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Successful treatment of MRSA empyema in children: A case report

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Abstract: The increasing prevalence of Methicillin-Resistant Staphylococcus aureus (MRSA) infection globally is largely attributed to community-acquired strains. Among pediatric patients, community-acquired MRSA has emerged as a significant cause of severe complications, including pneumonia with pleural effusion, empyema, necrotizing pneumonia, and abscess formation. Although staphylococcal pneumonia was previously uncommon in children, it is now associated with notable morbidity and mortality. This case report presents a 6-year-old and 11-month-old boy diagnosed with MRSA empyema. His treatment involved targeted antibiotic therapy guided by sputum culture results, pleural fluid drainage, and nutritional support. Given the limited available literature, this report highlights the diagnostic and therapeutic challenges in managing such cases and emphasizes the need for additional research to establish standardized treatment guidelines.

Keywords: *Children, Community-acquired pneumonia, Empyema, MRSA, Pneumonia.*

1. Introduction

Staphylococcus aureus the methicillin-resistant Staphylococcus aureus (MRSA) strain has recently received increased focus in clinical practice across several countries. Antibiotics from other classes, such as glycopeptides, macrolides, and aminoglycosides, are often ineffective against MRSA, in addition to being resistant to nearly all beta-lactam antibiotics. This poses a serious risk for children as it is such a significant challenge for physicians when it comes to deciding early diagnosis. Multiantibiotic resistance has been on the rise in recent years. Although MRSA was previously thought to be a major contributor to skin and soft tissue infection, it has recently been linked to invasive infections, particularly severe community-acquired pneumonia (CAP) in children, which is becoming more common globally. It has been our knowledge, that MRSA pneumonia often was healthcare-associated in children, but now community-associated methicillin-resistant Staphylococcus aureus pneumonia cases have emerged, even though typically less resistant to antibiotics than healthcare-associated pneumonia [1].

2. Case Report

A 6-year-old and 11-month-old boy was referred from a secondary hospital due to shortness of breath three weeks before admission. At first, shortness of breath appeared only when walking long distances, but then got worse, it occurred at any time of day or night. It didn't improve in any of his position changes. It was accompanied by a productive cough and fever with a temperature of up to 39°C. The patient was without a previous history of congenital heart disease. There was no vomiting, diarrhea, ear pain, discharge from the ear, abdominal pain, or seizure. The result from anamnesis leads to the diagnosis of pneumonia.

The patient was hospitalized but his condition was getting worse. He had breathing difficulty so the patient had to sleep in a leaning forward sitting position. He also began to feel tired and unable to eat or drink properly. The patient was sent to another facility for evaluation and was found to have a large

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right pleural effusion one week prior to admission. Even though he appeared feeble, the kid was awake and had tachypnea on the day of arrival. In addition, the patient presented with right-sided asymmetry in chest movement, right-sided subcostal retractions, right-sided dullness on percussion, right-sided reduced vesicular breath sound, and right-sided crackling on both lungs during the physical examination. Laboratories examination revealed respiratory acidosis and exudate pleural fluid. The AP chest radiograph (Figure 1) revealed a homogeneous covering in the right lower hemithorax, to upper lateral, covering the costophrenic angle and diaphragm. The second AP chest radiograph evaluation (Figure 2) was performed after chest tube insertion which revealed right homogenous opacity, there was a visible avascular loose area without lung parenchyma in the right hemithorax up to the upper lobe, visceral pleural line (+), chest tube on the right side of the lungs with tip distal at the right VTh5 side of the lungs. A sputum culture was done with the result of MRSA sensitive to amikacin, ciprofloxacin, gentamicin, and levofloxacin, the patient then got levofloxacin 250mg once daily intravenously. The result from anamnesis, physical examination, and other supporting evidence leads to the diagnosis of pleural effusion.

