

Immune-metabolic Failure in Fatal Septic Shock Caused by ESBL-producing *Escherichia coli* with a PICS-like Trajectory and Gastrointestinal Involvement: A Case Report

Lundu Suhut Philip^{1*}, Vera Irawany²

¹ Department of Anesthesiology and Intensive Care, Universitas Indonesia, Jakarta, Indonesia

² Department of Anesthesiology and Intensive Care, Universitas Indonesia, Fatmawati General Hospital, Jakarta, Indonesia

*Corresponding Author: Lundu Suhut Philip, E-mail: philipsihombing17@gmail.com 

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ABSTRACT

Introduction: Septic shock complicated by multiple organ dysfunction is a leading cause of death in critically ill patients. Infections caused by extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli* are particularly challenging because antimicrobial resistance may delay effective therapy. The gastrointestinal tract is increasingly recognized as an amplifier of systemic inflammation through barrier disruption and bacterial translocation, particularly in patients with chronic enteropathy and severe malnutrition.

Case presentation: A 29-year-old man with a history of intestinal tuberculosis, inflammatory bowel disease, and recent nephrotic syndrome presented with chronic watery diarrhea, vomiting, oliguria, and scleral icterus. Admission findings included leukocytosis, lymphopenia, a neutrophil-to-lymphocyte ratio of 25.9, acute kidney injury, hyponatremia, profound hypoalbuminemia (12.1 g/L), and procalcitonin above 32 ug/L. His course progressed to encephalopathy, recurrent seizures, upper gastrointestinal bleeding, coagulopathy, and vasopressor-dependent shock with anuric renal failure requiring continuous renal replacement therapy. Blood cultures grew ESBL-producing *E. coli*, and contrast-enhanced abdominal computed tomography showed diffuse bowel wall thickening. Serial biomarkers revealed progressive lymphopenia, persistent hypoalbuminemia, and rising lactate (10.5 mmol/L), consistent with immune-metabolic failure and a persistent inflammation, immunosuppression, and catabolism syndrome (PICS)-like trajectory. He died on the intensive care unit on day 10 due to refractory multiorgan failure.

Conclusion: In vulnerable hosts with chronic enteropathy and malnutrition, marked gastrointestinal involvement combined with serial immune-metabolic biomarkers may help identify early high-risk deterioration and support repeated source reassessment and timely antimicrobial optimization.

Septic Shock, *Escherichia Coli* Infections, Bacteraemia, Acute Kidney Injury, Hypoalbuminaemia, Protein-Energy Malnutrition, Intestinal Diseases, Critical Care

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INTRODUCTION

Sepsis and septic shock remain major causes of death in critically ill patients, especially when they progress to multiple organ dysfunction [1]. Infections caused by extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli* are particularly challenging because antimicrobial resistance may delay effective treatment and worsen outcomes [2]. The gastrointestinal tract is increasingly recognized as a key amplifier of systemic inflammation in critical illness through barrier disruption, altered host–microbiome interactions, and bacterial translocation [3,4].

These mechanisms may be especially relevant in patients with chronic intestinal disease, severe malnutrition, renal dysfunction, or recent immunosuppressive exposure [5]. In parallel, some patients with severe sepsis develop immune-metabolic features resembling persistent inflammation, immunosuppression, and catabolic syndrome, including lymphopenia, ongoing catabolism, and failure of biomarker recovery [6,7]. We report a fatal case of septic shock caused by ESBL-producing *E. coli* in a malnourished young adult with chronic enteropathy, marked gastrointestinal involvement, and a PICS-like trajectory during ongoing ICU deterioration despite organ support.

CASE DESCRIPTION

A 29-year-old man presented to the emergency department of a tertiary care hospital in Jakarta, Indonesia, in 2024 with a 2-day history of fatigue, watery diarrhea, vomiting, oliguria, dysuria, and scleral icterus. He also reported a 3-month history of chronic diarrhea and marked weight loss. His medical history was notable for intestinal tuberculosis and inflammatory bowel disease diagnosed 5 years earlier, and nephrotic syndrome treated 1 month before admission with diuretics and methylprednisolone use.

