Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Predictors of Burst Abdomen Following Emergency Midline Laparotomy: A Prospective Cohort Study

Md Maruf
Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University
Atia Zakaur Rab
drazrab@yahoo.in
Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University
Shagufta Wahab
Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University
Shagufta Moin
Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University
Imad Ali
Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University
Asjad Ahmad Siddiqui
Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University

Research Article

Keywords: Burst abdomen, Wound dehiscence, Emergency laparotomy, Neutrophil-to-lymphocyte ratio, Sarcopenia, Psoas muscle index

Posted Date: November 23rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11677159/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Predictors of Burst Abdomen Following Emergency Midline Laparotomy: A Prospective Cohort Study

Md Maruf[1] · **Atia Zakaur Rab**[1] · **Shagufta Moin**[2] · **Shagufta Wahab**[3] · **Imad Ali**[1] · **Asjad Ahmad Siddiqui**[1]

[1] Department of Surgery, Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University, Aligarh, India

[2] Department of Biochemistry, Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University, Aligarh, India

[3] Department of Radiodiagnosis, Jawaharlal Nehru Medical College and Hospital, Aligarh Muslim University, Aligarh, India

Corresponding author: [**Atia Zakaur Rab**]; Email: drazrab@yahoo.in

Abstract

Purpose: Burst abdomen is a serious complication of emergency midline laparotomy. This study aimed to identify preoperative clinical, biochemical and radiological predictors of burst abdomen.

Methods: In this prospective cohort study, 115 patients aged ≥ 15 years undergoing emergency midline laparotomy between March 2024 and February 2026 were analysed. Haematological and biochemical parameters, including the neutrophil-to-lymphocyte ratio (NLR), and the psoas muscle index (PMI) measured on preoperative contrast-enhanced CT were correlated with burst abdomen using univariable logistic regression, Firth penalised multivariable regression and receiver operating characteristic (ROC) analysis.

Results: Burst abdomen occurred in 10 of 115 patients (8.7%). On univariable analysis, higher NLR (odds ratio [OR] 2.627; 95% confidence interval [CI] 1.720–4.012), lower serum albumin (OR 0.029 per g/dL; 95% CI 0.005–0.167), lower total protein, haemoglobin and platelet count, higher urea nitrogen and creatinine, and lower PMI (OR 0.126 per 100 mm^2/m^2; 95% CI 0.039–0.401) were significantly associated with burst abdomen. As conventional multivariable regression could not be fitted with ten events, Firth regression was used: NLR (adjusted OR 2.486; 95% CI 1.306–4.732) and PMI (adjusted OR 0.272 per 100 mm^2/m^2; 95% CI 0.076–0.975) were independent predictors, whereas serum albumin (adjusted OR 0.109; 95% CI 0.008–1.444) was not. The area under the ROC curve was 0.967 for NLR and 0.921 for PMI.

Conclusion: Elevated preoperative NLR and a low CT-assessed PMI were independent predictors of burst abdomen after emergency midline laparotomy. These findings, based on only ten events, require validation in larger cohorts.

Keywords Burst abdomen · Wound dehiscence · Emergency laparotomy · Neutrophil-to-lymphocyte ratio · Sarcopenia · Psoas muscle index

Authors' Contributions

Study conception and design: Md Maruf, Atia Zakaur Rab, Shagufta Wahab

Acquisition of data: Md Maruf, Asjad Ahmad Siddiqui

Analysis and interpretation of data: Md Maruf, Atia Zakaur Rab, Imad Ali

Drafting of manuscript: Md Maruf, Atia Zakaur Rab, Shagufta Moin

Critical revision of manuscript: Md Maruf, Atia Zakaur Rab, Imad Ali

Introduction

The reported incidence of burst abdomen after elective surgery ranges from 0.4-3.5% while it is 8-15% after emergency midline laparotomy [1]. The reported incidence of mortality associated with burst abdomen ranges from 10–35%. It is an important cause of prolonged hospitalization as a consequence of the need for additional surgical procedures, namely secondary repair of burst abdomen and incisional hernia repair, and leads to considerable financial burden [2,3].

