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DOI: 10.1542/peds.2021-051904

Journal: Pediatrics

Article Type: Case Report


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Spontaneous Massive Pneumomediastinum in a Previously Well Infant With Covid-19

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Conflict of Interest Disclosure: None of the authors have any conflict of interest.

Funding/Support: No funding was secured for this Manuscript

Abbreviations: None

Article Summary

An infant presented with a massive spontaneous pneumothorax associated with COVID-19, requiring mediastinal exploration and drainage. A literature review of pneumomediastinum and COVID-19 is presented.
Contributors’ Statements

Dr Dixit is first author of original manuscript. She collected and analyzed patient data, drafted the manuscript initially and also participated in the literature review.

Drs Mohammed and Dr Canet-Tarres revised it critically for content

Dr Uvaise compiled figures/CT video, collected the pediatric critical care data and revised the manuscript critically, particularly the pediatric critical care management.

Dr Canet-Tarres collected and analyzed data for literature review, revised the manuscript critically, particularly the literature review.

Dr Lillie coordinated and supervised the data collection, literature review. He critically reviewed the manuscript, reworking the article into formal literature review.

All authors have approved the final manuscript as submitted and agree to be accountable for all aspects of the work.
Abstract

A previously healthy three-month-old, presented with a three-hour history of a neck lump and difficulty breathing after five days of fever and reduced feeding. Pneumomediastinum with subcutaneous emphysema were identified and the child was intubated due to severe work of breathing, requiring significant levels of oxygen and ventilatory pressure. CT chest scan demonstrated massive pneumomediastinum and significant bilateral parenchymal disease. The child deteriorated cardiovascularly so the mediastinum was dissected by cardiothoracic surgeons and two drains were placed. The patient clinically improved with resolution of air leak over two days. A diagnosis of Covid-19 pneumonia was confirmed.

Case Presentation

A three month-old male presented during the Covid-19 pandemic with three hours of increased work of breathing and mass in the neck on a background of five days of fever and reduced feeding. There were no other associated infective or coryzal symptoms. He had initially presented on the first day of fever to their general practitioner who had diagnosed otitis media and prescribed a course of oral antibiotics. After five days of fever, the mother noticed sudden swelling around the neck and increased breathing effort.

The infant was born at term with no complications and was previously fit and well with no history of immunocompromise, Covid-19 contact or relevant family history. There were no risk factors for non-accidental injury.

On examination, the infant was alert with a hyperextended neck due to a large soft swelling extending from the chin to the sternum. He was tachypneic at 77 breaths per minute with saturations of 66-70% on air with evidence of respiratory distress without stridor. All other
observations were within normal range with heart rate of 146 bpm. The child had a soft cry. There were quiet heart sounds and reduced air entry bilaterally. Widespread subcutaneous emphysema was palpated on the anterior chest and neck. With 15 L of supplemental facemask oxygen, his saturations fluctuated between 77-93%. Initial venous blood gas with supplementary oxygen showed respiratory and metabolic acidosis: pH 7.09, CO2 9.58 kPa, HCO3 16.9 mmol/L, Base -8.7 mmol/L and Lactate 3.7 mmol/L.

Chest radiograph at presentation showed pneumomediastinum with substantial surgical emphysema but it was difficult to interpret whether there was lung disease and a pneumothorax (Figure 1a).

Potential causes considered for the emphysema were non-accidental injury and infection with concerns that there was worsening upper airway obstruction due to the swelling. The anesthetic team applied positive end expiratory pressure (PEEP) via a facemask which improved the appearance of the neck swelling and the child was intubated due to the work of breathing, hypoxia and need to protect the airway before the emphysema worsened.

Using traditional laryngoscopy there was grade 3 visualization of the vocal cords but this was improved with video laryngoscopy. There was no visible trauma to pharynx or larynx with only mild laryngeal oedema observed at the level of the vocal cords. A cuffed endotracheal tube was placed at the level of the carina to try and prevent further air leak if there was a hole in the trachea or larynx. No further air collected in the neck from this time.
Significant levels of respiratory support were required with pressures of 30/5 cm H2O and 100% oxygen maintaining saturations of 94% and a pCO2 of 7.2 kPa. There were ongoing difficulties in radiograph interpretation despite a repeat film and lateral imaging (Figure 1b, 1c) so CT scans of chest, neck and head were performed, demonstrating massive pneumomediastinum and no significant pneumothorax (figure 2, video).

The child was transferred by the pediatric retrieval service to the regional PICU where a mediastinal drain was placed because the child became hemodynamically unstable with hypotension and ventricular ectopic beats in addition to ventilation difficulties. The mediastinum was accessed via a small midline incision in the lower third of the sternum. Pockets of subcutaneous air were extensively dissected with two drains left in situ. The drains resolved the hemodynamic instability but the patient continued to have ongoing issues with hypoxia despite drainage of the pneumo-mediastinum and the expanded lungs showed evidence of bilateral pneumonitis (Figure 1d).

