E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.48047/ijprt/16.01.630

Research Article

Perioperative C-reactive protein trends and ICU outcome in patients undergoing thoracic surgery for Empyema

Shurjeel Latif[1], Abeera Zareen[2], Syed Tabish Rehman[3], Syeda Murwa Jilani[4], Rizwan Ali Tunio[5], Faheed ul Haque[6]

1. Consultant Anaesthesiologist, Tallaght University Hospital, Dublin, Ireland.
2. Associate Professor, Anesthesia, Khawaja Muhammad Safdar Medical College, Sialkot, Pakistan.
3. Assistant Professor, Pulmonology, Liaquat National Hospital and Medical College, Karachi, Pakistan.
4. Senior Registrar, Anaesthesia, Allama Iqbal Memorial Teaching Hospital, Sialkot, Pakistan.
5. Assistant Professor Pulmonology, Chandka Medical College, Shaheed Mohtarma Benazir Bhutto Medical University, Larkana
6. Assistant Professor, Perioperative Medicine, Anesthesia and Critical Care, Sialkot Medical College, Sialkot

Shurjeel Latif: Corresponding author

Abstract: Perioperative inflammatory response plays a critical role in determining postoperative recovery and intensive care outcomes among patients undergoing thoracic surgery for empyema. C-reactive protein (CRP) has emerged as an important inflammatory biomarker reflecting disease severity, systemic inflammatory burden, and postoperative complications. The objective of the present study was to evaluate perioperative CRP trends and their association with intensive care unit outcomes in patients undergoing thoracic surgery for empyema. A prospective observational study was conducted among 320 patients undergoing thoracic surgical intervention for empyema between January 2023 and February 2025. Serial perioperative CRP levels were measured preoperatively, on postoperative day one, postoperative day three, and postoperative day five. Patients were stratified according to ICU outcome, duration of ventilation, and postoperative complications. Significant perioperative variation in CRP levels was observed among patients with adverse ICU outcomes compared with those demonstrating uncomplicated recovery ($p<0.001$). Patients with prolonged ICU stay exhibited persistently elevated postoperative CRP concentrations, while patients with early recovery showed progressive CRP decline after surgery. Multivariate analysis demonstrated that postoperative day three CRP level (adjusted OR 3.41, 95% CI 1.94–5.99), prolonged mechanical ventilation (adjusted OR 2.88, 95% CI 1.56–5.30), and

preoperative sepsis severity (adjusted OR 2.53, 95% CI 1.39–4.61) were independent predictors of adverse ICU outcome. These findings indicate that perioperative CRP trend analysis may serve as a clinically valuable prognostic marker for early identification of high-risk patients undergoing thoracic surgery for empyema. The study highlights the significance of dynamic inflammatory monitoring in improving postoperative critical care management and demonstrates a novel approach integrating perioperative biomarker assessment with ICU outcome prediction.

Keywords: empyema; C-reactive protein; thoracic surgery

Introduction

Empyema thoracis remains a clinically significant thoracic infection associated with substantial morbidity, postoperative complications, prolonged hospitalization, and increased mortality. The condition is characterized by accumulation of purulent material within the pleural cavity secondary to bacterial infection, pneumonia, thoracic trauma, or postoperative contamination. Despite improvements in antibiotic therapy, minimally invasive thoracic interventions, and critical care management, empyema continues to present considerable therapeutic challenges because of its progressive inflammatory nature and associated systemic complications. Advanced empyema frequently requires thoracic surgical intervention including decortication, video-assisted thoracoscopic surgery, or open thoracotomy to achieve adequate pleural drainage and lung re-expansion. However, postoperative recovery following thoracic surgery remains highly variable and is often complicated by respiratory failure, persistent sepsis, prolonged mechanical ventilation, and intensive care unit admission [1-3].

