

World Journal of *Clinical Cases*

World J Clin Cases 2023 October 26; 11(30): 7261-7507



Contents

Thrice Monthly Volume 11 Number 30 October 26, 2023

MINIREVIEWS

- 7261 Lower limb amputation rehabilitation status in India: A review
Swarnakar R, Yadav SL, Surendran D
- 7268 Magnetic resonance imaging for acute pancreatitis in type 2 diabetes patients
Ni YH, Song LJ, Xiao B

ORIGINAL ARTICLE

Retrospective Study

- 7277 Efficacy of lidocaine wet compress combined with red-light irradiation for chronic wounds
Bao MZ, Zhou LB, Zhao L, Zhang H, Li Y, Yang L, Tai AT
- 7284 Clinical implications of forkhead box M1, cyclooxygenase-2, and glucose-regulated protein 78 in breast invasive ductal carcinoma
Bai J, Li Y, Cai L
- 7294 Six-year analysis of key monitoring for bacterial strain distribution and antibiotic sensitivity in a hospital
Li ZY, Yang D, Hao CH
- 7302 Clinical pharmacists' involvement in carbapenem antibiotics management at Wenzhou Integrated Hospital
Xu XM, Pan CY, Zeng DL

Observational Study

- 7309 High risk for obstructive sleep apnea and risk of hypertension in military personnel: The CHIEF sleep study
Liu WN, Lin KH, Tsai KZ, Chu CC, Chang YC, Kwon Y, Lin GM

EVIDENCE-BASED MEDICINE

- 7318 Causal relationship association of cheese intake with gestational hypertension and diabetes result from a Mendelian randomization study
Zhong T, Huang YQ, Wang GM

META-ANALYSIS

- 7329 Left lateral decubitus sleeping position is associated with improved gastroesophageal reflux disease symptoms: A systematic review and meta-analysis
Simadibrata DM, Lesmana E, Amangku BR, Wardoyo MP, Simadibrata M
- 7337 Efficacy and safety of anti-vascular endothelial growth factor agents on corneal neovascularization: A meta-analysis
Lai SC, Loh EW, Chiou DI, Hong CT

- 7350** Efficacy and safety of different anti-osteoporotic drugs for the spinal fusion surgery: A network meta-analysis

He XY, Chen HX, Zhao ZR

SCIENTOMETRICS

- 7363** Construction of clinical research nurse training program based on position competence

Sun J, Shan WC, Liu JM, Zhang QQ, Ye Y, Huang ST, Zhong K

CASE REPORT

- 7372** Fatal hemophagocytic lymphohistiocytosis-induced multiorgan dysfunction secondary to *Burkholderia pseudomallei* sepsis: A case report

Sui MZ, Wan KC, Chen YL, Li HL, Wang SS, Chen ZF

- 7380** Interpeduncular cistern intrathecal targeted drug delivery for intractable postherpetic neuralgia: A case report

Fu F, Jiang XF, Wang JJ, Gong L, Yun C, Sun HT, Tang FW

- 7386** Using shape-memory alloy staples to treat comminuted manubrium sterni fractures: A case report

Zhang M, Jiang W, Wang ZX, Zhou ZM

- 7393** Lead helix winding tricuspid chordae tendineae: A case report

Liu TF, Ding CH

- 7398** Fournier gangrene in an infant, complicated with severe sepsis and liver dysfunction: A case report

Bakalli I, Heta S, Kola E, Celaj E

- 7403** Prenatal ultrasound diagnosis of congenital infantile fibrosarcoma and congenital hemangioma: Three case reports

Liang RN, Jiang J, Zhang J, Liu X, Ma MY, Liu QL, Ma L, Zhou L, Wang Y, Wang J, Zhou Q, Yu SS

- 7413** Iatrogenic bladder neck rupture due to traumatic urethral catheterization: A case report

Ekici O, Keskin E, Kocoglu F, Bozkurt AS

- 7418** Near obstructing painful anorectal mass and facial rash in a man with monkeypox: A case report

Akpoigbe K, Yannick J, Culpepper-Morgan J

- 7424** Traditional Chinese medicine for foot pain in a patient with complex regional pain syndrome: A case report

Shin WC, Kim H, Chung WS

- 7432** Diffuse large B-cell lymphoma successfully treated with amplified natural killer therapy alone: A case report

Nagai K, Nagai S, Okubo Y, Teshigawara K

- 7440** Pharmacogenomics-based individualized treatment of hypertension in preterm infants: A case report and review of the literature

Tang LF, Xu A, Liu K

- 7450** Warthin-like papillary renal cell carcinoma: A case report
Li XF, Wang ZJ, Zhang HM, Yang MQ
- 7457** Bladder stone due to late clip migration after prostatic urethral lift procedure: A case report
Bozkurt AS, Ekici O, Keskin E, Kocoglu F
- 7463** Acute-on-chronic liver failure induced by antiviral therapy for chronic hepatitis C: A case report
Zhong JL, Zhao LW, Chen YH, Luo YW
- 7469** Hemodynamic instability following intravenous dexmedetomidine infusion for sedation under brachial plexus block: Two case reports
Kim YS, Lee C, Oh J, Nam S, Doo AR
- 7475** Neonatal methicillin-resistant *Staphylococcus aureus* pneumonia-related recurrent fatal pyopneumothorax: A case report and review of literature
Li XC, Sun L, Li T
- 7485** Infrequent organ involvement in immunoglobulin G4-related prostate disease: A case report
Yu Y, Wang QQ, Jian L, Yang DC
- 7492** Gouty tenosynovitis with compartment syndrome in the hand: A case report
Lee DY, Eo S, Lim S, Yoon JS
- 7497** Acute myocardial infarction after initially diagnosed with unprovoked venous thromboembolism: A case report
Seo J, Lee J, Shin YH, Jang AY, Suh SY
- 7502** Distal clavicle fractures treated by anteroinferior plating with a single screw: Two case reports
Zhao XL, Liu YQ, Wang JG, Liu YC, Zhou JX, Wang BY, Zhang YJ

ABOUT COVER

Editorial Board Member of *World Journal of Clinical Cases*, Ravindra Shukla, MBBS, MD, Additional Professor, Department of Endocrinology and Metabolism, All India Institute of Medical Sciences, Jodhpur 342001, Rajasthan, India. ravindrashukla2@rediffmail.com

AIMS AND SCOPE

The primary aim of *World Journal of Clinical Cases* (WJCC, *World J Clin Cases*) is to provide scholars and readers from various fields of clinical medicine with a platform to publish high-quality clinical research articles and communicate their research findings online.

WJCC mainly publishes articles reporting research results and findings obtained in the field of clinical medicine and covering a wide range of topics, including case control studies, retrospective cohort studies, retrospective studies, clinical trials studies, observational studies, prospective studies, randomized controlled trials, randomized clinical trials, systematic reviews, meta-analysis, and case reports.

INDEXING/ABSTRACTING

The WJCC is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Journal Citation Reports/Science Edition, Current Contents®/Clinical Medicine, PubMed, PubMed Central, Reference Citation Analysis, China National Knowledge Infrastructure, China Science and Technology Journal Database, and Superstar Journals Database. The 2023 Edition of Journal Citation Reports® cites the 2022 impact factor (IF) for WJCC as 1.1; IF without journal self cites: 1.1; 5-year IF: 1.3; Journal Citation Indicator: 0.26; Ranking: 133 among 167 journals in medicine, general and internal; and Quartile category: Q4.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: Zi-Hang Xu, Production Department Director: Xu Gao, Editorial Office Director: Jin-Lei Wang.

