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Clinical analysis of patients with deep sternal wound infection-induced sepsis: a retrospective cohort study

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Abstract

Background: This study aimed to summarize the clinical characteristics of patients with deep sternal wound infection-induced sepsis after median sternotomy and improve the treatment outcomes of infection-related sepsis.

Methods: A retrospective cohort study was conducted on 21 patients with deep sternal wound infection-induced sepsis after median sternotomy who were admitted to the Department of Critical Care. The clinical manifestations, laboratory test results, infection control, and organ and nutritional support of the patients were summarized, and the follow-up data were obtained.

Results: The primary symptoms of deep sternal wound infection-induced sepsis included dyspnea, high fever, chills, and altered state of consciousness. Laboratory test results revealed increased inflammatory markers and decreased oxygenation index. Renal and liver function injury were observed in 8 and 4 patients, respectively; 18 and 12 patients demonstrated elevated D-dimer and N-terminal Pro B type natriuretic peptide levels, respectively. Of the 8 patients whose wound secretions tested positive for bacteria, *Acinetobacter baumannii* and *Staphylococcus aureus* infections were present in 6 and 2 patients, respectively. One of the 6 patients whose blood cultures tested positive for bacteria demonstrated *Candida albicans* infection. Fifteen patients received ventilator-assisted ventilation and 2 patients received renal replacement therapy. Of all the 21 patients, 17 were cured, 2 died, and 2 were discharged.

Conclusion: Postmedian sternotomy sepsis attributed to a deep sternal wound infection usually results from a preexisting condition. The most prominent clinical manifestation is dyspnea, which is sometimes accompanied by the impairment of organ function. Infection prevention, proper nutrition support, and maintenance of healthy organ function are the cornerstones for successful treatment outcomes.

Keywords: Clinical analysis, Deep sternal wound infection, Sepsis

Introduction

Median sternotomy is the standard approach for cardiovascular thoracotomy.[1] The most frequently encountered complications of median sternotomy include sternal nonunion, mediastinitis infection, osteomyelitis, and sternal displacement.[2] Deep sternal wound infection (DSWI) is a particularly severe complication of sternotomy, and increased mortality and extended hospitalization duration following cardiac surgery are primarily attributed to DSWI. The frequency of DSWI after cardiac surgery is generally low, ranging from 0.25% to 5%.[3–5] Although previous studies on DSWI have mostly focused on etiological variables, surgical treatment options, and bacterial analysis at the site of infection,[5–7] the complexities of DSWI in conjunction with sepsis have not been elucidated. This study aimed to investigate the clinical symptoms and outcomes of patients with DSWI complicated by sepsis by reporting uncommon instances of this condition.

Material and methods

Study design

Twenty-one patients (14 males and 7 females) who were treated for poststernotomy DSWI-induced sepsis in the Department of Critical Care, 7th Medical Center of Chinese PLA General Hospital from January 2017 to July 2022 were included in this study and followed up. Follow-up was conducted every 6 months from the time of discharge. The follow-up of the last patient was completed in July 2023.

This study was designed and conducted in accordance with the Declaration of Helsinki and International Ethical Guidelines for Biomedical Studies Involving Human Subjects. The study protocol was reviewed and approved by the Ethics Committee of the 7th Medical Center of Chinese PLA General Hospital (no. S2023-011-01, 2023/04/18). Written informed consent was obtained from all participants.

Diagnostic criteria

Patients developed postoperative fever, chest pain, or sternal instability and demonstrated any of the following symptoms: (1) purulent secretion in the surgical wound; (2) widened mediastinum upon imaging; and (3) positive mediastinal drainage fluid or tissue microbial culture or pathological evidence of mediastinal tissue inflammation.[8]

Sepsis refers to the life-threatening damage to organ function caused by a host immune response disorder due to severe infection.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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The organ damage score is based on the Sequential Sepsis-related Organ Failure Assessment (SOFA) score.[9] An SOFA score >2 points indicates sepsis.[10] Patients with DSWI who developed sepsis were transferred to the intensive care unit (ICU) (excluding those with infections attributed to other causes).