SARS-CoV-2 was detected by PCR from multiple sites including bronchoalveolar lavage with no evidence of bacterial or other viral infection. Blood tests were supportive of Covid-19 pneumonitis with raised lactate dehydrogenase (LDH) and ferritin. Initial bloods were: white cells of 9.4 $10^9$ cells/L, (lymphocytes 3.9 $10^9$ cells/L), C reactive protein of < 1 mg/L, procalcitonin 0.3 mcg/L, LDH 1423 U/L, and ferritin 1782 mcg/L. His initial liver function tests, lipids profile, brain natriuretic peptide, troponin and d-dimers were unremarkable. Immunodeficiency tests were normal, including: HIV, immunoglobulins and lymphocyte.
subsets. An empirical course of antibiotics was given; remdesivir was considered to treat Covid-19 but there were no data to support its use in a baby as young as this.

The management was challenging due to dual pathologies of ongoing air leak and acute respiratory distress syndrome with the air leak limiting high PEEP ventilation and precluding proning of the patient. He received: neuromuscular blockade, inhaled nitric oxide for 48 hrs and seven days of dexamethasone for Covid-19 pneumonitis. The mediastinal air leak continued for two days.

After the air leak ceased his ventilation progressively improved and he was successfully extubated after five days of mechanical ventilation and the mediastinal and pleural drains were removed on the seventh day. He was stepped down to the ward and successfully discharged home. Follow up at four months post discharge demonstrated no residual symptoms and normal examination/ chest radiograph.

Discussion

Covid-19 lung disease in children

The presentation of Covid-19 is milder in children compared to adults (1,2) with low absolute risk of critical illness although there is an increased relative risk in those with comorbidities including asthma, heart disease and obesity (3). Several hypotheses are suggested for this, including reduced Angiotensin-converting-enzyme-2 receptor activity resulting in poor binding,
cross immunity from other upper respiratory viruses and immature immune systems (4). If a child is symptomatic with Covid-19, typically there is a cough, fever, pharyngitis or gastrointestinal symptoms (5). Pediatric studies are incongruent with a suggestion that infants have a higher incidence of critical illness and ICU admission compared to older children (6), while others report milder symptoms in this age group (1, 7, 8). The reason why some children acquire severe disease is unknown; it is important to exclude underlying immunocompromise including HIV, concurrent infections and congenital genetic abnormalities e.g. Congenital cystic adenomatoid malformation. The most common positive CT findings are ground-glass opacities as in adults but with fewer lobes involved and increased bronchial wall thickening (9, 10).

**Covid-19 and pneumomediastinum**

Spontaneous pneumomediastinum is a rare diagnosis in children with a low incidence of 1 in 12,000 children presenting to the emergency department (11). It is characterized by air in the mediastinum without trauma or an iatrogenic procedure like endotracheal intubation and mechanical ventilation. A rise in intrathoracic pressures can cause alveolar damage resulting in air leaking from marginal pulmonary alveoli into the mediastinum (12). Pneumothoraces or pneumoperitoneum may also be present. Once air enters the mediastinum under pressure it can track up to the base of the skull and cause subcutaneous emphysema (Hamman’s syndrome). It is most commonly caused by lower respiratory tract infections in younger children and the Valsalva maneuver or coughing in adolescents with multiple potential triggers: asthma, laryngitis, drug inhalation and exercise. Rupture of trachea or upper airway can also lead to mediastinal air.
The occurrence of a spontaneous pneumomediastinum associated with Covid-19 in a previously well infant has not been documented. There are three other cases of pneumomediastinum reported in children with Covid-19 as of March 2021 (Table 1); one case the pneumomediastinum/pneumothorax were attributed to a transbronchial biopsy (13); the second case reported a 9 year old who developed Covid-19 and a pneumomediastinum post-craniecotomy but high ventilatory pressures intra-operatively may have contributed to barotrauma(14); the third case reported a spontaneous pneumomediastinum in a 17-year-old male with Covid-19. The mechanisms proposed were possible lung inflammation and 2 weeks of cough resulting in barotrauma (15). Interestingly in our case, there was no preceding cough nor other symptoms that would contribute to increased respiratory pressures, although wide-spread inflammatory changes were present on imaging and LDH and ferritin were raised which is typical of Covid-19.

In the context of Covid-19, pneumomediastinum in adults is a rare but well-documented presentation. While some cases are secondary to mechanical ventilation associated barotrauma (16), there are emerging cases of adults on no respiratory support suffering spontaneous pneumothorax and pneumomediastinum associated with underlying lung disease (17). As the mechanism of this is proposed to be alveolar damage secondary to Covid-19 it has been suggested that raised LDH level, as seen in our case, reflects widespread cell injury.

**Management of Pneumomediastinum**

The diagnosis of pneumomediastinum is established by chest radiograph with a chest CT performed in only a third of cases, as it is not considered necessary in uncomplicated cases (18).
In most cases, the movement of air through planes of subcutaneous tissues relieves pressure within the mediastinum allowing a conservative management approach. The majority of patients require hospitalization for observation and oxygen administration with up to 25% requiring admission to intensive care (19). If the air is leaking from the pharynx, larynx or trachea, further accumulation of air can be prevented by placing a cuffed ETT distal to the air leak as it was in this case when the cause of the air was unknown. However positive pressure ventilation in itself can exacerbate the pneumomediastinum.