NAME OF JOURNAL

World Journal of Clinical Cases

ISSN

ISSN 2307-8960 (online)

LAUNCH DATE

April 16, 2013

FREQUENCY

Thrice Monthly

EDITORS-IN-CHIEF

Bao-Gan Peng, Salim Surani, Jerzy Tadeusz Chudek, George Kontogeorgos, Maurizio Serati, Ja Hyeon Ku

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/2307-8960/editorialboard.htm>

PUBLICATION DATE

October 26, 2023

COPYRIGHT

© 2023 Baishideng Publishing Group Inc

INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION ETHICS

<https://www.wjgnet.com/bpg/GerInfo/288>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>



Neonatal methicillin-resistant *Staphylococcus aureus* pneumonia–related recurrent fatal pyopneumothorax: A case report and review of literature

Xing-Chao Li, Li Sun, Tao Li

Specialty type: Medicine, research and experimental

Provenance and peer review: Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): B
Grade C (Good): C
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Schwan WR, United States; Sunder T, India

Received: August 21, 2023

Peer-review started: August 21, 2023

First decision: September 13, 2023

Revised: September 25, 2023

Accepted: October 8, 2023

Article in press: October 8, 2023

Published online: October 26, 2023



Xing-Chao Li, Li Sun, Tao Li, Department of Pediatrics, Taihe Hospital, Hubei University of Medicine, Shiyan 442000, Hubei Province, China

Xing-Chao Li, Tao Li, Institute of Pediatric Research, Hubei University of Medicine, Shiyan 442000, Hubei Province, China

Xing-Chao Li, Tao Li, Institute of Pediatric Research, Taihe Hospital, Hubei University of Medicine, Shiyan 442000, Hubei Province, China

Corresponding author: Tao Li, MD, Chief Doctor, Director, Professor, Department of Pediatrics, Taihe Hospital, Hubei University of Medicine, No. 32 Renmin South Road, Maojian District, Shiyan 442000, Hubei Province, China. litao1963th@163.com

Abstract

BACKGROUND

Although neonatal *Staphylococcus aureus* pneumonia is common and usually curable, it can also be refractory and life-threatening. Herein, we report a case of severe neonatal community-acquired methicillin-resistant *Staphylococcus aureus* (CA-MRSA) necrotizing pneumonia with bilateral recurrent pyopneumothorax, respiratory failure, heart failure, and cardiac arrest. We hope our report will add to the understanding of this disease.

CASE SUMMARY

An 18-d-old boy presented with cough for five days, fever for three days, and dyspnea for two days. Preadmission chest radiograph revealed high-density shadows in both lungs. On admission, his oxygen saturation fluctuated around 90% under synchronized intermittent mandatory ventilation. He was unconscious, with dyspnea, weak heart sounds and hepatomegaly. Moist crackles were present throughout his left lung, while the breath sounds in the right lung were decreased. After high-frequency oscillatory ventilation, empiric antimicrobials (meropenem and vancomycin), improved circulation, and right pleural cavity drainage for right pneumothorax (approximately 90% compression), his oxygen saturation level stayed above 95%, and recruitment of the right lung was observed. His condition did not deteriorate until the 5th day of hospitalization (DOH 5). On the morning of DOH 5, his oxygen saturation decreased. Subsequent chest radiograph showed bilateral pneumothorax with nearly 100% compression

of the left lung. Desaturation was not relieved after urgent left pleural cavity drainage, and cardiac arrest occurred soon thereafter. Although his spontaneous heartbeat returned through emergency resuscitation and salvage antibacterial therapy (linezolid and levofloxacin) was administered given the detection and antimicrobial susceptibility of MRSA, he showed no improvement, with recurrent pyopneumothorax and continued drainage of purulent fluid and necrotic lung tissue fragments from the pleural cavity. Eventually, his parents refused extracorporeal membrane oxygenation (ECMO) and gave up all the treatments, and the newborn passed away soon after withdrawal on DOH 13.

CONCLUSION

Neonatal MRSA pneumonia can be refractory and lethal, especially in cases where necrotizing pneumonia leads to extensive lung necrosis and recurrent pneumothorax. Despite treatment with linezolid and other medical measures, it may still be ineffective. Currently, ECMO has been a remedial therapy, but if the lung tissue is too severely eroded to be repaired, it may be useless unless the infection can be controlled and lung transplantation can be performed. Regardless of whether ECMO is initiated, the key to successful treatment is to achieve control over the pneumonia caused by MRSA as soon as possible and to reverse lung injury as much as possible.

Key Words: Newborn; Methicillin-resistant *Staphylococcus aureus*; Pyopneumothorax; Linezolid; Extracorporeal membrane oxygenation; Case report

©The Author(s) 2023. Published by Baishideng Publishing Group Inc. All rights reserved.

Core Tip: Neonatal pneumonia can usually be prevented, controlled and cured, regardless of whether it is caused by hospital-associated methicillin-resistant *Staphylococcus aureus* or community-acquired methicillin-resistant *Staphylococcus aureus*, but sometimes it is refractory or incurable. We report a case of severe neonatal community-acquired methicillin-resistant *Staphylococcus aureus* necrotizing pneumonia with bilateral recurrent pyopneumothorax, respiratory failure, heart failure, and cardiac arrest. We hope our report furthers our understanding of this disease.

Citation: Li XC, Sun L, Li T. Neonatal methicillin-resistant *Staphylococcus aureus* pneumonia-related recurrent fatal pyopneumothorax: A case report and review of literature. *World J Clin Cases* 2023; 11(30): 7475-7484

URL: <https://www.wjgnet.com/2307-8960/full/v11/i30/7475.htm>

DOI: <https://dx.doi.org/10.12998/wjcc.v11.i30.7475>

INTRODUCTION

With the development and widespread application of antibiotics, methicillin-resistant *Staphylococcus aureus* (MRSA) has spread globally[1-3], exhibiting multidrug resistance and extensive colonization[1-2,4-5]. MRSA causes both hospital-associated infections and community-acquired infections[2,6-10]. In addition to skin and soft tissue infections (SSTIs)[5, 9], MRSA can lead to pneumonia, sepsis, intracranial infections, etc.[6,9], which are common in the elderly population, children, patients with neutrophil dysfunction, and inpatients[6]. Pneumonia caused by MRSA is severe and refractory, with acute onset, rapid progression and high mortality, manifested by repeated episodes of fever, symptoms of severe infection and dyspnea, and it can lead to shock and multiple-organ failure[11-12]. The characteristics of MRSA pneumonia on chest imaging vary, including such features as pneumothorax[11], empyema[11,13], and pneumatocoles[11,14-15]. Neonatal MRSA infections usually occur in critically ill newborns with long-term hospitalization[16-17], such as extremely premature infants[18-19], low-birth-weight infants[17,20], term infants undergoing surgery[18], and neonates with congenital heart disease[17]. MRSA infections in newborns can also involve multiple systems (e.g., SSTIs[17], pneumonia[13-15,17,19,21], bacteremia[13,15,17], central nervous system infections[17], bone and joint infections[17, 22], peritonitis[17], and liver abscess[23]) and cause related injuries that are severe and refractory[17,23].

Hospital-associated MRSA (HA-MRSA) infection is common[19,24-26], while community-acquired MRSA (CA-MRSA) infection[6,21,27], especially severe neonatal CA-MRSA refractory necrotizing pneumonia[13,15], is relatively rare. Although some neonates with MRSA pneumonia will recover[13-15,21], some cases cannot be cured[17]. Caregivers must pay attention to the importance of hand hygiene and other protective measures in the daily care of newborns and try to avoid MRSA infections in multiple ways[16,20,26,28-29].

Herein, we report a case of severe neonatal CA-MRSA necrotizing pneumonia with bilateral recurrent pyopneumothorax, respiratory failure, heart failure, and cardiac arrest.

CASE PRESENTATION

Chief complaints

An 18-d-old boy presented with cough for five days, fever for three days, and dyspnea for two days.