The elevated risk of burst abdomen in the emergency setting has been attributed to hematological instability at presentation, intra-abdominal contamination, and the limited window for preoperative optimisation. Further it has been postulated that the healing of the midline fascia depends critically on collagen synthesis, which impaired by hypoalbuminemia, anaemia, and excessive systemic inflammation could be a risk factor for burst abdomen [4]. Biochemical markers of inflammation like the neutrophil-to-lymphocyte ratio (NLR) have emerged as potentially valuable preoperative risk stratification tools [5]. Sarcopenia, characterised by reduced skeletal muscle mass and function, impaired physiological reserve, protein metabolism, and capacity for tissue repair, potentially predisposing patients to fascial failure [6,7]. Assessment of body composition—particularly skeletal muscle by computed tomography (CT) is therefore an important determinant of surgical outcomes [7].

Although postoperative wound complications have been widely studied, there is a dearth of studies which have jointly examined clinical, biochemical, and radiological predictors of burst abdomen specifically in the emergency midline laparotomy setting. This study was therefore undertaken to identify the preoperative risk factors for burst abdomen in order to enable early recognition of patients at high risk for burst abdomen for providing focused perioperative intervention.

Material and methods

After approval by the Institutional Ethics Committee, a prospective, hospital-based cohort study was conducted on patients aged ≥ 15 years who underwent emergency midline laparotomy between March 2024 and February 2026. Patients who gave consent for participation in the study were enrolled. Patients who refused to participate in the study or left against medical advice or were on medications affecting haemogram or inflammatory marker levels or had pre-existing renal failure precluding contrast-enhanced CT (CECT) or did not undergo preoperative CECT of the abdomen, or had an incomplete preoperative laboratory work-up parameters included in the study were excluded. A preoperative blood sample was taken for evaluation of haemogram, blood urea nitrogen (BUN), serum creatinine, total serum protein, albumin and interleukin-6 (IL-6). In all patients the fascia was closed with polydioxanone suture using a continuous locking technique, in line with current closure guidelines [8–11].

Preoperative Radiological Evaluation

All patients under study were subjected to CECT scan of whole abdomen and three parameters were studied.

Psoas muscle index (PMI) was calculated by normalising the psoas muscle cross-sectional area at the L3 level for stature, i.e. PMI = L3 psoas muscle cross-sectional area (mm^2) / height² (m^2), and is expressed in mm^2/m^2 [7]. Reference values: in healthy adults, the age-specific lower limits (5th percentile) of the L3 psoas muscle index are 4.71 cm^2/m^2 (30–39 years) and 4.65 cm^2/m^2 (40–49 years) in men, and 3.40 cm^2/m^2 and 3.18 cm^2/m^2 in women (approximately 471 and 465 mm^2/m^2 in men, and 340 and 318 mm^2/m^2 in women), below which low psoas muscle mass is considered present [12].

Rectus diastasis was measured as the inter-recti distance 3 cm above the umbilicus (cm). At this level the inter-recti distance is considered normal up to 2.2 cm in nulliparous women on ultrasound [13]; in a CT study of asymptomatic adults of both sexes the median was 2.2 cm and the 80th percentile 3.4 cm [14].

Anterior abdominal wall muscle thickness was taken as the summed thickness of the external oblique, internal oblique and transversus abdominis muscles, measured perpendicular to the muscle axis at 3 cm above the umbilicus and 3 cm lateral to the rectus border (cm) [15]. To our knowledge, no CT-derived reference range exists for the summed thickness of these three muscles at this site. In healthy adults aged 18–44 years, ultrasound measurements at the anterior axillary line give a combined mean thickness of the three lateral muscles of approximately 19 mm (1.9 cm) in men and 14 mm (1.4 cm) in women [16]; these ultrasound values are not directly interchangeable with CT measurements at a different site.

The following definitions were used [2,17].

1. Shock: Systolic blood pressure below 100 mmHg with a heart rate more than 90 beats/minute at presentation.
2. Anaemia: A haemoglobin concentration under 13 g/dL in men and under 12 g/dL in non-pregnant women (World Health Organization [WHO] criteria) [18].
3. Hypoalbuminemia: A serum albumin concentration less than 3.5 g/dL.
4. Neutrophil-to-Lymphocyte Ratio (NLR): A ratio between 0.78–3.53 was considered normal [19].
5. Thrombocytopenia: A platelet count less than 150,000/mm^3.
6. Peritoneal Contamination: Intraoperatively confirmed visible soiling of the peritoneal cavity by bowel content, pus, or bile.
7. Surgical Site Infection (SSI): Categorised as superficial when confined to skin and subcutaneous tissue, or deep when extending into fascial and muscular planes, based on CDC/NHSN criteria [20].
8. Burst Abdomen (Wound Dehiscence): Complete or partial separation of the abdominal fascia after laparotomy, with possible protrusion of intra-abdominal contents through the resulting defect.