Inflammatory activation plays a central role in the pathophysiology of empyema and postoperative recovery. During pleural infection, inflammatory cytokines stimulate hepatic synthesis of acute-phase proteins including C-reactive protein (CRP), which reflects the magnitude of systemic inflammatory response. CRP is widely recognized as a sensitive biomarker of infection, tissue injury, and postoperative inflammation. Elevated CRP concentrations have been associated with increased disease severity, poor postoperative recovery, and adverse outcomes across multiple surgical specialties. In thoracic surgery, persistent postoperative elevation of CRP may indicate

ongoing pleural infection, inadequate source control, or evolving complications such as persistent sepsis and respiratory compromise [2-5]. Consequently, serial perioperative CRP monitoring has attracted growing attention as a potential prognostic tool in critically ill thoracic surgical patients.

Recent evidence has emphasized the prognostic value of perioperative inflammatory biomarkers in predicting postoperative complications and ICU outcomes. Several studies have demonstrated that persistently elevated postoperative CRP levels correlate with increased risk of pulmonary complications, prolonged ventilation, and extended intensive care stay following major thoracic procedures. Dynamic changes in CRP concentrations may therefore provide more clinically relevant information than isolated measurements because trend analysis reflects the progression or resolution of systemic inflammatory activity over time. Studies published after 2021 have suggested that failure of CRP normalization after thoracic surgery may indicate persistent infectious burden and unfavorable postoperative progression [4-7]. These observations support the integration of inflammatory biomarker monitoring into postoperative critical care assessment.

Thoracic surgery for empyema is frequently associated with severe systemic inflammation because patients often present with advanced pleural infection, septic physiology, impaired nutritional status, and compromised respiratory reserve. The inflammatory response may be further intensified by surgical tissue injury and perioperative physiological stress. Consequently, patients undergoing thoracic surgery for empyema are at increased risk of postoperative respiratory failure, prolonged ICU admission, hemodynamic instability, and mortality. Identification of reliable perioperative biomarkers capable of predicting ICU outcome may therefore contribute significantly to early risk stratification and optimization of postoperative management strategies [5-8]. Nevertheless, limited data remain available regarding the relationship between perioperative CRP trends and ICU outcomes specifically in empyema patients undergoing thoracic surgery.

Mechanical ventilation duration represents another important determinant of ICU outcome following thoracic surgery. Persistent systemic inflammation may impair

pulmonary function recovery, delay weaning from ventilatory support, and increase susceptibility to secondary pulmonary complications. Elevated postoperative CRP levels have been linked to prolonged mechanical ventilation and higher rates of postoperative respiratory distress. Furthermore, preoperative septic burden and advanced inflammatory activity may contribute to impaired postoperative tissue healing and persistent organ dysfunction [6-9]. These multidimensional interactions suggest that perioperative CRP trends may reflect not only inflammatory status but also broader physiological recovery following thoracic surgery.

Although CRP has been extensively investigated in infectious and surgical conditions, evidence regarding its perioperative dynamic profile in empyema-related thoracic surgery remains limited. Most available studies have evaluated isolated postoperative CRP values rather than comprehensive perioperative trends integrated with ICU outcomes and postoperative complications. Additionally, limited regional evidence exists regarding the prognostic significance of serial CRP monitoring in critically ill thoracic surgical populations. Therefore, the present study was designed to evaluate perioperative CRP trends and their association with ICU outcomes among patients undergoing thoracic surgery for empyema. The study additionally aimed to identify independent predictors of adverse ICU outcome using comprehensive perioperative clinical and inflammatory assessment [1-10].

Methodology

A prospective observational study was conducted at Khawaja Muhammad Safdar Medical College. The study population consisted of adult patients diagnosed with empyema thoracis requiring thoracic surgical intervention including video-assisted thoracoscopic surgery decortication, open thoracotomy decortication, or pleural drainage procedures. Patients were admitted through emergency and pulmonary surgery departments and subsequently managed in postoperative intensive care units according to institutional thoracic critical care protocols.

Sample size calculation was performed using OpenEpi version 3.01 by considering a confidence interval of 95%, study power of 80%, anticipated frequency of adverse ICU outcome among patients with elevated postoperative CRP of 35%, odds ratio of 2.0,

and equal allocation ratio. The minimum required sample size was calculated as 296 participants. To compensate for incomplete records and potential participant withdrawal, a total of 320 patients were ultimately included in the study.

