CASE REPORT

Continuous left hemidiaphragm sign revisited: a case of spontaneous pneumopericardium and literature review

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In pneumopericardium, a rare but potentially life threatening differential diagnosis of chest pain with a broad variety of causes, rapid diagnosis and adequate treatment are crucial. In upright posteroanterior chest radiography, the apical limit of a radiolucent rim, outlining both the left ventricle and the right atrium, lies at the level of the pulmonary artery and ascending aorta, reflecting the anatomical limits of the pericardium. The band of gas surrounding the heart may outline the normally invisible parts of the diaphragm, producing the continuous left hemidiaphragm sign in an upright lateral chest radiograph. If haemodynamic conditions are stable, the underlying condition should be treated and the patient should be monitored closely. Acute haemodynamic deterioration should prompt rapid further investigation and cardiac tamponade must be actively ruled out. Spontaneous pneumopericardium in a 20 year old man is presented, and its pathophysiology described.

Pneumopericardium is a rare condition, less common than either isolated pneumothorax or pneumomediastinum. Nevertheless, clinicians should be familiar with this differential diagnosis of chest pain and its clinical and radiographic manifestations, since prompt recognition and treatment of potential complications—most importantly, pericardial tamponade—may be life saving.

CASE REPORT

A previously healthy 20 year old man was admitted to the hospital two hours after the acute onset of left sided chest pain radiating to his left arm and neck, worsening in the left lateral recumbent position and exacerbated by deep inspiration. Symptoms had developed one hour after he had been chopping wood. He reported rhinitis of two weeks' duration but did not have other respiratory tract symptoms or fever. He had a smoking history of two pack years.

On physical examination the patient was in moderate distress, his temperature was 36.6°C, pulse 74 beats/min, and blood pressure 130/65 mm Hg without pulsus paradoxus. Cardiac examination was notable for a left parasternal rub, but there was no clinically evident right heart failure or subcutaneous emphysema. Routine laboratory tests were within normal limits, including white cell count, C reactive protein, creatine phosphokinase, and troponin I. The ECG showed a sinus rhythm with normal repolarisation. Plain radiographs of the chest showed a pneumopericardium (fig 1) with the continuous left hemidiaphragm sign (fig 2) and a discrete pneumomediastinum. Transthoracic echocardiography was unremarkable.

Three days after admission with resolution of the radiographic findings, the patient's symptoms subsided spontaneously. He remained asymptomatic 12 months after discharge from the hospital.

Figure 1 Posteroanterior chest radiograph. Continuous radiolucent stripes follow the right and left cardiac borders and are outlined by a fine line (arrows) representing the pericardial sac. The stripes are limited at the level of the pulmonary artery and ascending aorta by the pericardial reflection.

DISCUSSION

Pneumopericardium is a rare but important differential diagnosis of chest pain. Symptoms such as radiation of pain towards the shoulders, the back, or the epigastrium, as well as dyspnoea and palpitations, are not always present and depend on the extent of pneumopericardium and the underlying disease. Clinical signs such as distant heart sounds, shifting precordial tympany, and a succussion splash with metallic tinkling (referred to as the mill wheel murmur, or “bruit de moulin” in hydropneumopericardium and first described by Bricketeau in 1844)^{1,2} and ECG findings such as low voltage, ST segment changes, and T wave inversion are non-specific and unreliable. Hamman's crunch of pneumomediastinum and palpable crepitation of subcutaneous emphysema should heighten suspicion.³

Sufficient accumulation of pericardial gas may impair right ventricular filling, resulting in pericardial tamponade with increase and equalisation of intracardiac pressures, pulsus paradoxus, arterial hypotension, and cardiogenic shock.^{4,5} The diagnosis of pneumopericardium can be confirmed by conventional chest radiographs,⁶ computed tomography, or echocardiography.^{7,8}

Radiographic findings of pneumopericardium and pneumomediastinum can be similar in the lower mediastinum. In posteroanterior chest radiographs, a continuous thin radiolucent rim of air follows the cardiac silhouette and is outlined by

Figure 2 Upright lateral chest radiograph. The normally invisible ventral part of the left hemidiaphragm (arrows) is outlined by a radiolucent rim, producing the continuous left hemidiaphragm sign. The air bubble in the stomach identifies the left hemidiaphragm.

a fine line representing the pericardial sac (fig 1). At the base of the heart, the gas may outline the superior surface of the normally obscured parts of the diaphragm, which can be seen on the lateral radiograph as the continuous left hemidiaphragm sign^{6,9} (fig 2) and on a frontal radiograph as the continuous diaphragm sign.⁶

