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Abstract

The incidence, aetiology and pathophysiology of pneumomediastinum (PM), an uncommon and potentially serious disease in neonates and children were evaluated. A retrospective chart review of all patients diagnosed with PM who were hospitalized in the intensive care unit of the University Children’s Hospital Zurich, Switzerland, from 2000 to 2006, was preformed. We analysed the incidence, severity and causes of PM, and investigated possible differences between neonatal and non-neonatal cases. Seven children and nine neonates were identified with PM. All patients had a good outcome. Six cases of PM in the group of children older than 4 weeks were deemed to be caused by trauma, infection and sports whereas one case was idiopathic. All nine neonatal cases presented with symptoms of respiratory distress. We were able to attribute four cases of neonatal PM to pulmonary infection, immature lungs and ventilatory support. Five neonatal cases remained unexplained after careful review of the hospital records. In conclusion, PM in children and neonates has a good prognosis. Mostly, it is associated with extrapulmonary air at other sites. It is diagnosed by chest x-ray alone. We identified mechanical events leading to the airway rupture in most children >4 weeks of life, whereas we were unable to identify a cause in half of the neonates studied (idiopathic PM).

Key words

Pneumomediastinum  Pneumopericardium  Subcutaneous emphysema  Air leak
Respiratory distress syndrome
Abbreviations

CPAP  continuous positive airway pressure
PM    pneumomediastinum
PP    pneumopericardium
PT    pneumothorax
Pip   positive inspiratory pressure
SE:   subcutaneous emphysema

Introduction

Pneumomediastinum (PM) is defined as a mediastinal air leak. The experimental works of Macklin and Macklin provided insights into its pathophysiology [4, 5]; alveolar rupture occurs because of a pressure gradient between the alveolus and surrounding tissues. This gradient develops either through overinflation of the alveolus or a reduction of interstitial pressure. The air that subsequently leaks into the interstitial tissue diffuses toward the peribronchial and perivascular tissue, and then towards the mediastinum, the neck and into the subcutaneous tissue. However, due to pressure equalisation between the affected and adjacent alveoli in the lungs, the interalveolar walls remain intact and the lungs inflated.

The diagnosis of PM is confirmed by frontal chest roentgenogram, including the cervical region. Typical radiological signs of PM include the continuous diaphragm sign (interposition of air between the pericardium and the diaphragm, which becomes visible in the central mediastinal part) and linear bands of mediastinal air paralleling the left side of the heart and the descending aorta (pleura is shown as a fine opaque
line) with extension superiorly along the great vessels into the neck. In infants, the “spinnaker sign” (an upwards and outwards deviation of thymic lobes) can be seen when the thymus is raised above the heart by pneumomediastinal air that elevates the thymus and separates it from the cardiac silhouette beneath [2].

Various causes of PM are found in the literature, such as airway obstruction (e.g. foreign body aspiration), iatrogenic (e.g. mechanical ventilation), infections (e.g. pneumonia), obstructive lung disease (e.g. asthma), toxic effects (e.g. smoking), trauma (e.g. chest trauma), Valsalva manoeuvres (e.g. vomiting) and weakness of tissue (e.g. anorexia nervosa). In spontaneous PM, the underlying lung is healthy and the air leak is thought to be atraumatic [3]. In neonates, known predisposing factors are mixed lung diseases, such as pneumonia or meconium aspiration syndrome, with coexisting atelectasis and airway obstruction [1]. However, only scarce literature is found about neonates with PM.

In this study, we retrospectively analysed the incidence, severity and causalities of PM in neonates and children > 4 weeks of life admitted to our intensive care unit, and we investigated possible differences between the groups.

Material and methods

We retrospectively reviewed all records of children diagnosed with PM who were hospitalised in the interdisciplinary neonatal and paediatric intensive care unit of the University Children’s Hospital in Zurich, Switzerland, between January 2000 and September 2006. The patients were divided into two groups according to their age: neonates (under 4 weeks of age) and children (over 4 weeks of age). We were interested in the causes of PM as documented by the treating physicians, the types
and results of radiologic investigations performed, any invasive interventions used to
treat PM, the severity of the PM and the length of stay in the intensive care unit.