Rarely, air accumulates in the mediastinum, compressing the intrathoracic structures as it did in this case, leading to both respiratory and cardiac compromise in which case exploration of the mediastinum is required. Unlike a pleural space, it is usually not adequate to just place a drain as there are multiple planes and pockets of tissue so cardiothoracic support is required to dissect the area of affected tissue without causing injury to vascular or airway structures.

As information around Covid-19 in children continues to evolve, our case highlights an important life-threatening complication associated with severe Covid-19 as a possible presentation in infancy. Other important differentials would include foreign body ingestion, non-accidental injury causing airway perforation and concurrent severe common viral/bacterial infections. In the absence of these, Covid-19 remains an important diagnosis to consider.
Prepublication Release

Acknowledgments

Evelina London Pediatric Intensive Care team and South Thames retrieval service, specifically: Louise Preston, Annie Bruce, Roxane Suggars.

Evelina London Cardiothoracic team: Conal Austin and Muhammed Mustapha

Woolwich pediatric and anesthetic team: Hayley Bowyer, Colin Cunningham, Andrew McKechnie and Pediatric Nursing team.

References

Table 1 Summary of literature on pneumomediastinum and Covid-19

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study type and size</th>
<th>Patient group</th>
<th>Respiratory support / Alternative mechanism</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oterino Serrano C et al 2020 (13)</td>
<td>Case series 1 patient Died</td>
<td>6 year old Systemic sclerosis</td>
<td>Bronchoscopy with transbronchial biopsy</td>
<td>Conservative</td>
</tr>
<tr>
<td>Carroll, A et al 2020 (14)</td>
<td>Case report 1 patient Survived</td>
<td>9 year old Neurosurgery</td>
<td>Elective mechanical ventilation for surgery</td>
<td>Conservative</td>
</tr>
<tr>
<td>Bellini D et al 2020 (15)</td>
<td>Case report 1 patient Survived</td>
<td>17 year old Asthmatic</td>
<td>Nil</td>
<td>Conservative</td>
</tr>
<tr>
<td>Campisi A et al 2020 (20)</td>
<td>Case report 1 patient Survived</td>
<td>65 year old Obesity</td>
<td>Invasive ventilation</td>
<td>Cardiovascular instability: Surgical insertion of a thoracic drain</td>
</tr>
<tr>
<td>Wali A et al 2020 (16)</td>
<td>Case series 5 patients 3 survivors</td>
<td>38-70 years</td>
<td>Invasive ventilation</td>
<td>Bilateral intrapleural and subcutaneous chest drains</td>
</tr>
<tr>
<td>Hamad AM et al 2020 (21)</td>
<td>Case series 5 patients 3 survivors</td>
<td>Not reported</td>
<td>Invasive ventilation</td>
<td>Prophylactic unilateral chest drain</td>
</tr>
<tr>
<td>Manna S et al 2020 (22)</td>
<td>Case series 10 patients 6 survivors</td>
<td>38-89 years</td>
<td>High flow/non-invasive ventilation</td>
<td>Conservative</td>
</tr>
<tr>
<td>Volpi S et al 2020 (23)</td>
<td>Case series 3 patients All survived</td>
<td>52-68 years</td>
<td>Non-invasive / invasive ventilation</td>
<td>Conservative</td>
</tr>
<tr>
<td>Juarez-Lloclla J. et al 2021 (24)</td>
<td>Case series 12 patients 6 survivors</td>
<td>36-75 years</td>
<td>Spontaneous pneumomediastinum-nil support prior to diagnosis</td>
<td>Conservative</td>
</tr>
</tbody>
</table>

A search of PubMed March 2021, using the terms “Covid” and “pneumomediastinum” demonstrated 9 case series and 49 case reports of which three were pediatric. Most cases were managed conservatively without surgical intervention or drain.

Publications shown in table: all pediatric cases, adult case report requiring mediastinal drain and adult series in which management was clearly reported.

Survivors defined as survivors to discharge.
Figure 1: plain films demonstrating pneumo-mediastinum and subcutaneous emphysema.

1a) Radiograph prior to intubation. Pneumomediastinum is suggested due to location of air in the middle of the chest and extending up to neck demonstrating the borders of the mediastinum. There are lung markings outside of this suggesting that there is no significant pneumothorax.

1b) Chest x-ray post intubation. Note the position of endotracheal tube at the level of carina to prevent air-leak if the perforation had been in upper trachea/airway.

1c) Lateral X-ray- post intubation, difficult to determine if large anterior pneumothorax or pneumo-mediastinum. Posterior lung atelectasis and consolidation

1d) Chest x-ray post mediastinal and right pleural drain insertion. Majority of air resolved from mediastinum.
Figure 2: CT imaging of the chest showing massive pneumo-mediastinum. The pneumomediastinum fills the entire anterior chest with collapse/consolidation of both lungs posteriorly.
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