Deep sternal wound infection surgical treatment protocols and antibiotic selection scheme

Based on the extent of surgical debridement and size of the tissue defect after debridement, one or both the sides of the pectoralis major and/or part of the rectus abdominis muscle were selected to pack the surgical wound. The necrotic tissue and sequestrum were thoroughly excised, eliminating the abscess and sinus. Thereafter, the lesion and hyperplastic tissue were entirely excised and the diseased sternum and ribs were surgically extracted. The wound was suitably expanded along the sinus canal and the remaining pacing lead was extracted. Throughout the debridement procedure, the surface of the wound was soaked with iodophor multiple times and ultimately rinsed repeatedly with hydrogen peroxide and normal saline to ensure complete removal of the sequestrum, pus cavity, and sinus tract. Finally, a decision to perform bilateral or unilateral pectoralis major muscle flap rotation was made based on the size and location of the chest incision defect. The dimensions and orientation of the muscular flap were determined based on the dimensions of the debridement defect. Unilateral or bilateral pectoralis major muscle flaps may be considered in cases of wound infection in the central and superior regions of the complete thoracic incision. In cases where wound infection is associated with the inferior margin of the chest incision, judicious use of a portion of the rectus abdominis muscle may be necessary. In individuals with substantial surgical abnormalities, exposure of the bilateral pectoralis major muscles is recommended to facilitate attachment of free chest flaps on both sides of the surgical incision. Upon verifying the configuration of the pectoralis major muscle flap, excision of the stump at the outer border of the pectoralis major muscle using an electric knife is recommended for hemostasis. The pedicled flap was rotated to occupy the debridement defect. The pectoralis major muscle flap should possess sufficient length to effectively eradicate the remaining cavity and mitigate the risk of infection recurrence. Caution should be exercised when addressing the muscle flap stump during hemostasis. The muscle flap was meticulously sutured using a 2-0 pollen suture to close the defect, and 2-3 negative pressure drainage tubes were strategically positioned based on the extent of the surgical site. Finally, the surgical cut was stitched periodically using a No. 7 silk suture, and a chest strap was affixed for a duration of 4 to 6 weeks.

Increased prevalence of gram-positive cocci, particularly methicillin-resistant *Staphylococcus aureus*, has been noted during the initial phase of DSWI.[11] Consequently, anti-infection approaches frequently involve the administration of glycopeptide antibiotics or linezolid. Healthcare professionals frequently use carbapenems, third-generation cephalosporins, or enzyme-enhanced β-lactams as part of their anti-infection protocols in cases with extended duration of DSWI indicative of increased negative bacilli and fungal infections.

Research methods

We extracted the patient demographics, medical history, clinical symptoms, disease diagnosis, peripheral blood laboratory test results (routine blood test, blood chemistry, coagulation, myocardial injury markers, inflammatory index factors, and blood gas analysis), and bacterial culture results from the electronic medical record system (PRIDE system; Zhejiang Helen Technology Co, Ltd, China) and retrospectively analyzed the clinical outcomes of the anti-infection treatment, mechanical ventilation, hemodialysis, nutritional support, and surgical treatment. In addition, the follow-up data of the patients were obtained.

Statistical analysis

Statistical analysis was performed using SPSS (version 22.0; SPSS, Chicago, IL, USA). Continuous data are expressed as mean ± standard deviation (SD) and median (interquartile range), and categorical data are expressed in percentages.

Results

A total of 21 patients with a mean age of 66.5 years (range, 51–82 years) were included in this study from January 2017 to July 2022. The main diagnoses included coronary heart disease (including comorbidity with mitral insufficiency in 2 cases), aortic insufficiency, aortic dissecting aneurysm, congenital heart disease, and atrial septal defect in 16, 1, 2, 1, and 1 case(s), respectively. Other associated conditions included hypertension (n = 14), type II diabetes (n = 9), previous cerebral infarction (n = 4), chronic anemia (n = 2), hyperlipidemia (n = 2), rheumatic arthritis (n = 1), and a history of mastectomy (n = 1). Surgical interventions included median thoracotomy, including coronary artery bypass surgery, Bentall procedure, Sun's procedure, valve repair surgery, and atrial septal defect repair in 16 (2 patients underwent concurrent mechanical mitral valve replacement surgery), 1, 1, 2, and 1 patient, respectively.