History of present illness

His body temperature peaked at 37.5 °C. Chest radiograph revealed high-density shadows in both lungs (Figure 1A). Antibiotics (meropenem and vancomycin) and mechanical ventilation had been performed at the local hospital. For further treatment, the newborn was transferred to our neonatal intensive care unit through a vehicle-mounted ventilator by ambulance.

Personal and family history

The boy, G3P2, was born to a 34-year-old woman at 38 wk 3 d of gestational age with a birth weight of 4.5 kg and an Apgar score of 9 points at 1 min after birth. His parents were not close relatives and were in good health. They lived in a rural area.

Physical examination

He had a fever of 38.2 °C, a heart rate of 210 beats/min, a respiratory rate of 100 breaths/min, a blood pressure of 95/65 mmHg, and a body weight of 4.75 kg. His oxygen saturation fluctuated around 90% under synchronized intermittent mandatory ventilation (FiO₂ 100%). He was unconscious, with dyspnea, weak heart sounds and hepatomegaly. Moist crackles were present throughout his left lung, while the breath sounds in the right lung were decreased.

Laboratory examinations

Changes in leukocyte, erythrocyte, hemoglobin, platelet, neutrophil (%), C-reactive protein, creatine kinase-MB, lactate dehydrogenase, and hydroxybutyrate dehydrogenase parameters (Table 1) indicated that the above items had increased to varying degrees, except for the decreases in erythrocytes, hemoglobin, and platelets. MRSA infection was confirmed by multiple cultures (sputum and pleural fluid) (Table 2), while other pathogen tests, such as *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, cytomegalovirus, herpes simplex virus, rubella virus, *Toxoplasma gondii*, *Mycobacterium tuberculosis*, adenovirus, parainfluenza virus 2, parainfluenza virus 3, human coronavirus 229E/NL63, influenza virus A, rhinovirus, and respiratory syncytial virus, along with cerebrospinal fluid culture and blood cultures, were all negative.

Imaging examinations

Chest radiographs at the local hospital (Figure 1A) and in Taihe Hospital (Figure 1B and C and Figures 2-4) are shown in detail in the History of present illness and Treatment sections, respectively. The latter revealed recurrent bilateral pyopneumothorax, multiple high-density shadows and pneumatoceles (Figure 4, orange arrows) in both lungs.

FINAL DIAGNOSIS

According to the clinical definition of CA-MRSA infection used by the United States Centers for Disease Control and Prevention[30], the diagnosis was severe neonatal CA-MRSA necrotizing pneumonia.

TREATMENT

Upon admission, after timely high-frequency oscillatory ventilation (HFOV), empiric antimicrobials (meropenem 40 mg/kg IV q8h plus vancomycin 15 mg/kg IV q8h), improved circulation, and right pleural cavity drainage for right pneumothorax (approximately 90% compression) (Figure 1B), his oxygen saturation level stayed above 95%, and recruitment of the right lung was observed (Figure 1C). Dynamic monitoring was performed by chest radiography (Figure 2), and his condition did not deteriorate until the 5th day of hospitalization (DOH 5).

On the morning of DOH 5, his oxygen saturation decreased. Subsequent chest radiograph showed bilateral pneumothorax with nearly 100% compression of the left lung (Figure 3A). Desaturation was not relieved after urgent left pleural cavity drainage, and cardiac arrest with nonshockable rhythm occurred soon thereafter. Emergency neonatal cardiopulmonary resuscitation (CPR) (including intravenous 1:10000 epinephrine 0.2 mL/kg every 3 to 5 min) was performed for 42 min, but he still had no spontaneous heartbeat. Then, his spontaneous heartbeat returned within 18 minutes by adjusting the resuscitation [infusion of 5% sodium bicarbonate (3 mL/kg), 1:10000 epinephrine (0.2 mL/kg), atropine (0.02 mg/kg), and 10% calcium gluconate (2 mL/kg) *via* a preset peripherally inserted central catheter (PICC) sequentially], and the left lung was partially recruited (Figure 3B and C).

Afterward, MRSA infection was confirmed by multiple cultures (Table 2). Although salvage antibacterial therapy (linezolid 10 mg/kg IV q8h plus levofloxacin 10 mg/kg IV q12h) was administered on DOH 6 according to the culture and antimicrobial susceptibility test results and the child did not experience cardiac arrest again, his condition showed no improvement. He had recurrent pyopneumothorax (Figure 4) and continued drainage of purulent fluid and necrotic lung tissue fragments from the pleural cavity.

Table 1 Laboratory data of this child												
	DOH 1	DOH 2	DOH 3	DOH 4	DOH 5	DOH 6	DOH 7	DOH 8	DOH 9	DOH 10	DOH 11	DOH 12
Leukocyte (10 ⁹ /L)	6.69	5.18	12.58	22.31	75.77	35.57	43.45	35.73	27.9	25.73	22.69	19.95
Erythrocyte (10 ¹² /L)	3.78	3.36	3.14	3.18	3.44	3.44	3.44	2.93	3.13	3.92	3.12	3.09
Hemoglobin (g/L)	134	119	113	111	125	122	122	102	109	133	106	103
Platelet (10 ⁹ /L)	290	197	199	187	269	105	149	166	88	169	115	95
Neutrophil (%)	63.2	75.6	75.6	74.9	80.6	80.0	NA	79.9	76.6	75.5	80.4	80.4
CRP (mg/L)	290.41	260.3	152.96	114.7	132.6	128.0	227.3	187.8	151.2	129.0	126.6	229.7
CK-MB (U/L)	-	-	-	171	150	-	47	-	-	-	-	-
LDH (U/L)	-	-	-	865	1885	-	1128	-	-	-	-	-
HBDH (U/L)	-	-	-	548	1006	-	684	-	-	-	-	-

CRP: C-reactive protein; CK-MB: Creatine kinase-MB; DOH: Day of hospitalization; HBDH: Hydroxybutyrate dehydrogenase; LDH: Lactate dehydrogenase; NA: Not available.

OUTCOME AND FOLLOW-UP

Eventually, owing to the high probability of poor prognosis, the parents refused extracorporeal membrane oxygenation (ECMO) and gave up all the treatments, and the newborn passed away soon after withdrawal on DOH 13.

DISCUSSION

As this case shows, neonatal MRSA pneumonia can be extremely challenging. The following aspects of this case are discussed in a clinical problem-oriented manner.

How was the initial antibacterial therapy selected, and then how was the antibiotic adjusted?

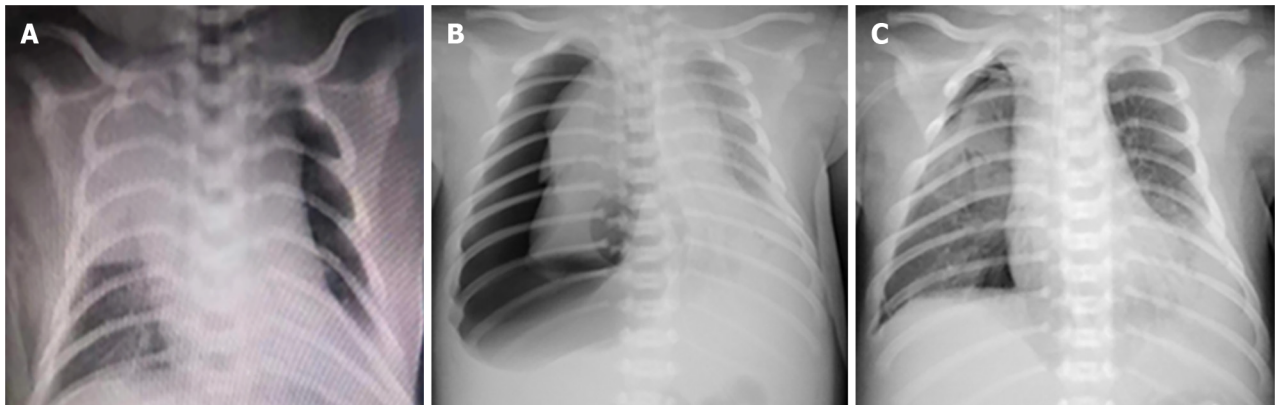
On admission, given the severity and rapid progression of the child’s condition and the presence of pneumothorax, the primary diagnosis was severe neonatal community-acquired pneumonia. Initial antibacterial therapy with meropenem and vancomycin was administered for coverage of gram-negative bacteria and gram-positive bacteria.