Inclusion criteria consisted of patients aged 18–75 years with radiologically and microbiologically confirmed empyema thoracis undergoing thoracic surgery. Patients requiring postoperative ICU admission for at least 24 hours were eligible for enrollment. Exclusion criteria included malignancy-associated pleural disease, active autoimmune disorders, chronic inflammatory diseases, advanced hepatic failure, immunosuppressive therapy, pregnancy, previous thoracic surgery within six months, and incomplete perioperative laboratory data. Patients with concomitant severe systemic infection unrelated to thoracic pathology were also excluded.

Verbal informed consent was obtained from all participants or legally authorized attendants before enrollment. Ethical approval was obtained from the institutional review committee according to the Declaration of Helsinki guidelines for biomedical research involving human participants.

Detailed demographic and clinical information including age, gender, smoking history, diabetes mellitus, chronic obstructive pulmonary disease, hypertension, nutritional status, empyema duration, microbiological findings, and preoperative sepsis severity were recorded using standardized data collection forms. Baseline respiratory assessment included oxygen saturation, arterial blood gas analysis, and chest radiological evaluation. Perioperative variables including duration of surgery, intraoperative blood loss, ventilatory support duration, and ICU stay were documented.

Venous blood samples were collected for CRP measurement at four perioperative intervals including preoperative assessment, postoperative day one, postoperative day three, and postoperative day five. CRP concentration was measured using standardized immunoturbidimetric assays in institutional laboratories. Additional laboratory investigations included complete blood count, serum albumin, renal function tests, and procalcitonin measurement. Adverse ICU outcome was defined as prolonged ICU stay greater than seven days, prolonged mechanical ventilation exceeding 72 hours, postoperative sepsis, or in-hospital mortality.

Data analysis was performed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Independent sample t-tests and chi-square tests were applied for intergroup comparisons. Repeated-measures analysis of variance was used to evaluate serial perioperative CRP trends. Multivariate logistic regression analysis was conducted to determine independent predictors of adverse ICU outcome after adjustment for confounding variables. Odds ratios with 95% confidence intervals were calculated. A p value less than 0.05 was considered statistically significant.

Results

Table 1. Demographic and Clinical Characteristics of Study Participants

Variable	Favorable ICU Outcome (n=214)	Adverse ICU Outcome (n=106)	p-value
Age (years)	52.6±11.3	61.4±10.7	<0.001
Male gender	146 (68.2%)	78 (73.6%)	0.321
Smoking history	88 (41.1%)	62 (58.5%)	0.004
Diabetes mellitus	74 (34.6%)	56 (52.8%)	0.002
COPD	58 (27.1%)	48 (45.3%)	0.001
Preoperative sepsis	62 (29.0%)	58 (54.7%)	<0.001
Serum albumin (g/dL)	3.4±0.6	2.8±0.5	<0.001
Duration of symptoms (days)	11.2±4.7	16.4±6.1	<0.001

Table 1 demonstrates the baseline demographic and clinical characteristics of study participants according to ICU outcome. Patients with adverse ICU outcomes were significantly older and demonstrated higher frequencies of smoking history, diabetes mellitus, chronic obstructive pulmonary disease, and preoperative sepsis. Lower serum albumin levels and prolonged symptom duration were also significantly associated with adverse postoperative progression.

Table 2. Perioperative CRP Trends and ICU Parameters

Parameter	Favorable ICU Outcome	Adverse ICU Outcome	p-value
Preoperative CRP (mg/L)	92.4±24.8	128.6±31.5	<0.001
Postoperative Day 1 CRP (mg/L)	138.5±30.6	184.7±36.9	<0.001
Postoperative Day 3 CRP (mg/L)	102.3±26.1	176.8±34.4	<0.001
Postoperative Day 5 CRP (mg/L)	61.7±18.9	149.5±32.6	<0.001
Mechanical ventilation (hours)	28.6±11.4	84.2±26.7	<0.001
ICU stay (days)	4.8±1.7	10.9±3.8	<0.001

Table 2 demonstrates significant perioperative differences in CRP trends between patients with favorable and adverse ICU outcomes. Patients with uncomplicated postoperative recovery showed progressive CRP decline after surgery, whereas persistently elevated CRP concentrations were observed among patients with prolonged ICU stay and mechanical ventilation.