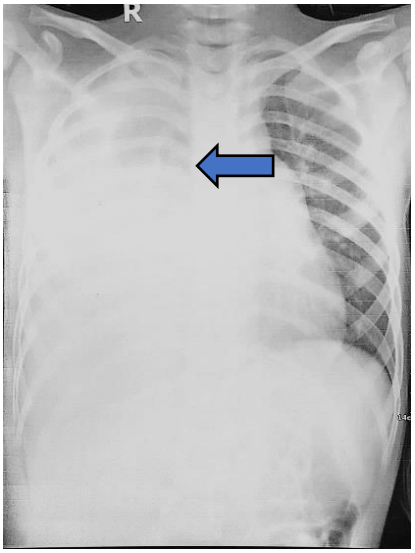

Figure 1.
Patient chest x-ray from previous hospital.

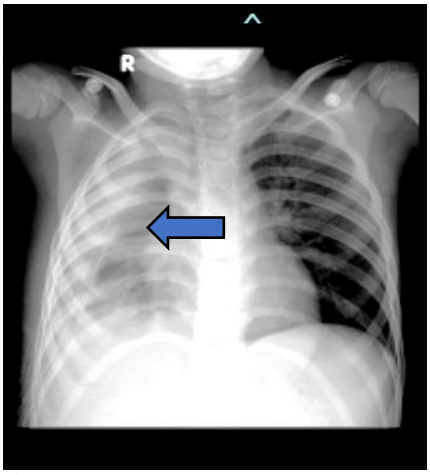

Figure 2.
Patient chest x-ray after chest tube insertion.

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Since the course of the disease, his appetite had decreased, and only ate small portions, body weight diminished from 18kg to 17kg. Currently, he has a body weight of 17kg and a height of 115 cm, with an ideal body weight is 21 kg. He did complete his immunization schedule. The nutritional status of this patient was moderate malnutrition.

On the 2nd to 5th days of observation, the shortness of breath subsided. He could sleep comfortably. His cough had stopped producing mucus, and he was fever-free. He was awake and quite unwell overall; his vitals included a pulse rate of 100 beats per minute, a respiration rate of 25 breaths per minute, a temperature in the axillary region of 36.7 degrees Celsius, and an oxygen saturation level of 98% with the help of a 2 liter per minute nasal cannula. The production of pleural effusion was 250-150ml every 24 hours. The TST result was no induration. The sputum Gene X-pert MTB/RIF revealed that MTB was not detected. The pleural culture was sterile, and analysis was exudate. Blood culture was showed sterile. He was consulted by Physical Rehabilitation Department for breathing exercises. We monitored closely for his symptoms, vital signs, fluid balance, and acceptance of nutritional management. He and his family were educated about the disease, its complications, transmission possibility, and how to prevent transmission.

On the 5th-7th day of observation his shortness of breath improved. There was no fever, and his cough was non-productive. He can do mild activity and walk around briefly. The patient's general condition was mildly ill and fully alert, with a blood pressure of 100/70 mmHg, heart rate of 100 bpm, respiratory rate of 22 tpm, axillary temperature of 36.7°C, and oxygen saturation of 99% without oxygen support. The production of pleural effusion was 50-100ml every 24 hours. He began to feel pain on the site of the chest tube. We continued his antibiotic therapy and gave him ibuprofen 200mg if needed.

On the 7th-9th day of observation he no longer had shortness of breath. There was no fever, and his cough was subsided. He can do mild activity and walk on long distance. The production of pleural effusion was 10-50ml every 24 hours. The pain from the site of chest tube was subsided. Thoracic and cardiovascular department planned to discharge him with IPC.

The patient was discharged the next morning on the 10th day of observation. In outpatient clinic, patient given levofloxacin 250mg once daily orally, nutritional management and psychosocial support. The patient had been scheduled to pediatric, thoracic and cardiovascular department outpatient clinic.

3. Discussion

This case described 6 years old 11-month boy with pneumonia, empyema, and moderate malnutrition. The patient came with a chief complaint of shortness of breath. He suffered from shortness of breath for 3 weeks, along with fever and cough. He had weight loss due to insufficient intake. The patient's vitals were found to be low on oxygen, had tachypnea, a right-sided asymmetry in chest movement, subcostal retractions, a right-sided dullness on percussion, a reduced right-sided vesicular breath sound, and crackle on both lungs.