Afterward, the diagnosis of severe neonatal CA-MRSA necrotizing pneumonia with bilateral pyopneumothorax was made. Based on the culture and antimicrobial susceptibility test results (Table 2) and a literature review, the antibiotics were switched to linezolid[9,31-35] and levofloxacin[36] for further salvage antibacterial therapy.

Table 2 Culture and antimicrobial susceptibility results of this child

	DOH 6	DOH 6	DOH 6	DOH 6	DOH 10	DOH 12
Specimen	Sputum	Sputum	Sputum	Pleural fluid	Pleural fluid	Pleural fluid
Pathogen	MRSA	MRSA	MRSA	MRSA	MRSA	MRSA
Chloromycetin	S	S	S	S	S	S
Erythromycin	R	R	R	R	R	R
Cefoxitin	R	R	R	R	R	R
Gentamicin	S	S	S	S	S	S
Oxacillin	S	R	R	R	S	S
Penicillin	R	R	R	R	R	R
Rifampin	S	S	S	S	S	S
Teicoplanin	S	S	S	S	S	S
Vancomycin	S	S	S	S	S	S
Clarithromycin	R	R	R	R	R	R
Clindamycin	R	R	R	R	R	R
Linezolid	S	S	S	S	S	S
Tigecycline	S	S	S	S	S	S
Amikacin	S	S	S	S	S	S
Azithromycin	R	R	R	R	R	R
Levofloxacin	S	S	S	S	S	S
Moxifloxacin	S	S	S	S	S	S

DOH: Day of hospitalization; MRSA: Methicillin-resistant *Staphylococcus aureus*; S: Sensitive; R: Resistant.

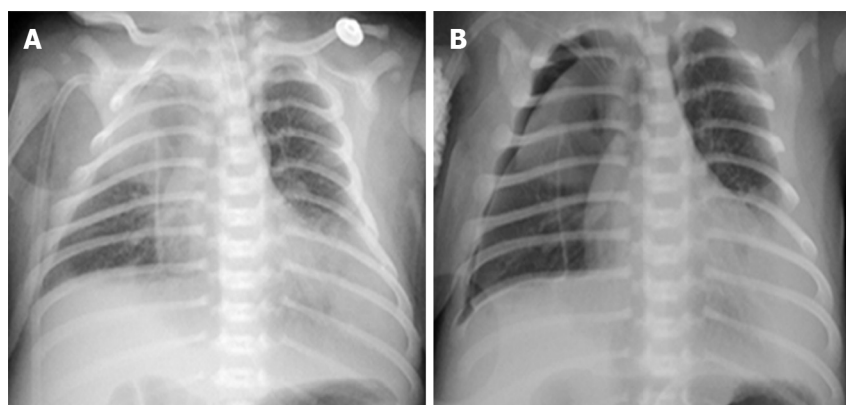


DOI: 10.12998/wjcc.v11.i30.7475 Copyright ©The Author(s) 2023.

Figure 1 Chest radiographs one day before admission and on the first day of hospitalization. A: High-density shadows in the right upper lung and left lower lung (one day before admission); B: Right pneumothorax (approximately 90% compression) with a blunt right costophrenic angle, blurring in the left lung, and a disappeared left costophrenic angle (on admission); C: High-density shadows in the right lung and left lower lung, with right pneumothorax, and blurred left diaphragm and costophrenic angle (after drainage of the right pleural cavity on the first day of hospitalization).

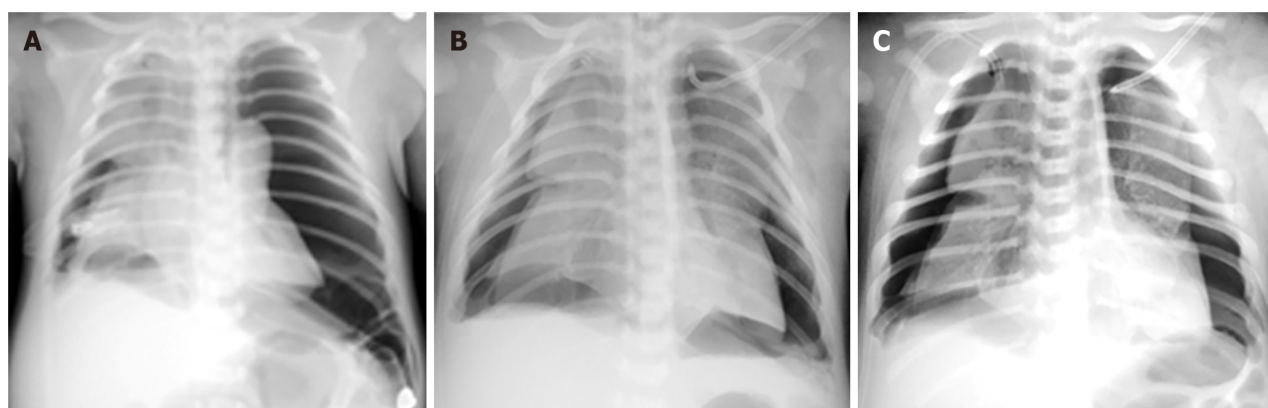
What caused the transient stability of the child after initial treatment, and what caused the subsequent rapid deterioration?

First, pathogens such as MRSA invade the body, proliferate, and cause damage in a gradual process. Second, neonatal diseases (including MRSA pneumonia) tend to be atypical and relatively less serious in the early stage. Third, MRSA strains should proliferate to a certain critical level and cause extensive damage before the patient's outward condition rapidly deteriorates. Furthermore, the various treatments administered (*e.g.*, vancomycin, HFOV, and pleural cavity drainage in this case) may have slowed the progression of the disease to a certain extent. However, the initial vancomycin



DOI: 10.12998/wjcc.v11.i30.7475 Copyright ©The Author(s) 2023.

Figure 2 Chest radiographs on the third and fourth days of hospitalization. A: High-density shadows in the right upper lung and left lower lung, with blurred left diaphragm and costophrenic angle (on the third day of hospitalization, DOH 3); B: High-density shadows in the right upper lung and left lower lung, with blurred left diaphragm, costophrenic angle, and right pneumothorax (on DOH 4).



DOI: 10.12998/wjcc.v11.i30.7475 Copyright ©The Author(s) 2023.

Figure 3 Chest radiographs on the fifth day of hospitalization. A: Bilateral pneumothorax (nearly 100% compression of the left lung) with right lung consolidation (before cardiac arrest on the morning of the fifth day of hospitalization, DOH 5); B: Obvious recruitment of the left lung (after drainage of the left pleural cavity and successful resuscitation on DOH 5); C: Bilateral pneumothorax was more obvious than that in Figure 3B (at night on DOH 5).