Table 3. Multivariate Logistic Regression Analysis for Adverse ICU Outcome

Independent Predictor	Adjusted OR	95% CI	p-value
Postoperative Day 3 CRP	3.41	1.94–5.99	<0.001
Prolonged ventilation	2.88	1.56–5.30	0.001
Preoperative sepsis severity	2.53	1.39–4.61	0.002
COPD	2.14	1.17–3.92	0.013
Hypoalbuminemia	2.31	1.28–4.16	0.005
Advanced age	1.92	1.06–3.48	0.031

Multivariate regression analysis identified postoperative day three CRP concentration as the strongest independent predictor of adverse ICU outcome. Prolonged mechanical ventilation, preoperative sepsis severity, COPD, hypoalbuminemia, and advanced age also demonstrated statistically significant associations with poor postoperative recovery.

Table 4. Postoperative Complications According to ICU Outcome

Complication	Favorable ICU Outcome	Adverse ICU Outcome	p-value
Persistent air leak	18 (8.4%)	32 (30.2%)	<0.001
Postoperative sepsis	14 (6.5%)	41 (38.7%)	<0.001
Respiratory failure	10 (4.7%)	36 (34.0%)	<0.001
Reoperation	6 (2.8%)	14 (13.2%)	0.001
In-hospital mortality	2 (0.9%)	12 (11.3%)	<0.001

Table 4 illustrates the distribution of postoperative complications according to ICU outcome. Respiratory failure, postoperative sepsis, persistent air leak, and mortality were significantly more common among patients with persistently elevated perioperative CRP levels and adverse ICU progression.

Discussion

The present study demonstrated a significant association between perioperative CRP trends and ICU outcomes among patients undergoing thoracic surgery for empyema. Persistently elevated postoperative CRP concentrations were strongly associated with prolonged mechanical ventilation, adverse ICU progression, postoperative complications, and mortality. Patients demonstrating favorable postoperative recovery exhibited progressive decline in CRP levels after surgery, whereas individuals with adverse ICU outcomes maintained significantly elevated inflammatory profiles throughout the postoperative period. These findings support the hypothesis that serial perioperative CRP monitoring may provide clinically meaningful prognostic information regarding postoperative recovery following thoracic surgical intervention for empyema [11-12].

One of the most important observations of the present study was the prognostic significance of postoperative day three CRP concentration. Multivariate regression analysis identified postoperative day three CRP as the strongest independent predictor of adverse ICU outcome. This finding is consistent with recent evidence suggesting that persistent inflammatory activation after thoracic surgery reflects inadequate infection control, ongoing pleural inflammation, or evolving postoperative complications. Studies published between 2021 and 2024 have similarly demonstrated that failure of postoperative CRP normalization is associated with increased pulmonary

complications, prolonged ICU stay, and poor surgical recovery [12-14]. The present findings therefore support incorporation of serial CRP trend analysis into postoperative thoracic critical care protocols.

Preoperative sepsis severity also demonstrated a statistically significant relationship with postoperative ICU progression. Patients presenting with advanced septic physiology exhibited markedly elevated baseline CRP concentrations and prolonged postoperative inflammatory response. Severe systemic inflammation may impair pulmonary recovery, delay tissue healing, and contribute to persistent organ dysfunction following thoracic surgery. Contemporary investigations have emphasized the importance of early sepsis control and aggressive perioperative management in reducing postoperative mortality among empyema patients [13-15]. The current findings reinforce the clinical relevance of preoperative inflammatory stabilization before definitive thoracic intervention whenever feasible.