On admission, the patient appeared critically ill. Laboratory investigations showed a white blood cell count of $21.5 \times 10^9/L$, an absolute lymphocyte count of $0.751 \times 10^9/L$, a neutrophil-to-lymphocyte ratio of 25.9, creatinine of $326 \mu\text{mol/L}$, sodium of 120 mmol/L , albumin of 12.1 g/L , and procalcitonin $>32 \mu\text{g/L}$. He was started on intravenous fluids, nutritional support, ceftriaxone, and metronidazole and was admitted to the ward. During the first hospital day, diarrhea worsened, melena developed, and oliguria persisted. Colonoscopy was planned to evaluate persistent diarrhea and gastrointestinal bleeding, but was deferred because of hemodynamic and neurological deterioration. On hospital days 3–4, he developed somnolence, worsening encephalopathy, and hypotension requiring intubation. He was transferred to the intensive care unit (ICU) on hospital day 5 because of progressive multiorgan dysfunction. A summary of the clinical course is shown in Table 1.

Table 1. Clinical timeline.

Day	Clinical Course and Interventions
5 years earlier	Intestinal tuberculosis and inflammatory bowel disease diagnosed after gastrointestinal endoscopy
1 month earlier	Nephrotic syndrome was treated with diuretics and methylprednisolone.
Day 0	Fatigue, chronic watery diarrhea, vomiting, oliguria, dysuria, scleral icterus, and weight loss; intravenous fluids, nutritional support, ceftriaxone, and metronidazole were initiated.
Day 1	Colonoscopy was deferred because of worsening diarrhea, melena, and persistent oliguria.
Days 3–4	Neurological deterioration and hypotension required intubation in the patient.
Day 5	ICU transfer, seizures, and norepinephrine initiation.
ICU 2	Upper gastrointestinal bleeding, coagulopathy, severe metabolic acidosis, vasopressor-dependent shock, and anuric renal failure; continuous venovenous haemodiafiltration was initiated; blood cultures later grew ESBL-producing <i>E. coli</i> .
ICU 3–8	Persistent critical illness with recurrent seizures, abdominal distension, profuse diarrhea, persistent anuria, and organ support; tracheostomy on day 6.
ICU 9	New hypodense lesion on repeat head CT and diffuse bowel wall thickening on abdominal CT.
ICU 10	Refractory shock, persistent anuria, severe hyperlactataemia, leukopenia, and lymphopenia; unsuccessful resuscitation and death from multiorgan failure.

At ICU admission, repeat laboratory evaluation showed a hemoglobin level of 81 g/L , white blood cell count of $16.2 \times 10^9/L$, creatinine level of $527 \mu\text{mol/L}$, sodium level of 120 mmol/L , albumin level of 12.1 g/L , and procalcitonin level $>32 \mu\text{g/L}$. Non-contrast head computed tomography (CT) revealed no acute intracranial hemorrhage, territorial infarction, or mass effect (Figure 1A). Abdominal ultrasonography revealed cystitis, bilateral grade 2 renal parenchymal disease, and mild ascites. Within 9 h of ICU admission, the patient developed three seizures, which were treated with intravenous phenytoin and diazepam. He subsequently became hypotensive and required norepinephrine at a dose of up to $1.2 \mu\text{g/kg/min}$. On ICU day 2, his condition worsened with upper gastrointestinal bleeding through the nasogastric tube, coagulopathy, severe metabolic acidosis, vasopressor-dependent shock, and anuric renal failure. Continuous venovenous hemodiafiltration was initiated. Blood cultures later grew extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli*, and

the antimicrobial therapy was escalated accordingly. From ICU days 3 to 8, the patient remained critically ill, with recurrent seizures, abdominal distension, profuse diarrhea, persistent anuria, and ongoing organ support. Tracheostomy was performed on ICU day 6. Temporary hemodynamic improvement was observed during renal replacement therapy; however, it was not sustained. Daily ICU events and selected immune-inflammatory and metabolic trends are summarized in Table 2. Expanded day-by-day organ support and laboratory data are provided in Supplementary Tables S1A and S1B

On ICU day 9, a repeat head CT demonstrated a new hypodense lesion in the posterior horn of the left lateral ventricle, with infarction included in the differential diagnosis (Figure 1B). Contrast-enhanced abdominal CT revealed diffuse bowel wall thickening involving the colon and small bowel without a definite focal source (Figure 2). On ICU day 10, the patient had refractory vasopressor-dependent shock, persistent anuria, severe hyperlactatemia, leukopenia, and worsening lymphopenia. Despite mechanical ventilation, vasopressors, renal support, broad-spectrum antimicrobials, and full resuscitative measures, the patient died on ICU day 10.