3.1. Diagnostic Approach

When oxygenation and ventilation are reduced due to poor air exchange, respiratory distress occurs. As part of this process, the lungs receive gas through ventilation, blood flows to the lungs through perfusion, and gases exchange along the alveoli through diffusion. The other causes of dyspnea are changes in the respiratory drive (central process) and impaired respiratory muscle (or their innervation) [2]. In this case, the patient never had a history of seizures or other neurological manifestations; the neurologic physical examination was within the normal limit. This would rule out dyspnea due to insufficient respiratory muscle or a shift in respiratory drive. While gas exchange problems may not produce respiratory discomfort, dyspnea due to control dysfunction may have reduced or regular effort of breathing due to a lack of or a muted brain response to hypoxemia and hypercapnia. On the other hand, dyspnea caused by respiratory muscle dysfunction might have a more subtle physical sign of distress because neural excitation arises, but respiratory muscles exert

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ineffective effort [3]. On the contrary with that condition, in this case, the patient had increased work of breathing.

Other causes of respiratory distress (ventilation, perfusion, and diffusion) might be lung, cardiac, or metabolic disorders. Cardiac disorders such as heart failure or cyanotic spells will decrease blood supply to the lung (perfusion problems), this causes a decrease in oxygenated blood flow, and chemoreceptors in the periphery (carotid bodies) and the brain (medullary areas) detect hypercapnia. The increased neuronal output to the respiratory muscles, brought about by this activation, is what causes the outward manifestations of respiratory distress [3, 4]. In this case, the patient was without a previous history of congenital heart diseases and the murmurs were not find on physical examination, so the perfusion problems might be excluded.

Those ventilation-perfusion mismatches also happened in the ventilation problem. The ventilation problems might be caused by upper airway obstruction and lower airway obstruction or inflammation. The upper airway obstruction is characterized by a specific stridor that we did not find in this case [5]. Thus, the possibility of upper airway obstruction as decreased perfusion cause can be excluded. The lower airway obstruction is characterized by wheezing. It can be caused by infection, allergy, or foreign bodies. In this patient, we did not hear wheezing [6]. Thus, the lower airway obstruction and its cause can be excluded.

As a defence mechanism against metabolic acidosis, hyperventilation is a hallmark of metabolic diseases such diabetic ketoacidosis and shock [4]. In this case, from history taking we did not find any possible cause of metabolic disorders such as vomiting, or diarrhea, and the patient was with CRT < 2 seconds. In this case, the possible cause of respiratory distress is pneumonia and pleural effusion which might disturb the diffusion process until the form of shunting in the ventilation-perfusion balance, depending on the severity [7].

3.2. Pneumonia

Inhalation, aspiration, or hematogenous dissemination allow germs to invade the lower respiratory tract, resulting in pneumonia. Anatomical features and the humoral and cellular immune systems both serve as defences against infection. As soon as the barriers are broken down, the infection starts to hurt or kill the surrounding epithelium and alveoli. In addition, inflammatory cells go to the infection site and cause an exudative process, which makes oxygenation worse. Beginning with alveolar edoema and vascular congestion, lobar pneumonia progresses through the following stages: red hepatization (deposition of red blood cells, desquamated epithelial cells, and fibrin in the alveoli), grey hepatization (accumulation of hemosiderin and hemolysis of red cells), and finally, resolution. The etiology of pneumonia can be classified as age-specific and pathogen-specific [8].

3.3. Diagnosis of Pneumonia

The tachypnea (RR more than 20/min) and O2 saturation of less than 96% have 34% sensitivity and 92% specificity in the diagnosis of pneumonia. Other studies presented that fever, decreased breath sound, crackles, and tachypnea at the same time have 98% sensitivity and 7.6% specificity to have pneumonia in chest radiographs. Fever, cough, shortness of breath, tachypnea, and hypoxia are all clinical symptoms that, when combined, increase diagnostic performance, according to the systematic review and meta-analysis [9]. In this case, the pneumonia was clinically established with fever, increased work of breathing, desaturation, and crackles that found on physical examination.