Some radiographic signs may help differentiate pneumopericardium from pneumomediastinum, although for pathophysiological reasons, both can coincide. In pneumopericardium a single band of gas, which is curved and sharply margined by the pericardial sac, outlines both the left ventricle and the right atrium, and its apical limit lies at the level of the pulmonary artery and ascending aorta, reflecting the anatomical limits of the pericardium (fig 1). Air outlining the aortic arch, the superior vena cava above the azygos vein, or the distal left pulmonary artery must be outside the pericardium.⁶ If present, any pericardial thickening or effusion (hydropneumopericardium) helps distinguish the two conditions.⁶ In pneumomediastinum, gas does not usually surround the heart completely, is not confined to the region of the heart, and can be seen as multiple thin streaks of gas extending to the superior mediastinum and neck. The mediastinal pleura follows the contours of the pericardium except in the perihilar region and behind the sternum. In lateral decubitus radiographs, gas in the pericardial (and pleural) space shifts to the non-dependent side, whereas intramediastinal air is trapped within the soft tissue and does not cross to the contralateral side.⁶ In tension pneumopericardium the cardiothoracic ratio may decrease and the heart may appear extremely slender (small heart sign).¹⁰

It has been suggested that shearing forces rupturing the marginal alveolar bases, dissecting the peribronchial and perivascular sheaths with resulting escape of air towards either the pleural space, the hilum, or both, are involved in the pathogenesis of pneumothorax and pneumomediastinum in barotrauma, as well as in blunt chest trauma.^{3,11} Air spreading peripherally along the pulmonary arteries and veins dissecting through the pericardium along these vessels can result in pneumopericardium.¹² Histological preparations have identified a site of potential weakness where the parietal

Table 1 Causes of pneumopericardium

Aetiology	References
Trauma	
Penetrating and blunt chest trauma	3, 24, 25
Invasive procedures	
Laparoscopy	26, 27, 28
Endoscopic colon perforation	29, 30
Sternal bone marrow aspiration	31
Thoracotomy	32, 33, 34
Tracheostomy	35
Endotracheal intubation	36
Endotracheal laser surgery	37
Thoracocentesis	24
Cauterisation of oesophageal webs	38
Endoscopic papillotomy	39
Dental extraction	40
Pneumoencephalography	41
Inert gas in the pleural space after pneumonectomy	42
Fistula to the pericardium	
Cancer of the oesophagus, stomach, and bronchus	43, 44, 45, 46
Oesophageal or gastric ulcer	23, 47, 48, 49, 50
Pressure gastric ulcer from phytobezoar	51
Achalasia	52
Pneumonia with abscess	9, 53
Pulmonary aspergillosis	54, 55
Tuberculosis (lung and pleura)	24
Subphrenic colonic abscess	56
Amoebic liver abscess	57, 58
Foreign body aspiration	59
Postoperative complications	50
Barotrauma	
High end expiratory pressure	
In adults	18, 20
In neonates and infants	13, 16, 17, 19, 21
Acute asthma	12
Coughing	61, 63
Heimlich manoeuvre	64
Valsalva manoeuvre in physical effort	This report
Labour and delivery	60, 65, 66, 67
Inhalation of illicit drugs with positive pressure devices	68, 69, 70
High pressure air injection	71
Rectal barotraumas	72
Pericardial infection	
Histoplasma capsulatum	73
Purulent pericarditis	74
Gas forming organisms	25

pericardium is reflected on the visceral pericardium near the ostia of the pulmonary veins.¹³ The pleural or tracheobronchial and pericardial spaces may be directly connected as a consequence of pericardial tear or rupture in chest trauma.^{3,14} Congenital pleuropericardial defects have been described.¹⁵ Positive pressure ventilation with large tidal volumes or high end expiratory pressure may cause or worsen the condition, particularly in neonates or infants.^{13,16–21} Since pneumopericardium in case of a pre-existing fistula to the pericardium may be worsened by insufflation of pressurised air during gastrointestinal endoscopy, this examination should be performed in a well controlled setting with access to emergency pericardiocentesis or surgery.²² Visualisation of the fistula with contrast media may be helpful.²³

As table 1 summarises, pneumopericardium has been reported to result from blunt and penetrating chest trauma,^{3,24,25} as a complication of invasive procedures,^{24,26–42} from abnormal communications such as fistulas from the pericardium to the adjacent structures containing air from different causes,^{9,23,24,43–59} from barotrauma,^{12,13,16–21,60–72} and from pericardial infections.^{25,73,74}

In our patient we hypothesise that barotrauma (Valsalva manoeuvre) during physical effort and probably impaired

alveolar integrity resulting from upper airway infection ultimately caused a pneumopericardium, which was accompanied by slight pneumomediastinum.