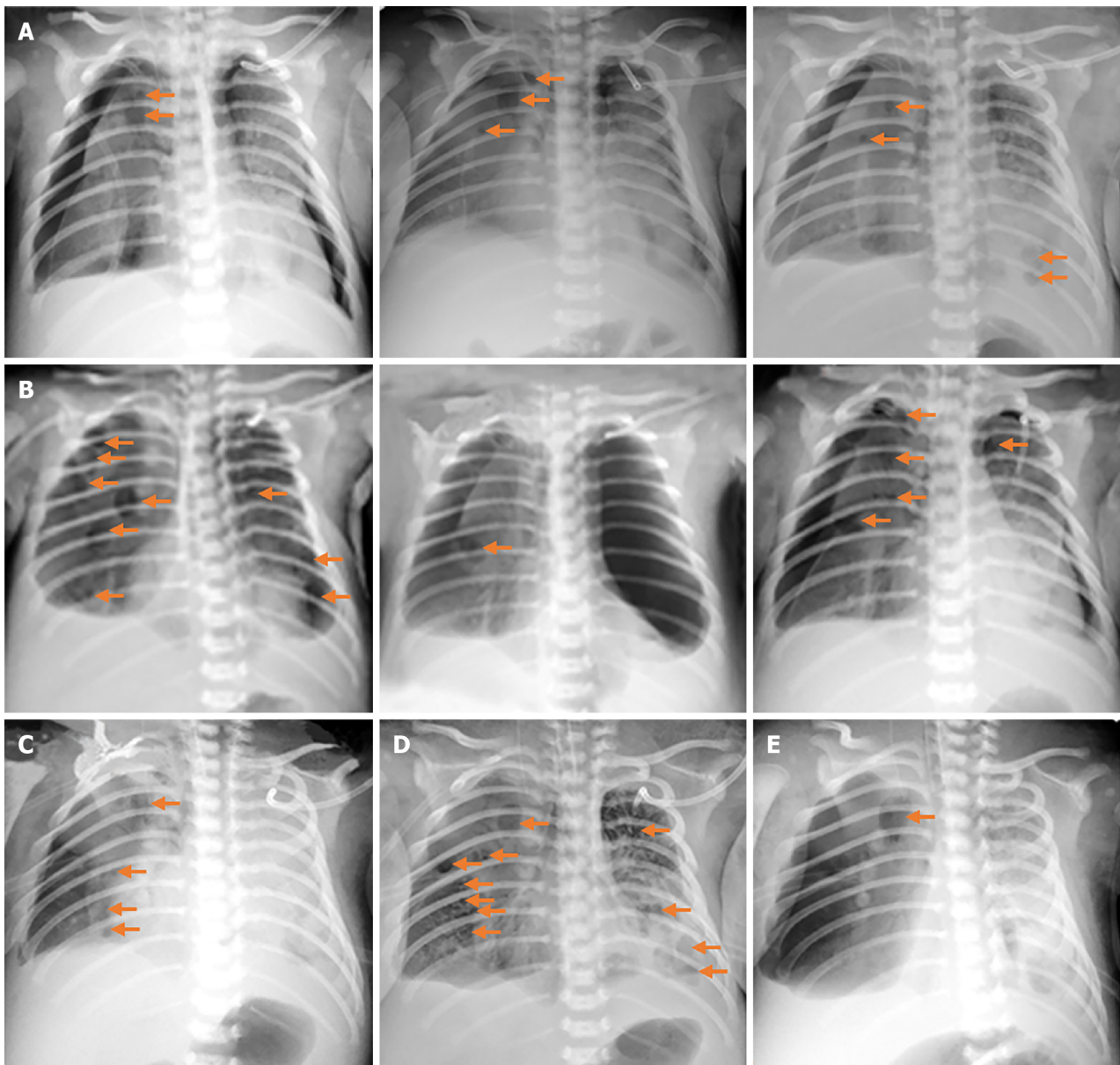
probably could not eliminate the accumulated MRSA from the lungs, thereby increasing the chance of rapid replication of MRSA[33]. All of the above factors may have contributed to the transient stability of the child's condition after initial treatment and the subsequent rapid deterioration. Most importantly, this strain of MRSA caused severe necrotizing pneumonia with extensive necrosis of the lung tissue and recurrent pyopneumothorax, which may be the primary reason for the rapid deterioration of this child's condition.

Compared with vancomycin[35,37], linezolid has a stronger ability to penetrate tissues and is more likely to concentrate in the lungs[35,38-39], which may be more helpful for controlling pneumonia caused by MRSA[7,33,35]. Although MRSA detection methods have improved[1,29], it is still difficult to make an early diagnosis of MRSA infection and to determine which antibiotics will be effective in a timely manner, let alone to make an accurate prognostic prediction early on. Thus, it is difficult to choose linezolid as the initial therapy.

What was responsible for the cardiac arrest, and how to manage this unresponsive patient when conventional neonatal CPR was not successful?

Acute respiratory and circulatory dysfunction secondary to myocardial damage (*e.g.*, weak heart sounds, elevated creatine kinase-MB), heart failure and pneumothorax resulting from severe necrotizing pneumonia caused by MRSA led to cardiac arrest in this patient. Among these factors, pneumothorax was the most important, and the failure of conventional neonatal CPR may also be related to the negative effects of pneumothorax on his breathing and circulation.

In our case, apart from continuing to address the pneumothorax, the resuscitation strategy should be adjusted in a timely manner. While undergoing infusion of sodium bicarbonate, the child still had no heartbeat. Upon reinjection of 1:10000 epinephrine, although he had not yet regained his own heartbeat, short bursts of ventricular escape rhythm occurred. After administration of atropine, his spontaneous sinus rhythm was elicited, and the weak heart sounds became stronger subsequent to infusion of 10% calcium gluconate. Soon afterward, the oxygen saturation rose to 97%. All first-aid drugs were injected *via* a preset PICC. If the above treatments do not work, extracorporeal cardiopulmonary resuscitation



DOI: 10.12998/wjcc.v11.i30.7475 Copyright ©The Author(s) 2023.

Figure 4 Chest radiographs on the sixth, seventh, eighth, ninth, and eleventh days of hospitalization. A: Recurrent bilateral pyopneumothorax, with multiple high-density shadows and pneumatoceles (orange arrows) in both lungs (on the sixth day of hospitalization, DOH 6); B: Recurrent bilateral pyopneumothorax, with multiple high-density shadows and pneumatoceles (orange arrows) in both lungs (on DOH 7); C: Multiple pneumatoceles (orange arrows) in the right lung and high-density shadows in both lungs (on DOH 8); D: Multiple high-density shadows and pneumatoceles (orange arrows) in both lungs (on DOH 9); E: Recurrent pyopneumothorax and pneumatocele (orange arrow) in the right lung and high-density shadows in both lungs (on DOH 11).

(ECPR) could be attempted[40].

Prolonged asphyxia can lead to acidosis[41-42], which not only inhibits cardiac contractility[42-43] but also reduces the sensitivity of cardiomyocytes to catecholamine[43] and can even result in death[42]. Therefore, when the effect of conventional neonatal CPR is not ideal, to antagonize the inhibition of cardiomyocytes by acidosis, sodium bicarbonate should be promptly injected to increase the blood pH[42]. In this patient, after a subsequent administration of epinephrine, short bursts of ventricular escape rhythm were observed, indicating that the myocardial inhibition had been partially relieved and that the sensitivity of cardiomyocytes to epinephrine had been partially restored after infusion of sodium bicarbonate, although sinus node function remained poor. Given the repeated administration of epinephrine, atropine was needed immediately to improve sinus node automaticity to restore sinus rhythm[43-44], and it was successful in this patient. At this time, although the sinus rhythm had been restored, the myocardial contraction was too weak to support adequate circulation. Prolonged asphyxia can not only lead to myocardial injury and depression[42] but also lead to hypocalcemia[45], which may further reduce the contractility of the already hypoxic and damaged myocardium, thereby decreasing cardiac output and resulting in persistent poor circulation. Neonatal hypocalcemia is common in neonatal asphyxia[45] and during plasma exchange[46]. Generally, intravenous calcium supplementation can quickly enhance myocardial contractility[43], thereby increasing cardiac output and stabilizing circulation, which occurred in this patient. The success of resuscitation in this case also benefited from the witnessed in-hospital cardiac arrest, the preexisting PICC,

and the close monitoring of his heart rhythm. However, the abovementioned drugs also have potential side effects that cannot be ignored. For instance, calcium may lead to myocardial damage, while sodium bicarbonate can cause hypercapnia, metabolic alkalosis, hypernatremia and hyperosmolality[43]. Therefore, during neonatal CPR, these drugs should not be used initially (unless there are indications), let alone routinely[43].

