo in three-layer tube-like shape (Figure 3). This establishes the primitive anatomical
Figure 1: The thoracoscopic image shows the pleura overlaying the tissue and organs in the thoracic cavity: chest wall (1) and the lung (2).

Figure 2: The thoracoscopic image shows the pleura overlaying the tissue and organs in the mediastinum: heart (1), descending aorta (2), inferior pulmonary ligament (3), and diaphragm (4).

Figure 3: Diagram shows the model of lateral folding of germ disc.

Figure 4: Lateral folding of germ disc in the level of pharyngeal arches. Diagram shows the cells in the mesoderm proliferates and neural tube is forming.

relationships of the embryo: ectoderm on the surface, mesoderm in the middle, and endoderm inside. Nevertheless, this also shows the anatomical relationships of embryo on the level of pharyngeal arches [5] (Figure 4).

The embryo below the level of pharyngeal arches develops to the body cavity, which is originated from the mesoderm on each side of the midline. The cells in the lateral plate of mesoderm starts to divide into the parietal and visceral mesoderms to form the intracellular cavities. The results of the lateral folding develops the parietal mesoderm and the ectoderm to form the body wall; the visceral mesoderm and endoderm to form the gut wall; the intracellular cavities within the mesoderm to form the intraembryonic coelomic
3. The Compartmentalization of the Mediastinum and the Continuum of the Visceral Space of the Mediastinum

Although the body cavity is further divided into thoracic, abdominal, and pericardial cavities by the pleuroperitoneal and pleuropericardial membranes, the cavities remain continuous throughout the visceral space [5].

4. The Radiological Manifestations of Aberrant Air Surrounding the Pleura

The embryonic development of compartmentalization of the mediastinum, and the continuum of the visceral space and its surrounding tissues, is associated well with the findings of the laboratory experiments [6, 8], cadaveric anatomy [7],...
Figure 6: Diagram shows that the formation of the continuity of the fascial planes connects cervical soft tissue with the mediastinum to the retroperitoneum. The space between fascia permits aberrant air arising in any of these areas to spread elsewhere.

5. Conclusion
The embryo development establishes the anatomy of body cavity. The compartmentalization in the body cavity and the continuum of the visceral space has significant impact on the radiological manifestations of pneumomediastinum and pneumothorax. It is crucial to review the radiological manifestations of the aberrant air surrounding the pleura from the embryological view.

Conflict of Interests
The authors declare no conflict of interests.

Disclosure
One of the authors certifies that all his affiliations with or financial involvement in, within the past 5 years and foreseeable future, any organization or entity with a financial interest in or financial conflict with the subject matter or materials...
Figure 7: Heart and pericardial cavity formation. Diagram shows that bilateral angiogenic cell cluster originated from the mesoderm fused in the midline along with lateral folding of germ disc and forms the heart and the visceral pericardium. The parietal mesoderm then forms the fibrous and serous layer of parietal pericardium.
1: peribronchial space
2: neck
3: chest wall
4: pleural cavity
5: mediastinum
6: peritoneum
7: pericardial cavity
8: paracardial space
9: thymic region
E: esophagus
T: trachea
Thy: thymus

(a)

Figure 8: Continued.
Figure 8: Air flow in the pneummediastinum: peribronchial space (1); neck (2); chest wall (3); pleural cavity (4); mediastinum (5); retroperitoneum (6); pericardial cavity (7); paracardial space and diaphragm (8).
discussed in the paper are completely disclosed (e.g., employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, royalties).

References

[1] A. M. R. Agur, *Grant’s Atlas of Anatomy*, Williams & Wilkins, Baltimore, Md, USA, 1991.

[2] R. J. Maunder, D. J. Pierson, and L. D. Hudson, “Subcutaneous and mediastinal emphysema. Pathophysiology, diagnosis, and management,” *Archives of Internal Medicine*, vol. 144, no. 7, pp. 1447–1453, 1984.

[3] C. M. Zylak, J. R. Standen, G. R. Barnes, and C. J. Zylak, “Pneumomediastinum revisited,” *Radiographics*, vol. 20, no. 4, pp. 1043–1057, 2000.

[4] R. J. Mason, V. C. Broaddus, T. R. Martin et al., *Mason: Murray and Nadel’s Textbook of Respiratory Medicine*, Saunders, Philadelphia, Pa, USA, 2010.

[5] T. W. Sadler, *Langman’s Medical Embryology*, Williams & Wilkins, Baltimore, Md, USA, 1990.

[6] P. Marchand, “The anatomy and applied anatomy of the mediastinal fascia,” *Thorax*, vol. 6, no. 4, pp. 359–368, 1951.

[7] C. J. Zylak, W. Pallie, and R. Jackson, “Correlative anatomy and computed tomography: a module on the mediastinum,” *Radiographics*, vol. 2, no. 555, p. 592, 1982.

[8] M. T. Macklin and C. C. Macklin, “Malignant interstitial emphysema of the lungs and mediastinum as an important occult complication in many respiratory disease and other conditions: an interpretation of the clinical literature in the light of laboratory experiment,” *Medicine*, vol. 23, p. 78, 1944.

[9] L. Hamman, “Mediastinal emphysema: the frank billings lecture,” *Journal of the American Medical Association*, vol. 128, p. 6, 1945.

[10] S. Y. Lee, C. Y. Sheu, C. L. Wu et al., “Spontaneous pneumomediastinum: a clinical radiologic analysis,” *International Journal of Gerontology*, vol. 2, no. 4, pp. 222–228, 2008.

[11] S. Giuliani, A. Franklin, J. Pierce, H. Ford, and T. C. Grikscbeit, “Massive subcutaneous emphysema, pneumomediastinum, and pneumopericardium in children,” *Journal of Pediatric Surgery*, vol. 45, no. 3, pp. 647–649, 2010.

[12] B. Levin, “The continuous diaphragm sign. A newly recognized sign of pneumomediastinum,” *Clinical Radiology*, vol. 24, no. 3, pp. 337–338, 1973.

[13] M. Gurjar, A. Chaudhary, B. Poddar, and A. K. Baronia, “Continuous diaphragm sign’ after endotracheal intubation,” *Pediatric Emergency Care*, vol. 26, no. 1, pp. 68–69, 2010.

[14] R. L. Lilard and R. P. Allen, “The extrapleural air sign in pneumomediastinum,” *Radiology*, vol. 85, no. 6, pp. 1093–1098, 1965.

[15] J. E. Moseley, “Loculated pneumomediastinum in the newborn. A thymic “spinnaker sail” sign,” *Radiology*, vol. 75, pp. 788–790, 1960.