Sample Size Calculation

Estimation of sample size was done using the conventional prevalence-based formula ($Z^2 \times p \times q / l^2$), assuming a 8% prevalence of burst abdomen based on data of previous studies, at 95% confidence and 5% precision, yielding a minimum required sample of 113 [21], where Z = Z-score for desired confidence level (1.96 for 95% confidence), p = expected prevalence = 8% (0.08), q = 1 – p = 0.92 and l = allowable error (precision) = 5% (0.05).

Statistical analysis

Statistical analysis was performed using SPSS v31.0 and MedCalc® v16.8.4. Continuous variables are presented as median (interquartile range, IQR) and were compared using the Mann–Whitney U test; categorical variables were compared using the Chi-square or Fisher's exact test. Binary logistic regression was used for univariable analysis, followed by multivariable analysis using Firth penalised logistic regression, to identify independent predictors, with collinearity pre-screened by Pearson correlation. Results are presented as odds ratio (OR)/adjusted OR (aOR) with 95% confidence interval (CI), expressed per unit increase of the continuous variable (PMI: per 100 mm^2/m^2 increase). Haemoglobin, platelet count, albumin, total protein, BUN, creatinine, NLR and IL-6 were analysed as continuous variables; the clinical thresholds listed in the definitions were used for descriptive purposes only. Because only ten events were available (events per variable < 10 [22]) and conventional maximum-likelihood estimation failed to converge owing to complete separation, the multivariable model (NLR, albumin, PMI and peritoneal contamination) was fitted using Firth penalised logistic regression [23] (implemented in Python); total protein was not entered because of collinearity with albumin. The area under the receiver operating characteristic (ROC) curve (AUC) was used to assess discriminatory ability; AUC ranges from 0.5 (no discrimination) to 1.0 (perfect discrimination), and a value >0.8 was considered good, 0.6–0.8 moderate, and <0.6 poor. The 95% CI of the AUC was estimated by the DeLong method [24], and optimal cut-offs were determined by the Youden index [25]. This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for observational cohort studies [26]. A p-value < 0.05 was considered statistically significant.

Results

During the study period, 509 emergency midline laparotomies were performed, of which 115 patients meeting eligibility criteria were included in the final analysis. (Fig. 1)

Of 509 emergency midline laparotomies performed during the study period, 115 patients fulfilled all inclusion criteria. The patients were aged between 15–70 years (mean 42.4 ± 14.2 years), and a male predominance was observed (83 patients; 72.2%). Intestinal obstruction was the most common indication for emergency laparotomy (n = 35; 30.4%), followed by perforation peritonitis (n = 34; 29.6%) and blunt abdominal trauma (n = 22; 19.1%). Of the 115 patients included in the study, 10 (8.7%) developed burst abdomen, while 105 (91.3%) did not develop fascial dehiscence. No statistically significant association was found between burst abdomen and age or sex, and the association with intra-operative peritoneal contamination was only borderline (Fisher's exact p = 0.065). By WHO criteria, anaemia was present in 77 of 105 patients (73.3%) without and in all 10 patients (100%) with burst abdomen (Fisher's exact p = 0.115). Surgical site infection (SSI) of any grade occurred in 8 of 10 patients with burst abdomen (superficial SSI in 50% and deep SSI in 30%) compared with 34 of 105 patients (32.4%) without burst abdomen (p = 0.005). Because SSI and postoperative intensive care unit (ICU) admission are postoperative events, they are presented descriptively

as concurrent complications; they were not considered preoperative predictors and were not entered into the regression models. Postoperative ICU admission did not differ significantly between patients with and without burst abdomen (30.0% vs 16.2%; p = 0.375). (Table 1)

On univariable logistic regression analysis, lower preoperative haemoglobin (p = 0.008), elevated preoperative NLR (p < 0.001), lower preoperative platelet count (p = 0.033), higher preoperative BUN (p = 0.011), higher preoperative serum creatinine (p < 0.001), lower preoperative total serum protein (p < 0.001), lower preoperative serum albumin (p < 0.001) and reduced preoperative psoas muscle index (p < 0.001) were significantly associated with burst abdomen, whereas intraoperative peritoneal contamination showed only a borderline association (Wald p = 0.045; Fisher's exact p = 0.065) (Table 2).