Acute haemodynamic deterioration in a patient with pneumopericardium should prompt further investigation and cardiac tamponade should be actively ruled out. In tension pneumopericardium, rapid fluid resuscitation and emergent pericardiocentesis with echocardiographic guidance and haemodynamic monitoring, followed by pericardial fenestration and pericardial drainage, should be performed.^{3,25} With stable haemodynamic conditions and absent tamponade, the underlying condition should be treated and the patient should be monitored closely.

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REFERENCES

- Bricketeau M. Observation d'hydropneumopéricarde accompagné d'un bruit de fluctuation perceptible à l'oreille. *Arch Gen Med* 1844;**4**:334.
- Tucker WS Jr. Symptoms and signs of syndromes associated with mill wheel murmurs. *N C Med J* 1988;**49**:569–72.
- Capizzi PJ, Martin M, Bannon MP. Tension pneumopericardium following blunt injury. *J Trauma* 1995;**39**:775–80.
- Reed JR, Thomas WP. Hemodynamics of progressive pneumopericardium in the dog. *Am J Vet Res* 1984;**45**:301–7.
- Mauer ER, Mendez FL, Finkelstein M, et al. Cardiovascular dynamics in pneumopericardium and hydropericardium. *Angiology* 1958;**9**:176–9.
- Bejvan SM, Godwin DJ. Pneumomediastinum: old signs and new signs. *Am J Roentgenol* 1996;**166**:1041–8.
- Antonini-Canterin F, Nicolosi GL, Mascitelli L, et al. Direct demonstration of an air-fluid interface by two-dimensional echocardiography: a new diagnostic sign of hydropneumopericardium. *J Am Soc Echocardiogr* 1996;**9**:187–9.
- Bedotto JB, McBride W, Abraham M, et al. Echocardiographic diagnosis of pneumopericardium and hydropericardium. *J Am Soc Echocardiogr* 1988;**1**:359–61.
- Maki DD, Sehgal M, Kricun ME, et al. Spontaneous tension pneumopericardium complicating staphylococcal pneumonia. *J Thorac Imaging* 1999;**14**:215–7.
- Mirvis SE, Indeck M, Schorr RM, et al. Posttraumatic tension pneumopericardium: the "small heart" sign. *Radiology* 1986;**158**:663–6.
- Macklin CC. Transport of air along sheaths of pulmonary blood vessels from alveoli to mediastinum. *Arch Intern Med* 1939;**64**:913–26.
- Toledo TM, Moore WL Jr, Nash DA, et al. Spontaneous pneumopericardium in acute asthma: case report and review of the literature. *Chest* 1972;**62**:118–20.
- Mansfield PB, Graham CB, Beckwith JB, et al. Pneumopericardium and pneumomediastinum in infants and children. *J Pediatr Surg* 1973;**8**:691–9.
- Borrie J, Lichter L. Pericardial rupture from blunt chest trauma. *Thorax* 1974;**29**:329–37.
- Siplovich L, Bar-Ziv J, Karplus M, et al. The pericardial window: a rare etiologic factor in neonatal pneumopericardium. *J Pediatr* 1979;**94**:975–6.
- Moodie DS, Kleinberg F, Hattery RR, et al. Neonatal pneumopericardium. *Mayo Clin Proc* 1976;**51**:101–6.
- Cohen DJ, Baumgart S, Stephenson LW. Pneumopericardium in neonates: is it PEEP or is it PIP? *Ann Thorac Surg* 1983;**35**:179–83.
- Hurd TE, Novak R, Gallagher TJ. Tension pneumopericardium: a complication of mechanical ventilation. *Crit Care Med* 1984;**12**:200–1.
- Fiser DH, Walker WM. Tension pneumopericardium in an infant. *Chest* 1992;**102**:1888–91.
- McEachern RC, Patel RG. Pneumopericardium associated with face-mask continuous positive airway pressure. *Chest* 1997;**112**:1441–3.
- Sugimoto M, Shimaoka M, Hagihira S, et al. Tension pneumopericardium following tracheoplasty for congenital stenosis. *Anaesth Intensive Care* 1997;**25**:539–41.
- Berg RA. Pulsus paradoxus in the diagnosis and management of pneumopericardium in an infant. *Crit Care Med* 1990;**18**:340–1.
- Cozart J, Sundaresan S, Chokshi HR, et al. Gastropericardial fistula with pneumopericardium: an unusual complication of benign peptic ulceration. *Gastrointest Endosc* 1999;**49**:387–90.
- Shackelford RT. Hydropneumopericardium: report of case with summary of literature. *JAMA* 1931;**96**:187–91.
- Cummings RG, Wesley RL, Adams DH, et al. Pneumopericardium resulting in cardiac tamponade. *Ann Thorac Surg* 1984;**37**:511–8.
- Beaver J, Safran D. Pneumopericardium mimicking acute myocardial ischemia after laparoscopic cholecystectomy. *South Med J* 1999;**92**:1002–4.
- Knos GB, Sung YF, Toledo A. Pneumopericardium associated with laparoscopy. *J Clin Anesth* 1991;**3**:56–9.
- Nicholson RD, Berman ND. Pneumopericardium following laparoscopy. *Chest* 1979;**76**:605–7.