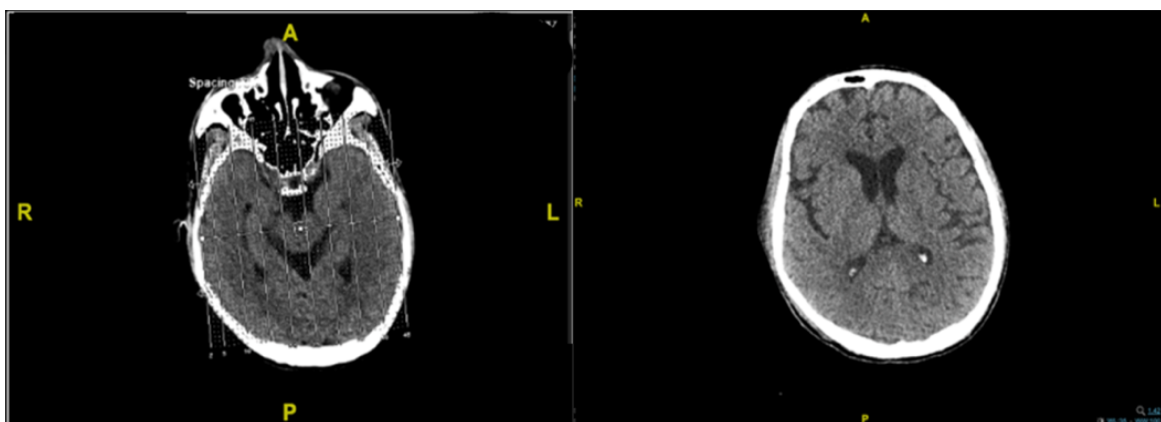


Figure 1. Serial non-contrast head CT at ICU admission and on day 9. (A) No acute intracranial abnormalities were observed at admission. (B) New hypodense lesion in the posterior horn of the left lateral ventricle on day 9, possibly indicating infarction.

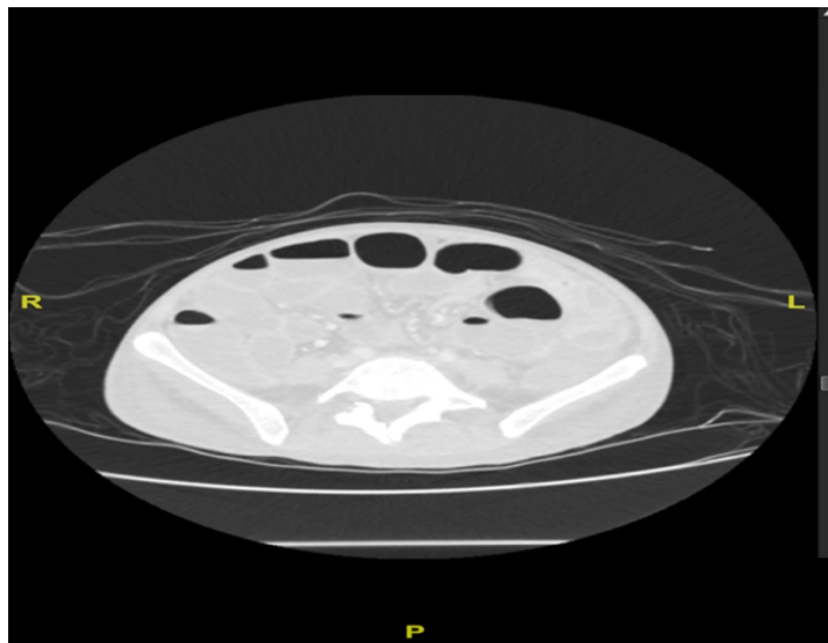


Figure 2. Abdominal contrast-enhanced CT on ICU day 9 showing diffuse colonic and small bowel wall thickening without a definite focal source.