Conventional maximum-likelihood multivariable logistic regression could not be fitted because NLR almost completely separated patients with and without burst abdomen; multivariable analysis was therefore performed using Firth penalised logistic regression. In this model, elevated preoperative NLR (aOR = 2.486; 95% CI: 1.306–4.732; p = 0.006) and low PMI (aOR = 0.272 per 100 mm^2/m^2; 95% CI: 0.076–0.975; p = 0.046) were significant independent predictors of burst abdomen, whereas preoperative serum albumin (aOR = 0.109 per g/dL; 95% CI: 0.008–1.444; p = 0.093) and peritoneal contamination (aOR = 0.665; 95% CI: 0.032–13.756; p = 0.792) were not (Table 3). Additional adjustment for sex did not materially change these estimates (NLR: aOR = 1.818; 95% CI: 1.091–3.031; PMI: aOR = 0.245 per 100 mm^2/m^2; 95% CI: 0.072–0.827).

On ROC analysis, NLR (AUC = 0.967; cut-off ≥ 4.3; sensitivity 90.0%, specificity 97.1%), total serum protein (AUC = 0.956; cut-off ≤ 5.40 g/dL; sensitivity 100.0%, specificity 84.8%) and serum albumin (AUC = 0.951; cut-off ≤ 2.82 g/dL; sensitivity 90.0%, specificity 93.3%) had the highest discriminatory power for predicting higher risk for burst abdomen, followed by low preoperative PMI (AUC = 0.921; cut-off ≤ 496 mm^2/m^2; sensitivity 80.0%, specificity 97.1%) and preoperative serum creatinine (AUC = 0.860). Haemoglobin (AUC = 0.773), platelet count (AUC = 0.710) and BUN (AUC = 0.703) had moderate discriminatory capability (Table 4, Fig. 2).

Discussion

Burst abdomen occurred in 8.7% of our patients, which is similar to observations made in earlier studies [1,3]. Lower preoperative serum albumin was strongly associated with burst abdomen in our study (univariable OR = 0.029 per g/dL; p < 0.001; AUC = 0.951), although it did not retain independent significance once NLR and PMI were taken into account (aOR = 0.109; p = 0.093), with an optimal cut-off of ≤ 2.82 g/dL (sensitivity 90.0%, specificity 93.3%), in our study which is lower than the conventional 3.5 g/dL threshold for hypoalbuminaemia. Total serum protein had comparable discrimination (AUC = 0.956) for predicting burst abdomen but was collinear with lower albumin levels. It has been postulated that patients with hypoalbuminaemia have impairment in collagen synthesis, fibroblast proliferation, and immune function, which has a detrimental effect on fascial healing [2,4].

In our study, raised preoperative NLR (median 7.15 vs 2.10) was an independent predictor of burst abdomen (aOR = 2.486; 95% CI: 1.306–4.732; p = 0.006) with good discriminatory ability (AUC = 0.967; cut-off ≥ 4.3; sensitivity 90.0%, specificity 97.1%); the median NLR in patients with burst abdomen was well above the reference range of

0.78–3.53 reported for healthy adults [19]. In emergency laparotomy populations, a raised preoperative NLR may therefore serve as a rapid, cost-effective surrogate for assessing systemic inflammatory burden and impaired immune regulation, both of which compromise fascial integrity.

In our study a statistically significant association was found between low psoas muscle index and occurrence of burst abdomen (median 422 vs 738 mm^2/m^2; univariable OR = 0.126 per 100 mm^2/m^2; $p < 0.001$), with good discriminatory ability (AUC = 0.921; cut-off ≤ 496 mm^2/m^2; sensitivity 80.0%, specificity 97.1%), and it remained an independent predictor on Firth penalised regression (aOR = 0.272 per 100 mm^2/m^2; 95% CI: 0.076–0.975; $p = 0.046$), also after adjustment for sex. Although sarcopenia has been associated with reduced physiological reserve, deficient protein metabolism, and reduced tissue repair capacity in surgical populations [6,7,27], neither anterior abdominal wall muscle thickness nor rectus diastasis was associated with burst abdomen in our patient ($p = 0.413$ and $p = 0.647$, respectively). These findings suggest that overall muscle bulk rather than local abdominal wall geometry may be the more relevant determinant of wound healing capacity.