The systematic review showed that in diagnosing pneumonia in children, there is no proven and accurate gold standard of laboratory tests. The leukocytosis and differential count can't differentiate the cause of pneumonia. The suggested laboratory test to differentiate them is blood culture [10]. Regrettably, the blood culture in this instance was sterile. Both bacterial and viral pneumonias were associated with elevated ESR or WBC levels, according to one research [11]. As a screening limit for bacterial pneumonia, there were significant differences in the CRP concentration level > 37,1 (sensitivity 77% and specificity 82% mg/L). Because differentiating between bacterial and viral

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pneumonia is so challenging in clinical practice, antibiotic treatment should be standard for all children diagnosed with pneumonia [12]. In clinical practice it is usually not necessary to perform a chest x-ray to make a diagnosis of pneumonia. Clinical definitions are preferred, and the chest x-ray is only needed in more severe cases to identify complications or abnormal features [13]. In this case, the patient was performed chest radiography because has respiratory distress and danger sign such as being unable to sleep and sit properly that classified as severe case of pneumonia. Chest radiography evaluation is not needed because the patient has clinical improvement and good response to therapy.

3.4. Risk Factor

Pneumonia is more common in children with weakened immune systems, but healthy youngsters can usually fend off infections on their own. Malnutrition may lower an infant's immune system [9]. No or non-exclusive breastfeeding, incomplete basic immunization, a history of low birth weight, also risk factor for childhood pneumonia [14]. In this case, the patient had moderate malnutrition before the illness which could be the risk factor of pneumonia. Pneumonia is more likely to occur in children who already have certain health conditions, such as measles or HIV infection that is causing symptoms. In this case, the patient did not have a pre-existing illness, but his brother did have pneumonia before, which increased the child's risk of contracting pneumonia.

3.5. Management therapy of pneumonia

The management approach of pneumonia comprises pharmacological and non-pharmacological including supplement of oxygenation, nutritional support, preventing dehydration, identifying signs of other serious illness. Parenteral ampicillin (or penicillin) and gentamicin should be used as a first-line therapy for severe pneumonia in children aged 2–59 months, according to the World Health Organisation. When other treatments for severe pneumonia in children have not been successful, ceftriaxone should be used as a second line of defence. After five days of treatment, if the patient still has not improved, definitive therapy will be necessary [15][17].

The age of the patient determines the etiologic agents of pneumonia. In children older than 5 years, the most common causes of pneumonia are Streptococcus pneumoniae, Mycoplasma pneumoniae, Bordetella pertussis, Staphylococcus aureus, Hemophilus influenza type B, Rhinovirus, Influenza virus, Parainfluenza virus, and Respiratory syncytial virus (RSV) [16]. This patient is six years old, and the sputum culture revealed MRSA, definitive therapy based on culture had be done. The sputum culture revealed MRSA sensitive to amikacin, ciprofloxacin, gentamicin, and levofloxacin, the patient then got levofloxacin 250mg once daily intravenously.

3.6. Empyema

Pleural effusion is an infection of the fluid next to the pleura. Antibiotics have greatly reduced its incidence, yet it is still a major contributor to global death and morbidity. The infected stage of pleural fluid is known as empyema. Untreated pleural effusion causes its appearance [17].

A pleural effusion may result from infection, inflammation, malignancy, or other causes. If the effusion is due to infection, it is termed a parapneumonic effusion. Bacterial infections like pneumonia can spread to the pleural space when bacteria or inflammatory mediators cross the pleura. The initially sterile effusion becomes infected, leading to the formation of empyema, characterized by pus in the pleural space. Empyema can develop without pneumonia in several conditions such as thoracic trauma, esophageal perforation leading to pleural space, septicemia, abscess nearby pleural space, or immunocompromised individuals which may develop empyema from unusual organisms with the absence of signs of pneumonia [17].