Table 2. Daily ICU events and selected immune-inflammatory and metabolic trends

ICU day	Key events	RRT	Lactate (mmol/L)	ALC ($\times 10^9/L$)	NLR	CRP (mg/L)	PCT ($\mu g/L$)	Albumin (g/L)
1	Seizures; hypotension	—	—	—	—	—	—	—
2	Upper GI bleeding, coagulopathy, acidosis, shock, anuria	CVVHDF	2.8	0.677	38.2	13.86	23.61	15.0
3	Transient stabilisation	CVVHDF	2.8	0.476	20.0	—	—	18.5
4	ESBL-producing <i>E. coli</i> bacteraemia	SCUF	4.5	0.604	18.5	—	—	20.0
5	Partial haemodynamic improvement	SCUF	2.6	0.636	15.5	16.94	12.53	23.0
6	Tracheostomy	Off RRT	3.9	0.417	14.5	—	—	22.8
7	Bilious drainage; ongoing GI dysfunction	HD	2.7	0.534	5.5	—	—	22.5
8	Recurrent seizures, distension, profuse diarrhoea	HD	4.3	0.350	5.4	28.0	30.0	—
9	Fever, bleeding, encephalopathy; bowel thickening on CT	CVVHDF	4.0	0.368	2.4	—	—	—
10	Refractory shock, anuria, hyperlactataemia; death	—	10.5	0.334	2.8	12.0	13.0	—

Nota: ALC, absolute lymphocyte count; CRP, C-reactive protein; CT, computed tomography; CVVHDF, continuous venovenous haemodiafiltration; ESBL, extended-spectrum beta-lactamase; GI, gastrointestinal; HD, hemodialysis; ICU, intensive care unit; NLR, neutrophil-to-lymphocyte ratio; PCT, procalcitonin; RRT, renal replacement therapy; SCUF, slow continuous ultrafiltration.

Table S1A. Expanded day-by-day intensive care unit clinical and organ-support dataset

ICU day	Key events / major interventions	Vasopressors	Ventilation / airway support	RRT modality	UOP (mL/24 h)	Fluid balance (mL/24 h)	Antibiotics
1	Central venous and femoral dialysis catheters inserted; three seizures treated with phenytoin and diazepam; post-treatment hypotension	NE up to 1.2 $\mu g/kg/min$	Intubated at ICU admission; ventilator settings not charted	—	70 mL/14 h	—	Ceftriaxone + metronidazole continued
2	Nasogastric tube bleeding (~50 mL/h); one seizure treated with thiopental; severe coagulopathy and acidosis; CVVHDF started; packed red cell transfusion	NE 1.2 $\mu g/kg/min$ + VP 0.04 U/min	MV, SIMV (TV 320 mL, RR 16/min, PEEP 5 cmH ₂ O, FiO ₂ 50%)	CVVHDF	0	+1606	Escalated to meropenem + levofloxacin + fluconazole
3	Icterus improved; no seizures; thromboelastography suggested prolonged intrinsic pathway	NE 0.7 $\mu g/kg/min$ + VP 0.04 U/min	SIMV	CVVHDF	30	-1859	Continued
4	Blood culture positive for ESBL-producing <i>E. coli</i> ; RRT switched to heparin-free SCUF; levofloxacin stopped and amikacin started	NE 0.3 $\mu g/kg/min$ + VP 0.04 U/min	SIMV	SCUF	20	-161	Amikacin started; levofloxacin stopped; carbapenem continued
5	Haemodynamic improvement; transfusion support as indicated	NE 0.1 $\mu g/kg/min$; VP off	SIMV	SCUF	50	+283	Continued
6	Tracheostomy performed; epidermolysis documented; CRRT stopped and circuit blood returned	NE 0.1 $\mu g/kg/min$	Tracheostomy; MV, SIMV (PS 12 cmH ₂ O, TV 320 mL, FiO ₂ 40%, PEEP 6 cmH ₂ O)	Off RRT	10	+1016	Continued
7	Intermittent HD (UF 1000 mL over 5 h); green/bilious nasogastric output	NE 0.05 $\mu g/kg/min$	Tracheostomy T-piece (6 L/min)	HD	60	+1720	Continued

Table S1A (continued 1)