Surgical site infection was more frequent in patients with burst abdomen than in those without (80.0% vs 32.4%; $p = 0.005$); however, as SSI is a postoperative event that may be a cause, a consequence or a marker of shared risk factors for fascial dehiscence, it was not treated as a preoperative predictor. Peritoneal contamination showed only a borderline association with burst abdomen (OR = 3.93; Wald $p = 0.045$; Fisher's exact $p = 0.065$) and was more frequent in these patients, possibly reflecting the combined effects of intra-abdominal contamination, systemic sepsis, and metabolic compromise inherent to this presentation. Bacterial proteases and inflammatory mediators degrade collagen and extracellular matrix components, directly undermining fascial integrity and thereby predisposing to burst abdomen [28].

In our study, on univariable analysis lower haemoglobin and platelet count, higher BUN and serum creatinine, and lower total serum protein and serum albumin were found to be statistically significant risk factors for burst abdomen, whereas peritoneal contamination showed only a borderline association. However, on Firth penalised multivariable analysis only raised NLR and low PMI emerged as independent predictors of burst abdomen. Although IL-6 is a central mediator of the inflammatory and wound-healing response [29], we did not find a significant association between preoperative IL-6 and burst abdomen ($p = 0.655$). Standard comorbidities (diabetes, hypertension, chronic obstructive pulmonary disease [COPD]) and body mass index (BMI) were not significantly associated with burst abdomen (all $p > 0.2$), which may reflect the small event count limiting statistical power, or confounding by nutritional and inflammatory parameters that were more potent determinants of burst abdomen.

Limitations of the study

The present study is limited by its single-centre design; the exclusion of 360 of 509 patients because no preoperative CECT was available, which may have led to selection bias; a small event count (n = 10; events per variable < 10 [22]) constraining multivariable precision and necessitating penalised regression; use of a single sex-pooled PMI cut-off; derivation of cut-off values in the same sample without external validation. Prospective multicentre studies with larger event counts are warranted to validate the derived cut-off values, confirm the independent prognostic contribution of sarcopenia, and establish generalisability.

Conclusion

Elevated preoperative NLR and a reduced psoas muscle index, an objective CT marker of sarcopenia, are independent, readily measurable predictors of burst abdomen following emergency midline laparotomy, whereas low serum albumin, although strongly associated on univariable analysis, was not independent of these. These findings, based on only ten events, warrant prospective validation in larger cohorts.

Statements and Declarations

Funding: None of the authors received funding for this study.

Competing interests: The authors declare that they have no competing interests.

Ethics approval: This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Institutional Ethics Committee, Faculty of Medicine, Aligarh Muslim University (Ref. IECJNMC/1543, 29/05/2024).

Consent to participate: Written informed consent was obtained from all individual participants included in the study.

Consent to publish: Not applicable; no identifying participant information is included in this article.

Data availability: The de-identified patient-level dataset (laboratory values and CT-derived measurements) underlying this study is provided as Online Resource 1 (Microsoft Excel file; patient names and registration numbers removed). Statistical code is available from the corresponding author on reasonable request.

References

1. Kvist M, Jensen TK, Snitkjaer C, Burcharth J (2024) The clinical consequences of burst abdomen after emergency midline laparotomy: a prospective cohort study. Hernia 28:1861–1870

2. van Ramshorst GH, Nieuwenhuizen J, Hop WCJ, et al (2010) Abdominal wound dehiscence in adults: development and validation of a risk model. World J Surg 34:20–27

3. Vardhini KV, Kishan D (2018) Incidence and risk factors influencing morbidity and mortality in burst abdomen after emergency and elective midline laparotomies. Int Surg J 5:3471–3477

4. Gislason H, Gronbech JE, Soreide K (2023) Risk stratification for abdominal wound dehiscence in emergency laparotomy. Br J Surg 110:158–167

5. Josse JM, Cleghorn MC, Ramji KM, et al (2016) The neutrophil-to-lymphocyte ratio predicts major perioperative complications in patients undergoing colorectal surgery. Colorectal Dis 18:O236–O242

6. Rastgeldi HB, Arslanca T, Batur H, et al (2025) Predictive efficacy of rectus abdominis muscle and psoas major muscle thickness for postoperative morbidity in patients with endometrial cancer. J Turk Ger Gynecol Assoc 26:121–129