Clinical manifestations of sepsis

The main symptoms of the 21 patients included dyspnea (19 cases, 90.5%), high fever (11 cases, 52.4%), agitation (5 cases, 23.8%), lethargy (3 cases, 14.3%), chills (3 cases, 14.3%), profuse perspiration (1 case, 4.8%), and asthenia (1 case, 4.8%). All the patients had DSWI after sternotomy. Patients with an SOFA score of ≥3 met the diagnostic criteria for sepsis and were admitted to the ICU for treatment of organ dysfunction attributed to sepsis. Four, 4, 2, and 1 patient(s) developed atelectasis due to pleural effusion after sternotomy, acute multiple cerebral infarction (2 patients with secondary epilepsy), acute renal failure, and incomplete intestinal obstruction, respectively. After wound debridement, 6 patients developed pulmonary infection, including 4 patients with deep venous thrombosis in the lower extremity; 2 patients developed gastrointestinal bleeding; and 6 patients developed a bloodstream infection. Further details are presented in Table 1.

Routine blood test and inflammatory indicators

Two, 12, 18, and 21 patients had elevated platelet, procalcitonin, white blood cell and neutrophil, and C-reactive protein levels, respectively. The medians and quartiles of each index are listed in Table 2. Elevated white blood cell and neutrophil counts were consistent with the hemogram characteristic of wound infection. Elevated C-reactive protein and procalcitonin levels suggested an infection. The nonelevated procalcitonin levels in some patients may be attributed to the long duration of infection.

Blood biochemical indicators

Two, 4, 4, and 12 patients demonstrated increased alanine aminotransferase levels, acute kidney injury due to increased serum creatinine levels, abnormal liver function due to increased bilirubin levels, and hypoproteinemia, respectively. The medians and quartiles for each indicator are presented in Table 2.

Coagulation and arterial blood gas analysis indicators

Activated partial prothrombin time, prothrombin time, and D-dimer levels were elevated in 3, 7, and 17 patients, respectively. Seven and 11 patients demonstrated metabolic acidosis and increased lactic acid levels, respectively, while all the patients

experienced a decrease in the oxygenation index. Decreased oxygenation index of the patients indicated acute respiratory function injury, whereas increased lactic acid levels and metabolic acidosis indicated hypoxia-microcirculation perfusion insufficiency of the tissues. The increase in the D-dimer levels may be related to infection and microcirculation thrombosis; however, abnormalities in other coagulation indices were not significant. These indicators are listed in Table 2.

Myocardial injury markers

Troponin and creatine kinase isoenzyme and N-terminal Pro B type natriuretic peptide levels were elevated in 2 and 12 patients, respectively. The means and quartiles of each indicator are listed in Table 2.

Table 1

Demographic Information of Patients, Disease Status, Main Diagnoses, Symptoms, and Related Complications

Items	Value
Sex, n (%)	
Male	14 (66.7)
Female	7 (33.3)
Age, mean ± SD	66.5 ± 8.4
Disease status, n (%)	
Hypertension	14 (66.7)
Diabetes	9 (42.9)
Previous cerebral infraction	4 (19.0)
Chronic anemia	3 (14.3)
Hyperlipoidemia	2 (9.5)
Rheumatoid arthritis	1 (4.8)
Excision of breast tumor	1 (4.8)
Primary diagnosis, n (%)	
Coronary heart disease	16 (76.2)
Valvular lesions	3 (14.3)
Aortic dissecting aneurysm	2 (9.5)
Congenital heart disease with atrial septal defect	1 (4.8)
Main surgical method, n (%)	
Coronary artery bypass surgery	16 (76.2)
Aortic replacement	2 (9.5)
Valve replacement/repair	2 (9.5)
Interatrial septal defect repair	1 (4.8)
Complications of sternotomy, n (%)	
Atelectasis of pleural effusion	4 (19.0)
Acute cerebral infarction	4 (19.0)
Secondary epilepsy	2 (9.5)
Acute kidney injury	2 (9.5)
Incomplete intestinal obstruction	1 (4.8)
Complications after debridement surgery, n (%)	
Lung infection	6 (28.6)
Deep vein thrombosis	4 (19.0)
Gastrointestinal bleeding	2 (9.5)
Bloodstream infection	2 (9.5)
Symptoms of sepsis, n (%)	
Dyspnea	19 (90.5)
High fever	11 (52.4)
Agitation	5 (23.8)
Lethargy	3 (14.3)
Shivers	3 (14.3)
Profuse perspiration	1 (4.8)
Asthenia	1 (4.8)
Other concomitant symptoms, n (%)	
Abdominal distention	2 (9.5)
Secondary epilepsy	2 (9.5)

Data are n (%) or mean ± standard deviation.