ICU day	Key events / major interventions	Vasopressors	Ventilation / airway support	RRT modality	UOP (mL/24 h)	Fluid balance (mL/24 h)	Antibiotics
8	Intermittent HD (UF 2500 mL over 5 h); one seizure before HD and three during HD; abdominal distension and profuse green diarrhoea; platelet transfusion (7 units)	NE 0.3 µg/kg/min	Tracheostomy T-piece (6 L/min)	HD	110	+132	Continued
9	Fever, neurologic deterioration, and bleeding from tracheostomy site; head CT showed a new CSF-density hypodense lesion; contrast-enhanced abdominal CT showed diffuse bowel wall thickening; CVVHDF restarted but circuit clotted after ~12 h	NE 1.0 µg/kg/min	Tracheostomy; MV, SIMV (PS 12 cmH ₂ O, TV 320 mL, FiO ₂ 40%, PEEP 6 cmH ₂ O)	CVVHDF (clotted)	0	+1864	Continued
10	Refractory vasopressor-dependent shock; persistent anuria; severe hyperlactataemia; leukopenia and lymphopenia; meropenem discontinued and vancomycin started; cardiopulmonary resuscitation unsuccessful, followed by death	NE 2.0 µg/kg/min + VP 0.04 U/min	Tracheostomy; MV, SIMV (PS 12 cmH ₂ O, TV 320 mL, FiO ₂ 40%, PEEP 6 cmH ₂ O)	—	0	+633	Vancomycin started; meropenem discontinued

Note: ICU day 1 urine output was recorded over the first 14 hours after ICU admission. CRRT = continuous renal replacement therapy; CSF = cerebrospinal fluid; CT = computed tomography; CVVHDF = continuous venovenous haemodiafiltration; FiO₂ = fraction of inspired oxygen; HD = hemodialysis; MV = mechanical ventilation; NE = norepinephrine; PEEP = positive end-expiratory pressure; PS = pressure support; RR = respiratory rate; RRT = renal replacement therapy; SCUF = slow continuous ultrafiltration; SIMV = synchronized intermittent mandatory ventilation; TV = tidal volume; UF = ultrafiltration; UOP = urine output; VP = vasopressin.

Table S1B. Expanded day-by-day intensive care unit laboratory trends.

ICU day	Hb (g/L)	WBC (×10 ⁹ /L)	ALC (×10 ⁹ /L)	NLR	Platelets (×10 ⁹ /L)	Lactate (mmol/L)	Urea (mg/dL)	Creatinine (µmol/L)	PT (s)	Fibrinogen (mg/dL)	D-dimer (ng/mL FEU)	CRP (mg/L)	PCT (µg/L)	Albumin (g/L)
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	69	28.2	0.677	38.2	391	2.8	219.0	587.0	>90	778	2030	13.86	23.61	15.0
3	90	10.6	0.476	20.0	103	2.8	106.9	240.4	60.1	780	1970	—	—	18.5
4	94	12.3	0.604	18.5	30	4.5	72.2	168.0	23.0	—	1660	—	—	20.0
5	79	11.0	0.636	15.5	45	2.6	80.0	162.7	18.8	735	1630	16.94	12.53	23.0
6	106	6.8	0.417	14.5	29	3.9	81.9	152.0	18.8	674	1420	—	—	22.8
7	93	3.9	0.534	5.5	19	2.7	144.7	206.0	18.8	655	1180	—	—	22.5
8	96	2.5	0.350	5.4	38	4.3	80.0	238.7	17.6	658	1170	28	30	—
9	89	4.0	0.368	2.4	18	4.0	125.6	207.7	18.4	733	1080	—	—	—
10	105	1.4	0.334	2.8	48	10.5	114.1	167.1	22.0	706	1030	12	13	—

Note: On ICU day 2, the international normalized ratio was reported as >5 together with a prothrombin time >90 seconds. Albumin levels on ICU day 10 were not available in the daily laboratory summary. ALC, absolute lymphocyte count; CRP, C-reactive protein; Hb, hemoglobin; NLR, neutrophil-to-lymphocyte ratio; PCT, procalcitonin; PT, prothrombin time; WBC, white blood cell count.

DISCUSSION

This case illustrates rapidly progressive septic shock with refractory multiorgan failure in a patient with gastrointestinal vulnerability. Chronic enteropathy, prior intestinal tuberculosis, severe malnutrition, nephrotic syndrome with renal involvement, recent methylprednisolone exposure, and profound hypoalbuminemia likely reduced gastrointestinal, renal, immune, and metabolic reserves before the onset of bloodstream infection. The course progressed from organ dysfunction at presentation to vasopressor-dependent shock, anuric acute kidney injury requiring renal replacement therapy, coagulopathy with bleeding, encephalopathy, recurrent seizures, and death on ICU day 10. This trajectory is consistent with the high mortality associated with septic shock complicated by multiple organ dysfunction [1]. Bloodstream infection caused by ESBL-producing *Escherichia coli* remains clinically significant because antimicrobial resistance may delay appropriate therapy and worsen outcomes [2]. Severe malnutrition and persistent hypoalbuminemia may have weakened host defence and physiological reserve [5].