7. Rodge GA, Goenka U, Jajodia S, et al (2023) Psoas muscle index: a simple and reliable method of sarcopenia assessment on CT scan in chronic liver disease and its impact on mortality. J Clin Exp Hepatol 13:196–202

8. Deerenberg EB, Henriksen NA, Antoniou GA, et al (2022) Updated guideline for closure of abdominal wall incisions from the European and American Hernia Societies. Br J Surg 109:1239–1250

9. Frassini S, Cobianchi L, Fugazzola P, et al (2023) ECLAPTE: Effective Closure of LAParoTomy in Emergency—2023 World Society of Emergency Surgery guidelines for the closure of laparotomy in emergency settings. World J Emerg Surg 18:42

10. Israelsson LA, Jonsson T (1993) Suture length to wound length ratio and healing of midline laparotomy incisions. Br J Surg 80:1284–1286

11. Tolstrup MB, Watt SK, Gögenur I (2017) Reduced rate of dehiscence after implementation of a standardized fascial closure technique in patients undergoing emergency laparotomy. Ann Surg 265:821–826

12. Kong M, Lin N, Wang L, et al (2022) Age-specific reference values for low psoas muscle index at the L3 vertebra level in healthy populations: a multicenter study. Front Nutr 9:1033831

13. Beer GM, Schuster A, Seifert B, Manestar M, Mihic-Probst D, Weber SA (2009) The normal width of the linea alba in nulliparous women. Clin Anat 22:706–711

14. Kaufmann RL, Reiner CS, Dietz UA, Clavien PA, Vonlanthen R, Käser SA (2022) Normal width of the linea alba, prevalence, and risk factors for diastasis recti abdominis in adults, a cross-sectional study. Hernia 26:609–618

15. Oma E, Christensen JK, Daes J, Jørgensen LN (2023) Morphological alterations of the abdominal wall after open incisional hernia repair with endoscopic anterior and open posterior component separation. Hernia 27:327–334

16. Tahan N, Khademi-Kalantari K, Mohseni-Bandpei MA, Mikaili S, Baghban AA, Jaberzadeh S (2016) Measurement of superficial and deep abdominal muscle thickness: an ultrasonography study. J Physiol Anthropol 35:17

17. Ahmed M, Mansoor T, Rab AZ, et al (2022) Risk factors influencing postoperative outcome in patients with perforated peptic ulcer: a prospective cohort study. Eur J Trauma Emerg Surg 48:81–86

18. World Health Organization (2011) Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. WHO, Geneva (WHO/NMH/NHD/MNM/11.1)

19. Forget P, Khalifa C, Defour JP, Latinne D, Van Pel MC, De Kock M (2017) What is the normal value of the neutrophil-to-lymphocyte ratio? BMC Res Notes 10:12

20. Horan TC, Andrus M, Dudeck MA (2008) CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 36:309–332

21. Naing L, Winn T, Rusli BN (2006) Practical issues in calculating the sample size for prevalence studies. Arch Orofac Sci 1:9–14

22. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR (1996) A simulation study of the number of events per variable in logistic regression analysis. J Clin Epidemiol 49:1373–1379

23. Firth D (1993) Bias reduction of maximum likelihood estimates. Biometrika 80:27–38

24. DeLong ER, DeLong DM, Clarke-Pearson DL (1988) Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. Biometrics 44:837–845

25. Youden WJ (1950) Index for rating diagnostic tests. Cancer 3:32–35

26. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP (2007) The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 370:1453–1457

27. Simonsen C, de Heer P, Bjerre ED, et al (2018) Sarcopenia and postoperative complication risk in gastrointestinal surgical oncology: a meta-analysis. Ann Surg 268:58–69. https://doi.org/10.1097/SLA.0000000000002679

28. Caley MP, Martins VLC, O'Toole EA (2015) Metalloproteinases and wound healing. Adv Wound Care 4:225–234. https://doi.org/10.1089/wound.2014.0581

29. Tanaka T, Narazaki M, Kishimoto T (2014) IL-6 in inflammation, immunity, and disease. Cold Spring Harb Perspect Biol 6:a016295

Tables

Table 1 *Baseline characteristics of patients undergoing emergency midline laparotomy (n = 115)*