- Bakker J, van Kersen F, Bellaar Spruyt J. Pneumopericardium and pneumomediastinum after polypectomy. *Endoscopy* 1991;**23**:46–7.
- Fitzgerald SD, Denk A, Flynn M, et al. Pneumopericardium and subcutaneous emphysema of the neck: an unusual manifestation of colonoscopic perforation. *Surg Endosc* 1992;**6**:141–3.
- Ackerman JL, Alden JW. Pneumopericardium following sternal bone marrow aspiration. *Radiology* 1958;**70**:408–9.
- Shaw FA, Chun PKC. Pneumopericardial tamponade post coronary artery bypass sternal dehiscence. *Am Heart J* 1982;**104**:160–3.
- Brandenhoff P, Hoier-Madsen K, Struve-Christensen E. Pneumopericardium after pneumonectomy and lobectomy. *Thorax* 1986;**41**:55–7.
- Hymes WA, Itani KM, Wall WJ Jr, et al. Delayed tension pneumopericardium after thoracotomy for penetrating chest trauma. *Ann Thorac Surg* 1994;**57**:1658–60.
- Posthumus DL, Peirce TH. Fatal tension pneumopericardium complicating tracheostomy. *Chest* 1978;**73**:107–9.
- O'Neill D, Symon DN. Pneumopericardium and pneumomediastinum complicating endotracheal intubation. *Postgrad Med J* 1979;**55**:273–5.
- Vourch G, Le Gall R, Colchen A. Pneumopericardium: an unusual complication of endotracheal laser surgery. *Br J Anaesth* 1985;**57**:451–2.
- Stephenson SE, Maness G, Scott HW. Esophagopericardial fistula of benign origin. *J Thorac Surg* 1958;**36**:208–13.
- Schoenemann J. Pneumoperikard sowie retroperitoneales und Skrotalemysem nach endoskopischer Papillotomie. *Z Gastroenterol* 2000;**38**:45–7.
- Sandler CM, Libshitz HI, Marks G. Pneumoperitoneum, pneumomediastinum and pneumopericardium following dental extraction. *Radiology* 1975;**115**:539–40.
- Tsai FY, Lee KF. Pneumopericardium and pneumomediastinum: rate complications of pneumoencephalography. *Radiology* 1974;**112**:95–7.
- Shirakusa T. Fatal pneumopericardium caused by SF₆ gas infusion into the pleural space after pneumonectomy and pericardial resection. *Chest* 1989;**95**:1350–1.
- Vennos AD, Templeton PA. Pneumopericardium secondary to esophageal carcinoma. *Radiology* 1992;**182**:131–2.
- Katzir D, Klinovsky E, Kent V, et al. Spontaneous pneumopericardium: case report and review of the literature. *Cardiology* 1989;**76**:305–8.
- Cramm RE, Robinson FW. Pneumopericardium associated with gastric cancer: report of a case and literature review. *Gastroenterology* 1971;**60**:311–5.
- Harris RD, Kostiner AI. Pneumopericardium associated with bronchogenic carcinoma. *Chest* 1975;**67**:115–6.
- Stridbeck H, Samuelsson L. Pneumopyopericardium. *Acta Radiol Diagn* 1983;**24**:305–8.
- Letoquart JP, Fasquel JL, L'Huillier JP, et al. Gastropericardial fistula: review of the literature apropos of an original case. *J Chir (Paris)* 1990;**127**:6–12.
- Miller WL, Osborn MJ, Sinak U, et al. Pyopneumopericardium attributed to an esophagopericardial fistula: report of a survivor and review of the literature. *Mayo Clin Proc* 1991;**66**:1041–5.
- Schneider F, Schenk M, Tempe JD, et al. Spontaneous gastropericardial fistula. *Ann Emerg Med* 1995;**26**:394.
- Bianchi C, Di Bonito L, Fonda F, et al. Pericardial perforation of a gastric ulcer secondary to phytobezoar. *Panminerva Med* 1977;**19**:353–6.
- Breatnach E, Han SY. Pneumopericardium occurring as a complication of achalasia. *Chest* 1986;**90**:292–3.
- Smith LG, Naqvi T. Images in clinical medicine: tension pneumopericardium. *N Engl J Med* 1995;**332**:1481.
- Van Ede AE, Meis JF, Koof RA, et al. Pneumopericardium complicating invasive pulmonary aspergillosis: case report and review. *Infection* 1994;**22**:102–5.
- Muller NL, Miller RR, Ostrow DN, et al. Tension pneumopericardium: an unusual manifestation of invasive pulmonary aspergillosis. *Am J Roentgenol* 1987;**148**:678–80.
- Pfaff C, Hunter TB, Silverstein ME, et al. Pneumopericardium secondary to a fistula: communication between pericardium and subphrenic-colonic abscess. *JAMA* 1976;**235**:2522–3.
- Freeman AL, Bhoola KD. Pneumopericardium complicating amoebic liver abscess. *S Afr Med J* 1976;**50**:551–3.
- Satiya VK, Eggleston FC, Pawar B, et al. Pneumopericardium complicating amoebic liver abscess. *J Assoc Physicians India* 1987;**35**:594–6.
- Tjhen KY, Schmaltz AA, Ibrahim Z, et al. Pneumopericardium as a complication of foreign body aspiration. *Pediatr Radiol* 1978;**7**:121–3.
- Bjorklund L, Lindroth M, Malmgren N, et al. Spontaneous pneumopericardium in an otherwise healthy full-term newborn. *Acta Paediatr Scand* 1990;**79**:234–6.