A central feature of this case was the gastrointestinal tract signal. Chronic watery diarrhea, gastrointestinal bleeding, abdominal distension, bilious nasogastric drainage, and diffuse bowel wall thickening on contrast-enhanced abdominal CT suggested intestinal involvement. The gut is increasingly recognized as an amplifier of systemic inflammation in critical illness through barrier disruption, altered host–microbiome interactions, local immune dysregulation, and bacterial or bacterial product translocation [8,9]. In this patient, chronic enteropathy, prior intestinal tuberculosis, and severe malnutrition may have compromised mucosal integrity. However, the source of the infection could not be definitively established. A gastrointestinal source remained biologically plausible, but a urogenital source was also possible because of the presence of dysuria, urinalysis abnormalities, and suspected cystitis. The most defensible interpretation was septic shock with gastrointestinal involvement and unresolved source localization rather than proven primary intra-abdominal sepsis. Another aspect is the longitudinal immune-metabolic pattern. The absolute lymphocyte count declined from $0.751 \times 10^9/\text{L}$ at presentation to $0.334 \times 10^9/\text{L}$ in the terminal phase, profound hypoalbuminemia persisted, and lactate levels increased to 10.5 mmol/L during refractory shock. The decline in the neutrophil-to-lymphocyte ratio did not indicate recovery because it occurred in the context of severe leukopenia and worsening lymphopenia rather than physiological improvement. Serial changes in lymphocyte count, neutrophil-to-lymphocyte ratio, and lactate levels have been associated with the prognosis of sepsis [10,11]. Taken together, persistent hypoalbuminemia, progressive lymphopenia, rising lactate levels, and failure of biomarker recovery support an immune-metabolic failure pattern with a PICS-like trajectory, although the short clinical course precludes a definitive diagnosis of PICS [7]. Neurological deterioration is likely multifactorial, and encephalopathy, recurrent seizures, and hypodense lesions on repeat head CT may reflect the mechanisms described in sepsis-associated encephalopathy [12].

From a therapeutic perspective, this case highlights empiric antibiotic selection in source-uncertain septic shock [13]. Given the severity of the illness, acute kidney injury, and subsequent confirmation of ESBL-producing *E. coli* bacteremia, early broad-spectrum gram-negative coverage may have been more appropriate in a high-risk patient with multidrug-resistant infection [14]. Anuric renal failure requiring continuous venovenous haemodiafiltration, slow continuous ultrafiltration, and hemodialysis underscores the importance of PK/PD-guided antimicrobial dose optimization during critical illness [15]. This case shows how host vulnerability, source uncertainty, resistant gram-negative bacteremia, progressive immune-metabolic deterioration, and organ-support complexity can converge in fulminant septic shock, leading to refractory decline despite antimicrobial escalation and maximal ICU support.

CONCLUSION

This case highlights immune-metabolic failure in septic shock caused by ESBL-producing *Escherichia coli* with gastrointestinal involvement. Hypoalbuminemia, lymphopenia, rising lactate levels, and absent biomarker recovery supported a PICS-like trajectory. Serial biomarkers may identify high-risk deterioration, supporting source reassessment and antimicrobial optimization.

DECLARATIONS

None

CONSENT FOR PUBLICATION

The Authors agree to the publication in the Journal of Society Medicine.

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AUTHORS' CONTRIBUTIONS

L.S.P. contributed to the conception and design of the case report, acquisition and interpretation of clinical data, visualization, and drafting of the manuscript. V.I. contributed to the supervision, critical revision of the manuscript for important intellectual content and manuscript refinement. All authors have read and approved the final manuscript and have agreed to be accountable for all aspects of the work.