Could ECMO reverse this condition?

This is possible, but the following factors should be considered. First, the chief indications for neonatal ECMO are that the primary disease is reversible and that the patient meets certain criteria, such as the absence of lethal congenital malformations, irreversible organ damage (unless transplantation is considered), severe intracranial hemorrhage, and uncontrollable bleeding[40]. Second, ECMO can only temporarily replace cardiopulmonary function, gaining some time to allow the comprehensive treatment of primary disease[47]. In this patient, it is unclear whether the MRSA infection could ultimately be controlled and whether the recurrent pyopneumothorax could be eliminated, especially given the extensive erosion of the lung tissue. If those conditions could not be met and lung transplantation could not be performed, ECMO would certainly fail. Moreover, ECMO itself can also lead to infection and organ dysfunction[47]. In short, ECMO has its own pros and cons[47]. If ECMO is used relatively early, it may be beneficial for reversing the course of a disease, but its premature application, especially its long-term application, may also lead to many ECMO-related complications, while its delayed initiation will inevitably decrease the success rate.

Neonatal ECMO is commonly used in patients with persistent pulmonary hypertension of the newborn (ECMO survival: 73%), meconium aspiration syndrome (ECMO survival: 92%), neonatal sepsis (ECMO survival: 45%), neonatal pneumonia (ECMO survival: 60%), congenital diaphragmatic hernia (ECMO survival: < 50%), ECPR (ECMO survival: 40%-50%), *etc.*[40] This child's lungs were so severely damaged by MRSA that he experienced recurrent lethal pyopneumothorax. If the MRSA infection cannot be controlled and/or the damaged lungs cannot be repaired, the prognosis will be poor, which is not even ameliorated by ECMO. However, during the coronavirus disease 2019 (COVID-19) pandemic, lung transplantation has been performed for COVID-19 patients supported with ECMO, improving the prognosis of COVID-19 patients with irreversible infection-related lung injury[48-52]. Moreover, a 7-year-old girl recovered from severe inhalational burn injury and secondary *Pseudomonas* necrotizing pneumonia after 605 d of ECMO support, providing us with new insight into "irreversible" lung injury and the exciting possibility of lung tissue regeneration or recovery[53]. Regrettably, long-term ECMO support and lung transplantation in newborns are difficult, expensive and challenging.

CONCLUSION

Neonatal MRSA pneumonia can be refractory and lethal, especially in cases where necrotizing pneumonia leads to extensive lung necrosis and recurrent pneumothorax. Despite treatment with linezolid and other medical measures, it may still be ineffective. ECMO has been a remedial therapy, but if the lung tissue is too severely eroded to be repaired, it may be useless unless the infection can be controlled and lung transplantation can be performed. Regardless of whether ECMO is initiated, the key to successful treatment is to achieve control over the pneumonia caused by MRSA as soon as possible and to reverse lung injury as much as possible.

FOOTNOTES

Author contributions: All the authors contributed to conceptualization, data curation, formal analysis, investigation, and methodology of this work, and approved the final version as submitted to be published; Li XC and Sun L drafted the original manuscript; Li T organized this work and revised the manuscript critically.

Supported by the Scientific and Technological Project of Shiyan City of Hubei Province, No. 21Y32; and the Medical Research Project of Hubei Pediatric Alliance, No. HPAMRP202114.

Informed consent statement: Written informed consent was obtained from the infant's parents to publish his clinical information.

Conflict-of-interest statement: All the authors report no relevant conflicts of interest for this article.

CARE Checklist (2016) statement: The authors have read CARE Checklist (2016), and the manuscript was prepared and revised according to CARE Checklist (2016).

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <https://creativecommons.org/licenses/by-nc/4.0/>

Country/Territory of origin: China

ORCID number: Xing-Chao Li 0000-0002-3019-9167; Li Sun 0009-0000-0926-0106; Tao Li 0000-0003-4199-063X.