- 61 **Vaccino P**, Ferrari G, Ferrando T. Pneumopericardium in pertussis. *Minerva Pediatr* 1975;**27**:1503–4.
- 62 **Ishii K**, Koga Y, Araki K. Idiopathic pneumopericardium induced by forced coughing during coronary arteriography. *Jpn Circ J* 1987;**51**:157–9.
- 63 **Van der Klooster JM**, Grootendorst AF, Ophof PJ, et al. Pneumomediastinum: an unusual complication of bronchial asthma in a young man. *Neth J Med* 1998;**52**:150–4.
- 64 **Nowitz A**, Lewer BM, Galletly DC. An interesting complication of the Heimlich manoeuvre. *Resuscitation* 1998;**39**:129–31.
- 65 **Al Maleh A**. Postpartum pneumopericardium. *Acta Obstet Gynecol Scand* 2000;**79**:150–1.
- 66 **Quigley RF**, Anthony GS. Spontaneous post partum pneumomediastinum and pneumopericardium. *Scott Med J* 1987;**32**:27–8.
- 67 **Luby BJ**, Georgiev M, Warren SG, et al. Postpartum pneumopericardium. *Obstet Gynecol* 1983;**62**:46s–50s.
- 68 **Leitman BS**, Greengart A, Wasser HJ. Pneumomediastinum and pneumopericardium after cocaine abuse. *Am J Roentgenol* 1988;**151**:614.
- 69 **Adrouny A**, Magnusson P. Pneumopericardium from cocaine inhalation. *N Engl J Med* 1985;**313**:48–9.
- 70 **Miller WE**, Spiekerman RE, Hepper NG. Pneumomediastinum resulting from performing valsalva maneuvers during marihuana smoking. *Chest* 1972;**62**:233–4.
- 71 **Olesen B**, Madsen PV. A high-pressure air injection injury. *Injury* 1991;**22**:163–5.
- 72 **Mirzayan R**, Cepkinian V, Asensio JA. Subcutaneous emphysema, pneumomediastinum, pneumothorax, pneumopericardium and pneumoperitoneum from rectal barotrauma. *J Trauma* 1996;**41**:1073–5.
- 73 **Rosenbaum AE**, Schweppe I, Rabin ER. Constrictive pericarditis, pneumopericardium and aortic aneurysm due to histoplasma capsulatum. *N Engl J Med* 1964;**270**:935.
- 74 **Park S**, Bayer AS. Purulent pericarditis. *Curr Clin Top Infect Dis* 1992;**12**:56–82.