3.7. Diagnosis of Empyema

Symptoms typical of empyema include, but are not limited to, lack of appetite, fever, malaise, cough, dyspnea, and pleuritic chest discomfort. It is reasonable to suspect empyema if a youngster experiences a

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worsening of symptoms followed by pneumonia [17]. This patient suffered from shortness of breath for 3 weeks, along with fever, cough, and had weight loss due to insufficient intake. On physical examination, you will find a dullness on percussion in the afflicted hemithorax, a reduction in respiratory sound, a decrease in chest movement, or a fever[19]. The patient had a number of abnormalities, including dyspnea, tachypnea, right-sided asymmetry in chest movement, subcostal retractions, right-sided dullness on percussion, reduced right-sided vesicular breath sounds, crackle in both lungs, and pleural effusion.

The results of the X-ray are reflective of sero-fibrinous pleurisy. Chest radiographs show a similar opacity due to atelectasis of the lung and pleural fluid. The heart and mediastinum are shifted to the healthy side if pleurisy spreads to fill the entire hemithorax. The patient AP chest radiograph revealed a homogeneous covering in the right lower hemithorax, to upper lateral, covering the costophrenic angle and diaphragm.

When it comes to radiological imaging, computed tomography (CT) is the way to go for diagnosing empyema. If the fluid cannot be aspirated during thoracentesis or if tube thoracostomy is not useful, a CT scan may be suggested as the initial radiological assessment for a patient with pleural effusion.

The most accurate and precise way to diagnose empyema and pleural effusion is with a thoracentesis. The fluid surrounding the pleura might be studied using a variety of microscopes, as well as biochemical and microbiological techniques. It is important to differentiate between transudate and exudate if the pleural fluid has a light colour. Pleural fluid should be cultured using Gramme staining, aerobic, anaerobic, and TB assays, if suspected. Purulent fluid is diagnostic for empyema [17]. In this patient, we did a chest tube and its initial production was 160ml with pus visible fluid, we did pleural culture which revealed sterile, and pleural analysis revealed exudate, which supported with empyema.

3.8. Management therapy of Empyema

For the time being, antibiotics alone are sufficient therapy. The fibro purulent stage is rapidly reached in cases where therapy is inadequate or nonexistent. Multiple loculations of fibrin membrane have formed in the pleural space as a result of the presence of germs, cell debris, and polymorphonuclear leukocytes. It is difficult for antibiotics to reach the empyema cavity. Empyema cavity makes lung expansion harder [17]. Re-expansion of the compressed lung is the primary goal of draining the pleural cavity during empyema treatment. Appropriate antibiotic medication is used to treat the parenchymal infection and avoid problems that may emerge during the acute and chronic phases. Patients who are already weak could benefit from dietary supplementation. It is important to identify and treat any underlying diseases. The stage and treatment of empyema typically determine the success of treatment. The level of lung entrapment, the reaction to early treatment, and the identified bacteria all have a role in the treatment's success or failure [17]. In this patient, we did a chest tube and WSD, we gave antibiotics based on culture, nutritional and supportive therapy.

Post-discharge, the patient receives IPC. Pleural effusion can also be treated using indwelling pleural catheters (IPC). Patients can gain control over their symptoms and enjoy the benefits of outpatient care with the insertion of indwelling pleural catheters as day-case operations. These catheters allow for domiciliary drainage [18].

3.9. MRSA (Methicillin Resistant Staphylococcus Aureus)

It is believed that community-acquired MRSA is primarily responsible for the global surge in MRSA infection rates. Complex pneumonia with pleural effusion, empyema, necrotizing pneumonia, and abscess development can be caused by a community-acquired MRSA infection. Although staphylococcal pneumonia was formerly rare in children, it is now a prevalent infection that causes significant illness and death. There was sepsis in 41% of cases, necrotizing pneumonia in 48%, and lobar or consolidation pneumonia in 46%. Empyema occurred in 96% of instances and pneumothorax in 35% of cases as complications. Gentamicin was resistant to 17% of strains, erythromycin to 13%, clindamycin to 11%, and trimethoprim-sulfamethoxazole to 2% [19]. In this case patient has pneumonia complicated with

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empyema and his sputum culture revealed of MRSA sensitivity to amikacin, ciprofloxacin, gentamicin, and levofloxacin.