S-Editor: Li L

L-Editor: A

P-Editor: Yu HG

REFERENCES

- Miao J, Chen L, Wang J, Wang W, Chen D, Li L, Li B, Deng Y, Xu Z. Current methodologies on genotyping for nosocomial pathogen methicillin-resistant *Staphylococcus aureus* (MRSA). *Microb Pathog* 2017; **107**: 17-28 [PMID: 28284852 DOI: 10.1016/j.micpath.2017.03.010]
- Guo J, Xie Z, Ruan W, Tang Q, Qiao D, Zhu W. Thiazole-based analogues as potential antibacterial agents against methicillin-resistant *Staphylococcus aureus* (MRSA) and their SAR elucidation. *Eur J Med Chem* 2023; **259**: 115689 [PMID: 37542993 DOI: 10.1016/j.ejmech.2023.115689]
- Wei J, Wang Y, Chen C, Lin J. Risk Factors Associated with Methicillin Resistance in Hospitalized Newborn Infants with *Staphylococcus aureus* Infection. *Infect Drug Resist* 2022; **15**: 2921-2928 [PMID: 35698533 DOI: 10.2147/IDR.S367912]
- Zaghen F, Sora VM, Meroni G, Laterza G, Martino PA, Soggiu A, Bonizzi L, Zecconi A. Epidemiology of Antimicrobial Resistance Genes in *Staphylococcus aureus* Isolates from a Public Database in a One Health Perspective-Sample Characteristics and Isolates' Sources. *Antibiotics (Basel)* 2023; **12** [PMID: 37508321 DOI: 10.3390/antibiotics12071225]
- Su W, Liu Y, Wang Q, Yuan L, Gao W, Yao KH, Yang YH, Ma L. Antibiotic susceptibility and clonal distribution of *Staphylococcus aureus* from pediatric skin and soft tissue infections: 10-year trends in multicenter investigation in China. *Front Cell Infect Microbiol* 2023; **13**: 1179509 [PMID: 37520432 DOI: 10.3389/fcimb.2023.1179509]
- Kumar P. A review on quinoline derivatives as anti-methicillin resistant *Staphylococcus aureus* (MRSA) agents. *BMC Chem* 2020; **14**: 17 [PMID: 32190843 DOI: 10.1186/s13065-020-00669-3]
- Algammal AM, Hetta HF, Elkeshish A, Alkhalifah DHH, Hozzein WN, Batiha GE, El Nahhas N, Mabrok MA. Methicillin-Resistant *Staphylococcus aureus* (MRSA): One Health Perspective Approach to the Bacterium Epidemiology, Virulence Factors, Antibiotic-Resistance, and Zoonotic Impact. *Infect Drug Resist* 2020; **13**: 3255-3265 [PMID: 33061472 DOI: 10.2147/IDR.S272733]
- Hsieh RC, Liu R, Burgin DJ, Otto M. Understanding mechanisms of virulence in MRSA: implications for antivirulence treatment strategies. *Expert Rev Anti Infect Ther* 2023; **21**: 911-928 [PMID: 37501364 DOI: 10.1080/14787210.2023.2242585]
- Liu C, Bayer A, Cosgrove SE, Daum RS, Fridkin SK, Gorwitz RJ, Kaplan SL, Karchmer AW, Levine DP, Murray BE, J Rybak M, Talan DA, Chambers HF. Clinical practice guidelines by the infectious diseases society of america for the treatment of methicillin-resistant *Staphylococcus aureus* infections in adults and children: executive summary. *Clin Infect Dis* 2011; **52**: 285-292 [PMID: 21217178 DOI: 10.1093/cid/cir034]
- David MZ, Daum RS. Community-associated methicillin-resistant *Staphylococcus aureus*: epidemiology and clinical consequences of an emerging epidemic. *Clin Microbiol Rev* 2010; **23**: 616-687 [PMID: 20610826 DOI: 10.1128/CMR.00081-09]
- Vardakas KZ, Matthaiou DK, Falagas ME. Incidence, characteristics and outcomes of patients with severe community acquired-MRSA pneumonia. *Eur Respir J* 2009; **34**: 1148-1158 [PMID: 19541719 DOI: 10.1183/09031936.00041009]
- Arumairaj A, Safavi A, Amin H, Poor A, Trenard N. Methicillin-Resistant *Staphylococcus aureus* (MRSA) Empyema Post-COVID Infection Causing Severe Septic Shock and Multiorgan Failure. *Cureus* 2023; **15**: e41054 [PMID: 37519525 DOI: 10.7759/cureus.41054]
- Zapata H, Wahba A. Severe necrotizing pneumonia complicated by empyema in a neonate. *Respir Med Case Rep* 2020; **31**: 101248 [PMID: 33101896 DOI: 10.1016/j.rmcr.2020.101248]
- Perdue S, Newberry D. Methicillin-Resistant *Staphylococcus aureus* Pneumatoceles in a Neonate With Sotos Syndrome : A Case Report. *Adv Neonatal Care* 2023; **23**: 409-417 [PMID: 37191941 DOI: 10.1097/ANC.0000000000001076]
- Yee-Guardino S, Kumar D, Abughali N, Tuohy M, Hall GS, Kumar ML. Recognition and treatment of neonatal community-associated MRSA pneumonia and bacteremia. *Pediatr Pulmonol* 2008; **43**: 203-205 [PMID: 18085688 DOI: 10.1002/ppul.20743]
- Heigl K, Zamfir M, Adler AC, Dammeyer A, Schomacher L, Karlin B, Frantitz M, Hörmansdorfer S, Tuschak C, Valenza G, Ochmann U, Herr C, Heinze S. Prevalence of methicillin-sensitive, methicillin-resistant *Staphylococcus aureus*, and extended-spectrum beta-lactamase-producing *Escherichia coli* in newborns: a cross-sectional study. *J Matern Fetal Neonatal Med* 2022; **35**: 4243-4249 [PMID: 33207996 DOI: 10.1080/14767058.2020.1849100]
- Wu X, Wang C, He L, Xu H, Jing C, Chen Y, Deng J, Lin A, Deng H, Cai H, Yang J, Zhang T, Cao Q, Hao J, Huang Y, Yu H. Clinical characteristics and antibiotic resistance profile of invasive MRSA infections in newborn inpatients: a retrospective multicenter study from China. *BMC Pediatr* 2023; **23**: 264 [PMID: 37231456 DOI: 10.1186/s12887-023-04084-0]
- Carey AJ, Duchon J, Della-Latta P, Saiman L. The epidemiology of methicillin-susceptible and methicillin-resistant *Staphylococcus aureus* in a neonatal intensive care unit, 2000-2007. *J Perinatol* 2010; **30**: 135-139 [PMID: 19710681 DOI: 10.1038/jp.2009.119]
- Salerno SN, Bernhardt J, Laughon M, Jhaveri R, Massaro M, Gonzalez D. Pharmacokinetics of Ceftriaxone in a Preterm Infant With Methicillin-Resistant *Staphylococcus Aureus* Pneumonia. *J Pediatric Infect Dis Soc* 2018; **7**: 342-345 [PMID: 29045693 DOI: 10.1093/jpids/pix084]
- Sakaki H, Nishioka M, Kanda K, Takahashi Y. An investigation of the risk factors for infection with methicillin-resistant *Staphylococcus aureus* among patients in a neonatal intensive care unit. *Am J Infect Control* 2009; **37**: 580-586 [PMID: 19535174 DOI: 10.1016/j.ajic.2009.02.008]
- Nicolaou EV, Bartlett AH. Necrotizing Pneumonia. *Pediatr Ann* 2017; **46**: e65-e68 [PMID: 28192581 DOI: 10.3928/19382359-20170120-02]
- Sankaran G, Zacharia B, Roy A, Purayil SP. Current clinical and bacteriological profile of septic arthritis in young infants: a prospective study from a tertiary referral centre. *Eur J Orthop Surg Traumatol* 2018; **28**: 573-578 [PMID: 29427091 DOI: 10.1007/s00590-018-2142-x]
- Heger ML, Al-Sayyad B. Ceftriaxone and Daptomycin Combination Antibiotic Therapy for a Methicillin-Resistant *Staphylococcus Aureus* Liver Abscess in a Premature Infant. *J Pediatric Pharmacol Ther* 2022; **27**: 754-759 [PMID: 36989005 DOI: 10.5863/1551-6776-27.8.754]
- Chew CH, Yeo CC, Che Hamzah AM, Al-Trad EI, Jones SU, Chua KH, Puah SM. Multidrug-Resistant Methicillin-Resistant *Staphylococcus aureus* Associated with Hospitalized Newborn Infants. *Diagnostics (Basel)* 2023; **13** [PMID: 36980357 DOI: 10.3390/diagnostics13061050]
- Shi ZY, Hou SL, Li XW. Silver dressing in the management of an infant's urachal anomaly infected with methicillin-resistant *Staphylococcus*