Table 2

Mean, Quartile, and Reference Values of the 21 Patients

Parameter	Value, Median (IQR)	Reference Value
Blood routine examination		
White blood cell count, $\times 10^9$/L	9.464 (7.75–10.47)	3.5–9.5
Neutrophil count, $\times 10^9$/L	8.21 (5.425–9.125)	2.0–7.5
Platelet count, $\times 10^9$/L	216.9 (120–288.5)	100–350
Biochemical marker		
ALT, U/L	29.5 (14–30.25)	0–40
Cr, μmol/L	94.3 (65.5–118)	44.2–115
TBIL, μmol/L	17.75 (10.61–18.25)	4.3–22.5
DBIL, μmol/L	7.5 (4.18–7.73)	0–8.84
Albumin, g/L	34.29 (31.45–34.69)	35–55
Coagulation index		
D-dimer, mg/L	2.24 (0.939–3.403)	≤0.243
PT, s	13.5 (11.85–14.2)	9.8–12.8
APTT, s	33.41 (31.1–35.57)	25.1–36.5
Inflammatory index		
C-reactive protein, mg/L	86.67 (67.45–99.77)	0–8
Procalcitonin, ng/mL	5.536 (0.315–5.92)	0–0.49
Blood gas analysis index		
PH value	7.34 (7.27–7.41)	7.35–7.45
Oxygenation index, mm Hg	209.8 (165.5–255.5)	400–500
Lactic acid, mmol/L	2.67 (1.25–2.95)	0.5–1.6
Myocardial injury biomarker		
Troponin, ng/mL	0.087 (0.0225–0.08)	0–0.1
NT-proBNP, pg/mL	4905.5 (1249–8424.75)	0–1800
CK-MB, ng/mL	3.128 (2.027–4.055)	0–5

ALT, alanine aminotransferase; APTT, activated partial thromboplastin time; CK-MB, creatine kinase isoenzymes; DBIL, direct bilirubin; IQR, interquartile range; NT-proBNP, N-terminal pro-B-type natriuretic peptide; PT, prothrombin time; TBIL, total bilirubin.

Treatment and treatment outcomes

Bacterial culture results and anti-infection treatment. Blood, sputum, and local secretion samples were collected for bacterial culture from the median sternotomy site of all the patients with sepsis admitted to the ICU. An empiric anti-infection treatment was administered before obtaining the culture result reports. The anti-infection plan was adjusted based on the findings of the culture report. The negative culture results in 6 patients were attributed to prior treatment with antibiotics. Among the 7 patients with positive cultures for wound secretions, 3, 2, 1, and 1 demonstrated *Acinetobacter baumannii*, *S. aureus*, *Staphylococcus epidermidis*, and *Klebsiella pneumoniae* infections, respectively. Of the 6 patients with positive blood cultures, 3, 2, and 1 had *A. baumannii*, *K. pneumoniae*, and *C. albicans* and *Staphylococcus haemolyticus* infections, respectively. Among the 4 patients with positive sputum cultures, 2 demonstrated *K. pneumoniae* and *K. pneumoniae* complicated with *A. baumannii*, respectively. The general poor health of the patients and persistent use of antibiotics could have contributed to the prevalence of fungi in their blood cultures (Fig. 1).

Respiratory, circulatory, and nutritional support. After admission to the ICU, 17 patients required mechanical ventilation. Two patients older than 80 years had to undergo a tracheotomy procedure after receiving mechanical ventilation for more than 30 days; 15 patients underwent mechanical ventilation for less than 30 days. One patient with acute renal failure who was treated with hemodialysis demonstrated improved renal function over the course of 25 days. After admission to the ICU, 9 patients required treatment with vasoactive drugs (dopamine and norepinephrine) for low blood pressure. At the same time, the volume of intravenous infusion exceeded 3000 mL,