Careful antibiotic selection based on culture requires definitive treatment. Despite the fact that the sensitivity of blood cultures can range from 0.5% to 14%, they should nevertheless be acquired in children who require hospitalization with suspected bacterial CAP that is mild to severe, especially those with complex pneumonia. It is recommended to collect sputum samples from children who are able to cough in order to do gram stain and culture tests. The specificity of sputum gram stain was 23% and the total sensitivity was 70%, whereas the specificity of sputum culture was 70% and the overall sensitivity was 64%. It is standard practice to do a Gram stain and bacterial culture on pleural fluid specimens whenever possible. Possible diagnostic benefits of pleural fluid parameter analysis include pH, glucose, and LDH levels. BAL (Bronchoalveolar lavage) should be reserved as the gold standard [20, 21]. In this case, the pleural culture was sterile, the pleural analysis was exudate and the blood culture was showed sterile. This could be due to antibiotics already being given before pleural culture and blood culture had been performed. Fortunately, sputum culture was already performed before the antibiotic was given. Antibiotic then given based on sputum culture.

For antibiotic choice, the drug of choice for MRSA preferred vancomycin or clindamycin. For children with not fully immunized for H. influenza type B and S. pneumoniae, suspected community MRSA, an alternative for the antibiotic should be levofloxacin. Treatment courses of 6-8 weeks have been best studied; in many cases patient be given antibiotic by mouth when discharged from the hospital. Instead of going to the hospital, it's best to switch to oral outpatient treatment. Normal vital signs, increased activity and hunger, decreasing temperature, and a pulse oximetry reading of 90% or above for 12 to 24 hours constitute the discharge criteria [20]. In this case, the patient then got levofloxacin 250mg once daily intravenously, patient was discharged on the 10th day and prescribed with oral levofloxacin.

4. Conclusion

MRSA-associated empyema in children is a rare condition in children. An early diagnosis is critical. Treatment with proper antibiotics and drainage should be combined. This report would be strong evidence to suggest drainage management should be practiced in all hospitals. When diagnosis and treatment are initiated early, the result should be better. Additional findings are needed to support diagnostic and treatment criteria, and a high index of suspicion is required to prevent complications from this emerging disease.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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References

[1] K. Q. Tran, T. T. D. Nguyen, V. H. Pham, Q. M. Pham, and H. D. Tran, "Pathogenic role and antibiotic resistance of methicillin-resistant Staphylococcus aureus (MRSA) strains causing severe community-acquired pneumonia in Vietnamese children," *Advances in Respiratory Medicine*, vol. 91, no. 2, pp. 135-145, 2023.

[2] A. Sharma, *Respiratory distress*, 1st ed. China: Elsevier Inc, 2018.

[3] C. B. Coccia, G. H. Palkowski, N. Ntusi, B. Schweitzer, and T. Motsohi, "Dyspnoea: Pathophysiology and a clinical approach," *South African Medical Journal*, vol. 106, no. 1, pp. 32-36, 2016. https://doi.org/10.7196/samj.2016.v106i1.10324

[4] A. Sarnaik, S. Heidemann, and J. Clark, *Respiratory pathophysiology and regulation. In: Kliegman RM, Stanton BF, St Geme III JW, Schor NF, Behrman RE, editors. Nelson Textbook of Pediatrics*, 20th ed. Philadelphia: Elsevier Inc, 2016.

[5] J. Virbalas and L. Smith, "Upper airway obstruction," *Pediatrics in Review*, vol. 36, no. 2, pp. 62-73, 2015.

[6] S. Grover, J. Mathew, A. Bansal, and S. C. Singhi, "Approach to a child with lower airway obstruction and bronchiolitis," *The Indian Journal of Pediatrics*, vol. 78, pp. 1396-1400, 2011. https://doi.org/10.1007/s12098-011-0492-z

[7] J. Petersson and R. W. Glenny, "Gas exchange and ventilation–perfusion relationships in the lung," *European Respiratory Journal*, vol. 44, no. 4, pp. 1023-1041, 2014. https://doi.org/10.1183/09031936.00037014

[8] C. Ebeledike and T. Ahmad, "Pediatric pneumonia," *Stat Pearls*, pp. 135-145, 2020.