Results

About 1200 children are admitted to our intensive care unit per year. The incidence of
PM in our intensive care unit was 0.08% for children >4 weeks of age and 0.1% for
neonates. In all patients, PM was diagnosed by chest x-ray and all had a positive
outcome related to the PM. All five patients with pneumopericardium (PP) did not
suffer of any complications (e.g. pericardial tamponade).

Seven children were >4 weeks of age (Table 1). Their mean age was 7.1 years
(range 1.3 – 15.8 years). In addition to PM, two children of this group had
subcutaneous emphysema (SE), two a pneumothorax (PT) and two a PP. Different
causes were found for the air trapping. There were two traumatic aetiologies (rib
fracture after a severe car accident, lesion in the hypopharynx after a fall). Two
children were diagnosed with obstructive bronchitis and in one child, barotrauma
occurred intraoperatively due to a clamped expiratory tube during mechanical
ventilation (Fig. 1). One child had exercised vigorously three days before
hospitalisation, which may have caused the PM. In one adolescent, PM occurred
spontaneously. All children were hospitalised in the intensive care unit for one to
seven days depending on the severity of their underlying disease. Only two children
required pleural drainage and intubation. All other children were treated for their
underlying conditions and received oxygen therapy. Diagnostics for the PM other
than chest X-rays were performed in four patients. All of these had received a
thoracic CT scan. In one child, who also had a huge subcutaneous emphysema and
dysphagia, the reason of the air trapping could only be found by means of a
laryngotracheoscopy, which showed a traumatic lesion in the hypopharynx. The
patient’s history revealed that she had fallen onto a piece of wood by her neck.
The group of children older than 4 weeks group stayed in the intensive care unit for a
mean of 3.2 days (range 1-7 days), depending on the severity of the PM and the
underlying disease. Compared to the neonatal group, the length of stay in the
intensive care unit was shorter. However, most neonates stayed in the intensive care
unit longer, primarily because of comorbid conditions and not because of the PM.
We found nine neonates who were diagnosed with PM (Table 2); two premature and
seven term infants, all of whom presented with signs of respiratory distress. Three
neonates were also diagnosed with a PP, one with SE and five with a PT. Birth
weight ranged from 2150g to 4140g (mean 3340g). Five children were born vaginally
and four by caesarean section. All children were vigorous at birth and none required
resuscitation with bag mask ventilation or surfactant. Before arriving in the intensive
care unit, where the diagnosis of PM was confirmed by chest x-ray, two infants had
received ventilatory support by CPAP and one of the premature infants had to be
intubated for respiratory failure. During hospitalisation in the intensive care unit, two
children deteriorated and required mechanical ventilation for three and four days,
respectively, and two other children needed CPAP for a few hours. Only one child
received pleural drainage. All children received oxygen therapy and specific therapy
for their underlying disease. Age at admission to the intensive care unit ranged from
a few hours to four days. One neonate was admitted to the intensive care unit due to
convulsions and developed a PM on day six of life. The treating physicians felt that
the PM may have been associated with a Valsalva manoeuvre, which occurred
during the seizure. Other causes of PM were a pulmonary infection due to maternal
infection and a possible barotrauma due to peak inspiratory pressure of 25 cm H2O in a mechanically ventilated premature neonate. Two newborns had PM related to CPAP and four neonates were diagnosed with spontaneous PM. Neonates stayed in the intensive care unit for 3-13 days (mean 5.6 days), depending on the severity of the underlying diseases.

Discussion

All children with PM had a good outcome without any complications due to air trapping.

In the group of children older than 4 weeks, only two children developed a respiratory insufficiency, leading to mechanical ventilation. In both of them, respiratory failure was related to their underlying condition (polytrauma with haematothorax and severe obstructive bronchitis, respectively). These were also the children who stayed longest in the intensive care unit. All other children were treated with oxygen only and stayed in the intensive care unit until they improved clinically and radiographically.

Regarding radiologic diagnostics, four patients of the group of children > 4 weeks of life had CT-scans (three of them had been done in outside clinics from where the patients had been admitted to our intensive care unit). Retrospectively, the utility of the CT scans was put into question as these scans did not change patient management. The only patient in whom the CT scan changed management was the child with polytrauma, in this patient, other intrathoracic injuries needed to be ruled out.
In the group of neonates, it was much more difficult to find the aetiology of the PM, since all neonates had presented with respiratory disease, and radiologic investigations were partially performed only after use of CPAP or tracheal intubation.