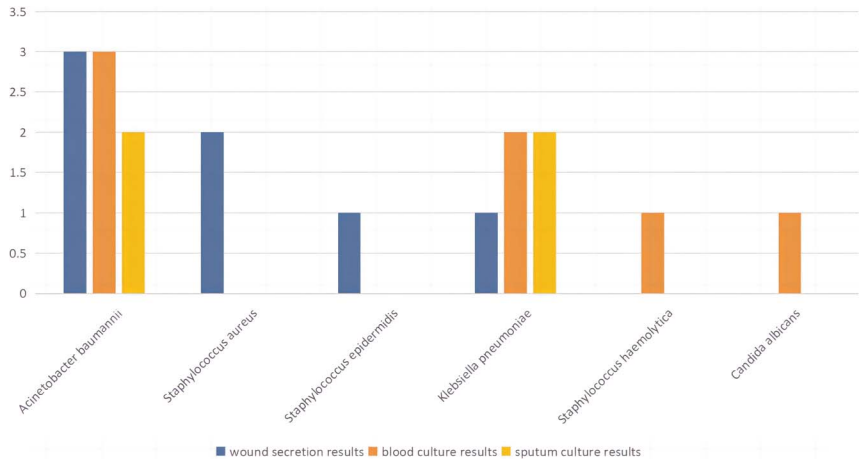

Figure 1. Bacterial culture results.

while that for patients with stable circulation was less than 2000 mL. Nutritional support therapy was administered to all the patients; 11 required enteral nutrition alone, while the remaining 10 required both intravenous and enteral nutritional support owing to gastrointestinal dysfunction. Specific patient characteristics are listed in Table 3.

Follow-up outcomes. Of the 18 patients who required mechanical ventilation, 15 were successfully weaned off the device and demonstrated good wound healing, 2 were weaned off the device and demonstrated unhealed wounds, and 1 was discharged from the hospital without further treatment. One patient was admitted to the ICU for low blood pressure but later died from respiratory failure because the family members refused intubation. The other 2 patients did not have respiratory failure and were successfully treated and discharged. Table 3 shows the individual patient conditions and follow-up data. In the follow-up of the surviving patients, 4, 3, and 1 death(s) attributed to pneumonia combined with respiratory failure (with survival time of 3, 4, 20, and 24 months), cardiac failure (with survival time of 18, 23, and 32 months), and operative complications (after aortic valve replacement because of rupture of an artificial blood vessel at the time of reoperation 1 year after discharge from the hospital), respectively, were noted.

Discussion

The sternal wound is the most common site of infection after median sternotomy. Fortunately, most sternal wound infections are superficial, affecting only the skin and fascia, and can be treated with conventional local dressing changes, debridement, or antibiotic therapy. Deep sternal wound infection, which occurs when infection spreads to the sternum or mediastinum, is typically caused by coagulase-negative staphylococci and manifests clinically as sternal osteomyelitis, mediastinal abscess, and sepsis.[12] Bilateral internal mammary artery transplantation, low body mass index, diabetes, lung disease, atrial fibrillation, and poor postoperative general condition are potential risk factors for the development of DSWI after surgery.[13] Postoperative complications or preexisting risk factors for DSWI were prevalent in all the patients in this study.

A retrospective analysis revealed that most sternal wound infections after early coronary artery bypass surgery were caused by gram-positive bacteria, primarily single bacterial infections (94%). However, most secondary DSWIs are caused by gram-negative bacteria, with multibacterial infections accounting for 71% of all cases.[14] Only 4 of the 10 patients in this study demonstrated positive wound secretion culture, and 3 had gram-negative bacillus infection indicative of inferior early treatment effect, thereby suggesting the need for greater precaution to prevent gram-negative bacillus infection during the pectoralis major flap transplantation procedure. Additionally, studies have demonstrated that microorganisms are randomly dispersed throughout infected wounds. Thus, at least 2 sites should be used for tissue sampling or molecular nucleic acid amplification technology for attaining successful culture results.[7] Patients with DSWI often receive anti-infection treatment for common infectious bacteria (coagulase-negative staphylococci) or in cases of inadequate initial anti-infection treatment compared with those with superficial sternal wound infections who are treated with conventional dressing changes and debridement. Pathogenic bacteria are often gram-negative bacilli associated with poor incision drainage, secondary infection, or prolonged use of mechanical ventilators and vasoactive drugs.[15] Reconstruction of the thoracic anatomical structure using a pectoralis major flap promotes healing and achieves good therapeutic effects.[16] However, some patients are hospitalized for long periods, resulting in organ function impairment due to sepsis associated with incision infections. This is attributed to the underlying diseases and poor general health of the patients.