[9] C. Rambaud-Althaus, F. Althaus, B. Genton, and V. D'Acremont, "Clinical features for diagnosis of pneumonia in children younger than 5 years: A systematic review and meta-analysis," *The Lancet Infectious Diseases*, vol. 15, no. 4, pp. 439-450, 2015.

[10] J. Bradley, C. Byington, S. Shah, B. Alverson, E. Carter, and C. Harrison, "Executive summary: The management of community-acquired pneumonia in infants and children older than 3 months of age: Clinical practice guidelines by the pediatric infectious diseases society and the infectious diseases society of America," *Pediatr Community Pneumonia Guidel*, vol. 53, pp. 617–330, 2011.

[11] R. Virkki, T. Juven, H. Rikakainen, E. Svedstrom, J. Mertsola, and O. Ruuskanen, "Differentiation of bacterial and viral community-acquired pneumonia in children," *Thorax*, vol. 57, pp. 438–441, 2002.

[12] X. Xiao, L. Xue, H.-L. Sheng, and Z.-H. Xiao, "Correlation between serum levels of C-reactive protein and infant pneumonia: A meta-analysis," *Experimental and Therapeutic Medicine*, vol. 9, no. 6, pp. 2331-2338, 2015. https://doi.org/10.3892/etm.2015.2417

[13] S. Andronikou *et al.*, "Guidelines for the use of chest radiographs in community-acquired pneumonia in children and adolescents," *Pediatric Radiology*, vol. 47, pp. 1405-1411, 2017. https://doi.org/10.1007/s00247-017-3944-4

[14] V. N. Sutriana, M. N. Sitaresmi, and A. Wahab, "Risk factors for childhood pneumonia: A case-control study in a high prevalence area in Indonesia," *Clinical and Experimental Pediatrics*, vol. 64, no. 11, p. 588, 2021. https://doi.org/10.3345/cep.2020.00339

[15] M. Harris *et al.*, "British thoracic society guidelines for the management of community acquired pneumonia in children: Update 2011," *Thorax*, vol. 66, no. Suppl 2, pp. ii1-ii23, 2011. https://doi.org/10.1136/thoraxjnl-2011-200598

[16] Z. V. Rueda *et al.*, "Etiology and the challenge of diagnostic testing of community-acquired pneumonia in children and adolescents," *BMC Pediatrics*, vol. 22, no. 1, p. 169, 2022. https://doi.org/10.1186/s12887-022-03235-z

[17] M. Kuru and T. Altinok, "Empyema in children," *Turkish Journal of Thoracic and Cardiovascular Surgery*, vol. 32, no. Suppl1, pp. S29-S36, 2024.

[18] H. E. Davies *et al.*, "Effect of an indwelling pleural catheter vs chest tube and talc pleurodesis for relieving dyspnea in patients with malignant pleural effusion: The TIME2 randomized controlled trial," *Jama*, vol. 307, no. 22, pp. 2383-2389, 2012. https://doi.org/10.1001/jama.2012.5535

[19] G. Ensinck *et al.*, "Community-acquired methicillin-resistant Staphylococcus aureus pneumonia in a pediatric hospital, Our 10-year experience," *Arch Argent Pediatr* pp. 11-17, 2021. https://doi.org/10.5546/aap.2021.11

[20] J. S. Bradley *et al.*, "The management of community-acquired pneumonia in infants and children older than 3 months of age: Clinical practice guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America," *Clinical Infectious Diseases*, vol. 53, no. 7, pp. e25-e76, 2011.

[21] R. Zhang, Y. Wu, G. Deng, and J. Deng, "Value of sputum Gram stain, sputum culture, and bronchoalveolar lavage fluid Gram stain in predicting single bacterial pathogen among children with community-acquired pneumonia," *BMC Pulmonary Medicine*, vol. 22, no. 1, p. 427, 2022. https://doi.org/10.1186/s12890-022-02234-1