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REFERENCE

1. La Via L, Maniaci A, Lentini M, Cuttone G, Ronsivalle S, Tutino S, et al. The burden of sepsis and septic shock in the intensive care unit. *J Clin Med*. 2025;14:6691.
2. Asmarawati TP, Widyatama FS, Notobroto HB, Nasronudin N, Sugai M, Kuntaman K. Risk factors and clinical impact of extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli* bacteremia among hospitalized patients. *Antibiotics (Basel)*. 2025;14:882.
3. Potruch A, Schwartz A, Ilan Y. The role of bacterial translocation in sepsis: a new target for therapy. *Ther Adv Gastroenterol*. 2022;15:17562848221094214.
4. Chanchaoenthana W, Kamolratanakul S, Schultz MJ, Leelahavanichkul A. The leaky gut and the gut microbiome in sepsis: targets in research and treatment. *Clin Sci (Lond)*. 2023;137:62-645.
5. Hawkins RB, Raymond SL, Stortz JA, Horiguchi H, Brakenridge SC, Gardner A, et al. Chronic critical illness and the persistent inflammation, immunosuppression, and catabolism syndrome. *Front Immunol*. 2018;9:1511.
6. Chadda KR, Blakey EE, Davies TW, Puthuchearu Z. Risk factors, biomarkers, and mechanisms for persistent inflammation, immunosuppression, and catabolism syndrome (PICS): a systematic review and meta-analysis. *Br J Anaesth*. 2024;133:49-538.
7. Baek MS, Kwon YS, Kang SS, Shim D, Yoon Y, Kim JH. Association of malnutrition status with 30-day mortality in patients with sepsis using objective nutritional indices: a multicenter retrospective study in South Korea. *Acute Crit Care*. 2024;39:37-127.
8. Klingensmith NJ, Coopersmith CM. The gut as the motor of multiple organ dysfunction in critical illness. *Crit Care Clin*. 2016;32:12-203.
9. Haussner F, Chakraborty S, Halbgebauer R, Huber-Lang M. Challenge to the intestinal mucosa during sepsis. *Front Immunol*. 2019;10:891.
10. Ma H, Di J, Xiao S, Chen L, Zhao W, Cui J. Monitoring immune cell dynamics for potential prognostic biomarker of sepsis. *BMC Infect Dis*. 2025;25:1765.

11. Liu Y, Zheng J, Zhang D, Jing L. Neutrophil-lymphocyte ratio and plasma lactate predict 28-day mortality in patients with sepsis. *J Clin Lab Anal.* 2019;33:e22942.
12. Li J, Jia Q, Yang L, Wu Y, Peng Y, Du L. Sepsis-associated encephalopathy: mechanisms, diagnosis, and treatments update. *Int J Biol Sci.* 2025;21:28-3214.
13. Evans L, Rhodes A, Alhazzani W, Antonelli M, Coopersmith CM, French C, et al. Surviving Sepsis Campaign: international guidelines for management of sepsis and septic shock 2021. *Crit Care Med.* 2021;49:e1063-143.
14. Tamma PD, Aitken SL, Bonomo RA, Mathers AJ, van Duin D, Clancy CJ. Infectious Diseases Society of America 2024 guidance on the treatment of antimicrobial-resistant Gram-negative infections. *Clin Infect Dis.* 2024;79:e91-116.
15. Hong LT, Downes KJ, FakhriRavari A, Abdul-Mutakabbir JC, Kuti JL, Jorgensen SCJ, et al. international consensus recommendations for the use of prolonged-infusion beta-lactam antibiotics. *Pharmacotherapy.* 2023;43:72-740.
16. Hutasuhut AF, Rismawan B. Management of septic shock secondary to submandibular phlegmon and ventilator-associated pneumonia in the intensive care unit. *Journal of Society Medicine.* 2025;4(9):91-284.
17. Irawati D, Pradian E. Management of severe head injury patients with concurrent metabolic disorders, hyperkalemia, stage III acute kidney injury, and suspected alcohol intoxication using renal replacement therapy in ICU. *Journal of Society Medicine.* 2025;4(11):63-358.
18. Nasution I, Arto KS, Lubis BM. Correlation between glycated hemoglobin and calcium levels in pediatric with type 1 diabetes mellitus. *Journal of Society Medicine.* 2023;2(11):83-377.
19. Ariaty GM, Rismawan B. Management of intra-abdominal infection patients with septic shock in the ICU. *Journal of Society Medicine.* 2025;4(9):298-304.