Five of the nine neonates had a spontaneous PM without risk factors, such as mechanical respiratory support (bag mask ventilation after birth, CPAP, mechanical ventilation) or restrictive lung disease. Three of these five babies were delivered by caesarean section. In the remaining four newborns, possible mechanical incidents leading to the air leak could be revealed: mechanical ventilation with high inspiratory pressure, CPAP, pulmonary infection and convulsion. Further investigations are needed to find the aetiology of spontaneous PM in healthy, term neonates.

In conclusion, PM in children and neonates has a good prognosis. Mostly, it is associated with extrapulmonary air at other sites. It is diagnosed by chest X-ray alone. Whereas in older children mechanical events leading to the airway rupture can be revealed in most cases, about half of the neonates in our series suffered from PM without obvious reason.

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Table 1  Results for the group of children >4 weeks of life

| Air leak | Aetiology                                      | Age (years) | Intubation (after diagnosis) | Pleural drainage | Diagnostic tests                                                                 | Days in ICU |
|---------|-----------------------------------------------|-------------|------------------------------|------------------|----------------------------------------------------------------------------------|-------------|
| PM, PP, SE | Spontaneous/3 days earlier intensive sport | 15.8        | no                           | no               | Chest x-ray 3x                                                                    | 2           |
| PM, PT | Traumatic                                    | 7.5         | 3 days                       | yes              | CT/chest x-ray 3x                                                                | 5           |
| PM, SE | Traumatic (lesion in hypopharynx)             | 1.3         | no                           | no               | CT/chest x-ray 3x, esophagogram with contrast medium, larygotracheoscopy         | 4           |
| PM, PP | Iatrogenic: equipment failure with barotrauma during mechanical ventilation | 2.3         | no                           | no               | Chest x-ray 2x                                                                    | 2           |
| PM     | Spontaneous                                  | 15.4        | no                           | no               | Chest x-ray/CT                                                                  | 1           |
| PM     | Obstructive bronchitis                       | 5.6         | no                           | no               | Chest x-ray 2x/CT                                                                | 2           |
| PM, PT | Obstructive bronchitis                       | 1.9         | 7 days                       | yes              | Chest x-ray 7x                                                                   | 7           |
### Table 2 Results for the group of neonates

| Air leak Aetiology | Birth weight | Gestational age (weeks) | Mode of delivery | Mechanical ventilation before diagnosis | Duration of ventilatory support after diagnosis | Pleural drainage | Days in ICU |
|-------------------|--------------|-------------------------|------------------|----------------------------------------|-----------------------------------------------|-----------------|-------------|
| PM Spontaneous    | 4140g        | 40 0/7                  | Vaginal          | no                                     | no                                            | no              | 4           |
| PM, PP, SE Premature lungs, barotrauma | 2150g        | 34 4/7                  | Caesarian section | Pip max. 25 cm H₂O                      | 3 days (Intubation)                            | no              | 4           |
| PM, PT, PP Premature lungs, spontaneous or CPAP | 2480g        | 35 6/7                  | Vaginal          | CPAP                                   | 4 days (Intubation)                            | yes             | 6           |
| PM, PT Spontaneous | 3485g        | 38 1/7                  | Caesarian section | no                                     | no                                            | no              | 3           |
| PM, PT Spontaneous | 3440g        | 37 5/7                  | Vaginal          | no                                     | 6 hours (CPAP)                                | no              | 3           |
| PM, PP Spontaneous | 2830g        | 39 1/7                  | Caesarian section | no                                     | no                                            | no              | 13          |
| PM, PT Spontaneous | 3970g        | 38 5/7                  | Caesarian section | no                                     | no                                            | no              | 9           |
| PM, PT Pulmonary infection due to maternal infection | 3440g        | 38 5/7                  | Vaginal          | CPAP                                   | 1 day (CPAP)                                  | no              | 5           |
| PM Convulsions or spontaneous | 4130g        | 40 5/7                  | Vaginal          | no                                     | no                                            | no              | 4           |
Fig. 1  Pneumomediastinum (PM), subcutaneous emphysema (SE) and pneumopericardium (PP) in a 2-year-old intubated patient