Because of the unique nature of the underlying disease in patients undergoing sternotomy, sepsis from DSWI manifests clinically differently from sepsis attributed to other infections. Most patients who require sternotomy have coronary heart disease in addition to symptoms, such as chills and high fever associated with an infection. Compared with sepsis, which is frequently complicated by septic shock attributed to other causes, respiratory failure was the most common clinical manifestation of sepsis in these patients.[17] Sepsis impairs respiratory function by increasing tissue oxygen consumption and decreasing thoracic stability. Infected sternal wounds frequently result in sepsis; respiratory failure is a common clinical manifestation.

Prolonged infection and unique bacterial strains may account for the insignificant increase in the white blood cell and neutrophil count in patients with DSWI-induced sepsis. Some patients with inflammatory factors do not show an increase in the procalcitonin levels; however, worsening of their condition due to DSWI cannot be ruled out. An increased C-reactive protein level can better reflect the progression of infection and can be used to gauge the success of the treatment performed.[18] Only 1 case of acute kidney injury

Table 3

Organ Support and Outcomes in Patients

Case	Age, y	Duration of Organ Support		Tracheotomy	Intravenous Fluid Volume in the First 24 h	Vasoactive Drug	Nutritional Patterns	ICU Hospitalization Duration, d	Outcomes	Follow-up		
		Mechanical Ventilation, d	Hemodialysis							Survival Time, mo	Cause of Death	Incision Situation
1	65	10	No	No	2235	None	Enteral nutrition	14	Wound healed + weaned from mechanical ventilation	23	Heart failure	No complications
2	53	10	No	No	2745	Dopamine + norepinephrine	Enteral nutrition	10	Discharged	>42 Still alive	None	No complications
3	60	None	No	No	4520	Dopamine + norepinephrine	Enteral nutrition	14	Wound healed	12	Rupture of artificial blood vessel during reoperation	No complications
4	82	3	No	Yes	4200	Dopamine + norepinephrine	Intravenous nutrition	5	Wound healed + weaned from mechanical ventilation	3	Pneumonia Respiratory failure	No complications
5	73	103	No	No	2500	None	Intravenous nutrition + enteral nutrition	178	Successful weaning + Wound unhealed	4	Pneumonia Respiratory failure	No complications
6	51	Refused	No	No	2600	Norepinephrine	Intravenous nutrition + enteral nutrition	14	Death	None	None	None
7	51	None	No	No	3200	None	Intravenous nutrition + enteral nutrition	7	Successful weaning	>40 Still alive	None	Formed chronic sinus tract
8	82	82	25	Yes	5449	Norepinephrine + adrenaline		85	Successful weaning + wound unhealed	32	Heart failure	No complications
9	76	27	No	No	1600	None	Intravenous nutrition + enteral nutrition	29	Wound healed + Weaned from mechanical ventilation	25	Pneumonia Respiratory failure	No complications
10	64	22	No	No	1750	None	Intravenous nutrition + enteral nutrition	29	Wound healed + Weaned from mechanical ventilation	>20 Still alive	None	No complications
11	71	12	No	No	2040	None	Enteral nutrition	15	Wound healed + weaned from mechanical ventilation	>31 Still alive	None	No complications
12	58	15	No	No	2450	None	Enteral nutrition	17	Wound healed + weaned from mechanical ventilation	>22 Still alive	None	No complications
13	67	18	No	No	3260	Norepinephrine	Intravenous nutrition + enteral nutrition	20	Wound healed + weaned from mechanical ventilation	>20 Still alive	None	No complications
14	69	20	No	No	3450	Norepinephrine	Intravenous nutrition + enteral nutrition	23	Wound healed + weaned from mechanical ventilation	20	Pneumonia Respiratory failure	No complications
15	66	12	No	No	2850	None	Intravenous nutrition + enteral nutrition	14	Wound healed + weaned from mechanical ventilation	>19 Still alive	None	No complications