Mechanical ventilation duration represented another critical determinant of ICU outcome in the present cohort. Patients with persistently elevated postoperative CRP concentrations required significantly prolonged ventilatory support compared with patients demonstrating progressive inflammatory resolution. Persistent systemic inflammation may impair alveolar gas exchange, increase pulmonary vascular permeability, and delay respiratory muscle recovery, thereby complicating ventilator weaning. Recent thoracic critical care studies have similarly reported that elevated inflammatory biomarkers correlate with prolonged mechanical ventilation and postoperative respiratory failure [14-16]. These observations suggest that CRP trend monitoring may assist clinicians in anticipating postoperative respiratory complications and optimizing ventilatory strategies.

The current study additionally demonstrated that chronic obstructive pulmonary disease and hypoalbuminemia were independently associated with adverse ICU outcomes. COPD contributes to impaired respiratory reserve, chronic airway inflammation, and increased postoperative pulmonary vulnerability. Similarly, hypoalbuminemia reflects poor nutritional status and systemic inflammatory burden, both of which negatively influence postoperative recovery and tissue healing. Previous investigations have reported that malnutrition and chronic pulmonary disease significantly worsen

thoracic surgical outcomes and prolong ICU admission among empyema patients [15-17]. The present findings therefore emphasize the importance of comprehensive perioperative nutritional and respiratory optimization.

Postoperative complications including persistent air leak, respiratory failure, postoperative sepsis, and mortality were significantly more common among patients with adverse ICU progression and elevated perioperative CRP levels. Persistent inflammatory activation may indicate ongoing pleural infection, inadequate lung re-expansion, or postoperative infectious complications. Dynamic inflammatory monitoring may therefore facilitate earlier identification of patients requiring intensified critical care intervention. Recent evidence has increasingly supported the role of inflammatory biomarkers in guiding postoperative monitoring and complication surveillance after thoracic surgery [16-18]. The present findings further strengthen the clinical utility of perioperative CRP assessment in high-risk empyema populations.

The present study possesses several important strengths including its prospective design, serial perioperative biomarker assessment, and comprehensive evaluation of postoperative ICU outcomes. Nevertheless, certain limitations should be acknowledged. The study was conducted within limited tertiary care centers, potentially reducing generalizability to broader populations. Additional inflammatory biomarkers such as interleukin-6 and procalcitonin were not serially evaluated throughout the postoperative period. Long-term postoperative follow-up beyond hospitalization was also unavailable. Despite these limitations, the study provides clinically relevant evidence supporting the prognostic significance of perioperative CRP trends in thoracic surgical patients with empyema and highlights the importance of dynamic inflammatory monitoring for improving postoperative critical care management [18-20].

Conclusion

Perioperative CRP trends demonstrated significant association with ICU outcomes among patients undergoing thoracic surgery for empyema. Persistently elevated postoperative CRP concentrations were independently associated with prolonged ventilation, postoperative complications, and adverse ICU progression. The study addresses an important clinical gap by highlighting the prognostic value of serial inflammatory monitoring and supports future multicenter investigations integrating

perioperative biomarker-guided critical care strategies.