- aureus: A case report. *World J Clin Cases* 2022; **10**: 2629-2636 [PMID: 35434059 DOI: 10.12998/wjcc.v10.i8.2629]
- 26 **Barrett RE**, Fleiss N, Hansen C, Campbell MM, Rychalsky M, Murdzek C, Krechevsky K, Abbott M, Allegra T, Blazeovich B, Dunphy L, Fox A, Gambardella T, Garcia L, Grimm N, Scoffone A, Bizzarro MJ, Murray TS. Reducing MRSA Infection in a New NICU During the COVID-19 Pandemic. *Pediatrics* 2023; **151** [PMID: 36625072 DOI: 10.1542/peds.2022-057033]
 - 27 **Budimir A**. MRSA in Croatia: prevalence and management. *Expert Rev Anti Infect Ther* 2016; **14**: 167-176 [PMID: 26559874 DOI: 10.1586/14787210.2016.1116384]
 - 28 **Tidwell J**, Kirk L, Luttrell T, Pike CA. CA-MRSA Decolonization Strategies: Do They Reduce Recurrence Rate? *J Wound Ostomy Continence Nurs* 2016; **43**: 577-582 [PMID: 27820584 DOI: 10.1097/WON.0000000000000277]
 - 29 **Hassoun A**, Linden PK, Friedman B. Incidence, prevalence, and management of MRSA bacteremia across patient populations-a review of recent developments in MRSA management and treatment. *Crit Care* 2017; **21**: 211 [PMID: 28807042 DOI: 10.1186/s13054-017-1801-3]
 - 30 **Pichereau S**, Rose WE. Invasive community-associated MRSA infections: epidemiology and antimicrobial management. *Expert Opin Pharmacother* 2010; **11**: 3009-3025 [PMID: 20955116 DOI: 10.1517/14656566.2010.511614]
 - 31 **Kullar R**, Sakoulas G, Deresinski S, van Hal SJ. When sepsis persists: a review of MRSA bacteraemia salvage therapy. *J Antimicrob Chemother* 2016; **71**: 576-586 [PMID: 26565015 DOI: 10.1093/jac/dkv368]
 - 32 **Rae N**, Jarchow-MacDonald A, Nathwani D, Marwick CA. MRSA: treating people with infection. *BMJ Clin Evid* 2016; **2016** [PMID: 26881888]
 - 33 **Wunderink RG**, Rello J, Cammarata SK, Croos-Dabrera RV, Kollef MH. Linezolid vs vancomycin: analysis of two double-blind studies of patients with methicillin-resistant *Staphylococcus aureus* nosocomial pneumonia. *Chest* 2003; **124**: 1789-1797 [PMID: 14605050]
 - 34 **Chavanet P**. The ZEPHYR study: a randomized comparison of linezolid and vancomycin for MRSA pneumonia. *Med Mal Infect* 2013; **43**: 451-455 [PMID: 24238896 DOI: 10.1016/j.medmal.2013.09.011]
 - 35 **Pletz MW**, Burkhardt O, Welte T. Nosocomial methicillin-resistant *Staphylococcus aureus* (MRSA) pneumonia: linezolid or vancomycin? - Comparison of pharmacology and clinical efficacy. *Eur J Med Res* 2010; **15**: 507-513 [PMID: 21163725 DOI: 10.1186/2047-783X-15-12-507]
 - 36 **Bhagwat SS**, Nandanwar M, Kansagara A, Patel A, Takalkar S, Chavan R, Periasamy H, Yeole R, Deshpande PK, Bhavsar S, Bhatia A, Ahdal J, Jain R, Patel M. Levonadifloxacin, a Novel Broad-Spectrum Anti-MRSA Benzoquinolizone Quinolone Agent: Review of Current Evidence. *Drug Des Devel Ther* 2019; **13**: 4351-4365 [PMID: 31920285 DOI: 10.2147/DDDT.S229882]
 - 37 **Cruciani M**, Gatti G, Lazzarini L, Furlan G, Broccoli G, Malena M, Franchini C, Concia E. Penetration of vancomycin into human lung tissue. *J Antimicrob Chemother* 1996; **38**: 865-869 [PMID: 8961057 DOI: 10.1093/jac/38.5.865]
 - 38 **Honeybourne D**, Tobin C, Jevons G, Andrews J, Wise R. Intrapulmonary penetration of linezolid. *J Antimicrob Chemother* 2003; **51**: 1431-1434 [PMID: 12746375 DOI: 10.1093/jac/dkg262]
 - 39 **Conte JE Jr**, Golden JA, Kipps J, Zurlinden E. Intrapulmonary pharmacokinetics of linezolid. *Antimicrob Agents Chemother* 2002; **46**: 1475-1480 [PMID: 11959585 DOI: 10.1128/AAC.46.5.1475-1480.2002]
 - 40 **Wild KT**, Rintoul N, Kattan J, Gray B. Extracorporeal Life Support Organization (ELSO): Guidelines for Neonatal Respiratory Failure. *ASAIO J* 2020; **66**: 463-470 [PMID: 32282347 DOI: 10.1097/MAT.0000000000001153]
 - 41 **Hoeger H**, Labudova O, Mosgoeller W, Herrera-Marschitz M, Fuerst G, Kitzmüller E, Lubec B. Deficient transcription of subunit RPA 40 of RNA polymerase I and III in heart of rats with neonatal asphyxia. *Life Sci* 1998; **62**: 275-282 [PMID: 9450498 DOI: 10.1016/S0024-3205(97)01108-9]
 - 42 **Dawes GS**, Jacobson HN, Mott JC, Shelley HJ, Stafford A. The Treatment of Asphyxiated, Mature Foetal Lambs and Rhesus Monkeys with Intravenous Glucose and Sodium Carbonate. *J Physiol* 1963; **169**: 167-184 [PMID: 14078056 DOI: 10.1113/jphysiol.1963.sp007248]
 - 43 **Papastylianou A**, Mentzelopoulos S. Current pharmacological advances in the treatment of cardiac arrest. *Emerg Med Int* 2012; **2012**: 815857 [PMID: 22145080 DOI: 10.1155/2012/815857]
 - 44 **Yano T**, Kawana R, Yamauchi K, Endo G, Nagamine Y. The Additive Effect of Atropine Sulfate during Cardiopulmonary Resuscitation in Out-of-hospital Non-traumatic Cardiac Arrest Patients with Non-shockable Rhythm. *Intern Med* 2019; **58**: 1713-1721 [PMID: 30799340 DOI: 10.2169/internalmedicine.1932-18]
 - 45 **Aldana Valenzuela C**, Romaro Maldonado S, Vargas Origel A, Hernández Arriaga J. [Acute complications in full term neonates with severe neonatal asphyxia]. *Ginecol Obstet Mex* 1995; **63**: 123-127 [PMID: 7744293]
 - 46 **Sawyer T**, Billimoria Z, Handley S, Smith K, Yalon L, Brogan TV, DiGeronimo R. Therapeutic Plasma Exchange in Neonatal Septic Shock: A Retrospective Cohort Study. *Am J Perinatol* 2020; **37**: 962-969 [PMID: 31176309 DOI: 10.1055/s-0039-1692184]
 - 47 **Lin JC**. Extracorporeal Membrane Oxygenation for Severe Pediatric Respiratory Failure. *Respir Care* 2017; **62**: 732-750 [PMID: 28546375 DOI: 10.4187/respcare.05338]
 - 48 **Chen JY**, Qiao K, Liu F, Wu B, Xu X, Jiao GQ, Lu RG, Li HX, Zhao J, Huang J, Yang Y, Lu XJ, Li JS, Jiang SY, Wang DP, Hu CX, Wang GL, Huang DX, Jiao GH, Wei D, Ye SG, Huang JA, Zhou L, Zhang XQ, He JX. Lung transplantation as therapeutic option in acute respiratory distress syndrome for coronavirus disease 2019-related pulmonary fibrosis. *Chin Med J (Engl)* 2020; **133**: 1390-1396 [PMID: 32251003 DOI: 10.1097/CM9.0000000000000839]
 - 49 **Han W**, Zhu M, Chen J, Zhang J, Zhu S, Li T, Cai H, Fang Q, Wei G, Liang T. Lung Transplantation for Elderly Patients With End-Stage COVID-19 Pneumonia. *Ann Surg* 2020; **272**: e33-e34 [PMID: 32301803 DOI: 10.1097/SLA.0000000000003955]
 - 50 **Lang C**, Jaksch P, Hoda MA, Lang G, Staudinger T, Tschernko E, Zapletal B, Geleff S, Prosch H, Gawish R, Knapp S, Robak O, Thalhammer F, Indra A, Koestenberger M, Strassl R, Klikovits T, Ali K, Fischer G, Klepetko W, Hoetzenecker K, Schellongowski P. Lung transplantation for COVID-19-associated acute respiratory distress syndrome in a PCR-positive patient. *Lancet Respir Med* 2020; **8**: 1057-1060 [PMID: 32857987 DOI: 10.1016/S2213-2600(20)30361-1]
 - 51 **Bharat A**, Querrey M, Markov NS, Kim S, Kurihara C, Garza-Castillon R, Manerikar A, Shilatfard A, Tomic R, Politsanska Y, Abdala-Valencia H, Yeldandi AV, Lomasney JW, Misharin AV, Budinger GRS. Lung transplantation for pulmonary fibrosis secondary to severe COVID-19. *medRxiv* 2020 [PMID: 33140069 DOI: 10.1101/2020.10.26.20218636]
 - 52 **Cozzi E**, Faccioli E, Marinello S, Loy M, Congedi S, Calabrese F, Romagnoli M, Cattelan AM, Rea F. COVID-19 pneumonia in lung transplant recipients: Report of 2 cases. *Am J Transplant* 2020; **20**: 2933-2937 [PMID: 32400074 DOI: 10.1111/ajt.15993]
 - 53 **Nelson-McMillan K**, Vricella LA, Stewart FD, Young J, Shah AS, Hibino N, Coulson JD. Recovery from Total Acute Lung Failure After 20 Months of Extracorporeal Life Support. *ASAIO J* 2020; **66**: e11-e14 [PMID: 30908288 DOI: 10.1097/MAT.0000000000000990]



Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA

Telephone: +1-925-3991568

E-mail: bpgoffice@wjgnet.com

Help Desk: <https://www.f6publishing.com/helpdesk>

<https://www.wjgnet.com>