Continued next page

Table 3 *(Continued)*

Case	Age, y	Duration of Organ Support: Mechanical Ventilation, d	Duration of Organ Support: Hemodialysis	Tracheotomy	Intravenous Fluid Volume in the First 24 h	Vasoactive Drug	Nutritional Patterns	ICU Hospitalization Duration, d	Outcomes	Follow-up: Survival Time, mo	Follow-up: Cause of Death	Follow-up: Incision Situation
16	68	6	No	No	2450	None	Intravenous nutrition + Enteral nutrition	9	Wound healed + weaned from mechanical ventilation	>18 Still alive	None	No complications
17	72	8	No	No	2040	None	Enteral nutrition	10	Wound healed + weaned from mechanical ventilation	18	Heart failure	No complications
18	72	10	No	No	2410	Norepinephrine	Enteral nutrition	12	Wound healed + weaned from mechanical ventilation	>15 Still alive	None	No complications
19	67	12	No	No	2240	None	Enteral nutrition	13	Wound healed + weaned from mechanical ventilation	>8 Still alive	None	No complications
20	63	14	No	No	3240	Norepinephrine	Intravenous nutrition + enteral nutrition	15	Wound healed + weaned from mechanical ventilation	>7 Still alive	None	No complications
21	67	8	No	No	2160	None	Enteral nutrition	11	Wound healed + weaned from mechanical ventilation	>6 Still alive	None	No complications

ICU, intensive care unit.

associated with DSWI-associated sepsis was present; however, as the patient had no preexisting renal dysfunction, complete renal function was restored after aggressive treatment.

Multidisciplinary comprehensive treatment is the key to improving the treatment outcomes of patients with DSWI-induced sepsis.[19] Rehabilitation opportunities are available through organ support in addition to reasonable anti-infection treatment and surgical debridement in cases of compromised organ function. Combined anti-infection therapy may be required in many cases of DSWI because the type of bacterial infection varies from that in the early stage of infection. Surgery for infected tissue removal is the gold standard anti-infection treatment.

The successful treatment of patients with sepsis and organ function injury is contingent on maintaining organ function. A ventilator aids in breathing and ensures adequate oxygenation. Hemodialysis is used as a substitute for kidney function, providing patients with more treatment options and more time to recover. Patients were more likely to develop respiratory failure after thoracotomy due to its effect on thoracic stability; moreover, the time required for regaining spontaneous breathing after ventilator support was greater in patients with sepsis and respiratory failure. Some studies have reported tracheotomy as a risk factor for DSWI after sternotomy.[20] The 2 elderly patients in this study required mechanical ventilation for 103 and 82 days, respectively. Age is a significant factor associated with the time for recovery of spontaneous breathing.[21] Aspiration pneumonia was avoided, and the likelihood of successful spontaneous breathing increased after tracheotomy in patients with respiratory distress. Therefore, each patient should be considered individually when planning intubation due to the difficulties associated with spontaneous breathing. Respiratory muscle training and early exercise can aid in weaning off the ventilator as prolonged bed rest attributed to the use of the device negatively affects spontaneous breathing function recovery.[22] This can be accomplished by increasing bedside muscle training and gradually increasing the time spent off the ventilatory support. Meanwhile, the patients' heart function should be closely monitored to prevent overtraining-related heart failure. Hemodialysis is an active and effective treatment for patients without an underlying renal disease that can reduce their liquid load; it stabilizes their water and electrolyte levels and restores normal kidney function.

Limitations

This study has the following limitations. First, the number of included cases was low, which could be attributed to the low incidence of DSWI-related sepsis. Second, long-term follow-up data were missing.

Conclusion

The clinical manifestations of DSWI-induced sepsis after median sternotomy include dyspnea, fever, agitation, altered state of consciousness, and respiratory and circulatory failure. Hypertension, type II diabetes mellitus, and cardiac surgery complications are common comorbidities associated in these patients. Active wound debridement, prudent antibiotic use, adequate nutrition support, and organ function support (such as mechanical ventilation and hemodialysis) can result in positive therapeutic outcomes in patients with DSWI-induced sepsis.

Conflict of interest statement

The authors declare no conflict of interest.

Author contributions

Song B, Cui Z, and Li G participated in the study conception and design. Ju H, Sun Y, and Cui Z participated in data acquisition. Song B and Liu D participated in data analysis and interpretation as well as the statistical analysis. Song B wrote the manuscript. Ju H, Sun Y, and Li G participated in the critical revision of the manuscript for intellectual content. All the authors have read and approved the final draft of the manuscript.

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Ethical approval of studies and informed consent

The study followed the principles of the Declaration of Helsinki as revised in 2013. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the 7th Medical Center of Chinese PLA General Hospital (S2023-011-01, 2023/04/18). Written informed consent was obtained from all participants.

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