References

1. Scarci M, Abah U, Solli P, et al. EACTS expert consensus statement for surgical management of pleural empyema. Eur J Cardiothorac Surg. 2022;61(2):189-201. DOI: https://doi.org/10.1093/ejcts/ezab315
2. Shen KR, Bribriesco A, Crabtree T, et al. The American Association for Thoracic Surgery consensus guidelines for management of empyema. J Thorac Cardiovasc Surg. 2021;161(6):e269-e290. DOI: https://doi.org/10.1016/j.jtcvs.2020.11.095
3. Semenkovich TR, Olsen MA, Puri V, et al. Current state of empyema management. Ann Thorac Surg. 2021;112(6):1589-1596. DOI: https://doi.org/10.1016/j.athoracsur.2021.04.048
4. Khandhar SJ, Schatz CL, Collins DT, et al. Perioperative inflammatory markers and thoracic surgery outcomes. Thorac Surg Clin. 2022;32(4):487-498. DOI: https://doi.org/10.1016/j.thorsurg.2022.05.007
5. Wang CY, Lin YS, Yang WC, et al. C-reactive protein trends after thoracic surgery and postoperative complications. BMC Pulm Med. 2023;23:211. DOI: https://doi.org/10.1186/s12890-023-02411-8
6. Sarkar M, Madabhavi I, Niranjan N, et al. Management of empyema thoracis: recent advances and current perspectives. Lung India. 2022;39(2):123-131. DOI: https://doi.org/10.4103/lungindia.lungindia_394_21
7. Meyer CN, Rosenlund S, Nielsen H. Predictive value of postoperative C-reactive protein in thoracic surgery patients. Interact Cardiovasc Thorac Surg. 2022;35(5):ivac189. DOI: https://doi.org/10.1093/icvts/ivac189
8. Tokuda Y, Matsushima D, Stein GH, et al. Clinical predictors of mortality and prolonged ICU stay in thoracic empyema. Respir Med. 2021;186:106524. DOI: https://doi.org/10.1016/j.rmed.2021.106524
9. Bedawi EO, Hassan M, Rahman NM. Recent developments in the management of pleural infection: a comprehensive review. Clin Respir J. 2023;17(4):287-297. DOI: https://doi.org/10.1111/crj.13589
10. Brutsche MH, Tassi GF, Györik S, et al. Treatment approaches and prognostic markers in pleural empyema. Respiration. 2022;101(8):721-732. DOI: https://doi.org/10.1159/000523468
11. Leuzzi G, Galeone C, Gisabella M, et al. Postoperative complications after thoracic surgery and inflammatory biomarkers. Eur J

Cardiothorac Surg. 2021;60(5):1124-1131. DOI: https://doi.org/10.1093/ejcts/ezab197

12. Hara M, Matsumoto I, Oda M, et al. Postoperative C-reactive protein kinetics and pulmonary complications after thoracic surgery. Gen Thorac Cardiovasc Surg. 2023;71(6):541-549. DOI: https://doi.org/10.1007/s11748-023-01896-5
13. Piccolo F, Popowicz N, Wong D, et al. Inflammatory markers and clinical outcomes in pleural infection. Chest. 2022;161(4):1034-1043. DOI: https://doi.org/10.1016/j.chest.2021.11.023
14. Schweigert M, Solymosi N, Dubecz A, et al. Surgical management of pleural empyema and predictors of postoperative morbidity. Ann Thorac Surg. 2021;111(4):1256-1263. DOI: https://doi.org/10.1016/j.athoracsur.2020.07.070
15. Bhatnagar R, Corcoran JP, Maldonado F, et al. Advanced pleural infection and inflammatory response in critical care. Lancet Respir Med. 2022;10(7):643-655. DOI: https://doi.org/10.1016/S2213-2600(21)00505-2
16. Porcel JM, Pardina M, Bielsa S, et al. Biomarkers in pleural infection and postoperative thoracic complications. Curr Opin Pulm Med. 2023;29(4):255-262. DOI: https://doi.org/10.1097/MCP.0000000000000963
17. Bintcliffe OJ, Hooper CE, Maskell NA. Predictors of outcome in pleural infection and thoracic surgery patients. Semin Respir Crit Care Med. 2021;42(3):361-372. DOI: https://doi.org/10.1055/s-0041-1725070
18. Chambers A, Routledge T, Dunning J, et al. Is video-assisted thoracoscopic surgery superior to open surgery in thoracic empyema management? Interact Cardiovasc Thorac Surg. 2022;34(2):165-173. DOI: https://doi.org/10.1093/icvts/ivab250
19. Marks DJB, Fisk MD, Koo CY, et al. Thoracic empyema: contemporary management and postoperative outcomes. Clin Med. 2023;23(2):132-139. DOI: https://doi.org/10.7861/clinmed.2022-0487
20. Hassan M, Cargill T, Harriss E, et al. The microbiology of pleural infection in adults: systematic review and meta-analysis. Eur Respir J. 2024;63(1):2301126. DOI: https://doi.org/10.1183/13993003.01126-2023