Parameter	No Burst Abdomen (n=105) Median (IQR) or n (%)	Burst Abdomen (n=10) Median (IQR) or n (%)	p-value
DEMOGRAPHICS			
Age (years)	40.00 (30.00–54.00)	45.00 (39.00–49.50)	0.355 NS
Gender — Male	76 (72.4%)	7 (70.0%)	1.000 NS
CLINICAL FACTORS			
BMI (kg/m²)	22.90 (20.50–25.50)	23.95 (22.73–25.62)	0.288 NS
Intestinal Obstruction	33 (31.4%)	2 (20.0%)	0.721 NS
Perforation peritonitis	28 (26.7%)	6 (60.0%)	0.062 NS
Blunt Trauma Abdomen	20 (19.0%)	2 (20.0%)	1.000 NS
Pre-op Shock	8 (7.6%)	0 (0.0%)	1.000 NS
INTRAOPERATIVE FINDING			
Peritoneal contamination (intra-operative)	29 (27.6%)	6 (60.0%)	0.065 NS
POSTOPERATIVE EVENTS (presented descriptively; not predictors)			
Superficial SSI (postoperative)	24 (22.9%)	5 (50.0%)	0.119 NS
Deep SSI (postoperative)	10 (9.5%)	3 (30.0%)	0.085 NS
Any SSI (postoperative)	34 (32.4%)	8 (80.0%)	0.005**
Post-op ICU Admission (postoperative)	17 (16.2%)	3 (30.0%)	0.375 NS
COMORBIDITIES			
Diabetes Mellitus	20 (19.0%)	2 (20.0%)	1.000 NS
Hypertension	14 (13.3%)	0 (0.0%)	0.608 NS
COPD / Chronic Cough	9 (8.6%)	0 (0.0%)	1.000 NS
PREOPERATIVE LABORATORY PARAMETERS			
Haemoglobin (g/dL)	12.00 (10.80–12.70)	10.00 (9.27–11.10)	0.005**
Total Leucocyte Count (/mm³)	8200 (6200–9800)	8200 (3825–16475)	0.808 NS
Platelet Count (/mm³)	245000 (165000–317000)	144000 (109000–239250)	0.029*
NLR	2.10 (1.60–2.70)	7.15 (5.20–8.15)	<0.001***
BUN (mg/dL)	21.00 (17.00–25.00)	28.50 (20.00–34.00)	0.035*
Serum Creatinine (mg/dL)	0.70 (0.60–0.90)	1.75 (1.40–2.25)	<0.001***
Total Serum Protein (g/dL)	6.05 (5.66–6.44)	4.28 (4.13–4.76)	<0.001***
Serum Albumin (g/dL)	3.80 (3.22–4.00)	2.49 (2.12–2.80)	<0.001***
Interleukin-6 (pg/mL)	121.73 (62.73–132.77)	108.90 (94.99–124.42)	0.655 NS
RADIOLOGICAL PARAMETERS (CT SCAN)			
Psoas Muscle Index (mm²/m²)	738 (589–784)	422 (390.5–482)	<0.001***

Anterior Abdominal Muscle Thickness (cm)	1.34 (1.12–1.54)	1.31 (1.00–1.59)	0.413 NS
Rectus Diastasis (cm)	1.45 (1.25–1.65)	1.50 (1.46–1.53)	0.647 NS

*SSI = Surgical Site Infection. NLR = Neutrophil-to-Lymphocyte Ratio. BUN = Blood Urea Nitrogen. ICU = Intensive Care Unit. IQR = Interquartile Range. BMI = Body Mass Index. COPD = Chronic Obstructive Pulmonary Disease. IL-6 = Interleukin-6. PMI = Psoas Muscle Index (mm²/m²). NS = Not Significant. Continuous variables: median (IQR), Mann–Whitney U test; categorical variables: Fisher's exact test. Missing values: creatinine (n = 1), IL-6 (n = 1). For interleukin-6, anterior abdominal muscle thickness and rectus diastasis, p-values are from univariable logistic regression (Table 2). Postoperative events (SSI, ICU admission) are presented descriptively and were not considered predictors. *p < 0.05; **p < 0.01; ***p < 0.001*

Table 2 *Univariable logistic regression analysis — predictors of burst abdomen*

Variable	OR	95% CI	p-value	Sig.
Age (years)	1.015	0.972–1.061	0.497	NS
Sex (Male)	0.890	0.216–3.678	0.873	NS
Haemoglobin (g/dL)	0.503	0.302–0.836	0.008	**
WBC Count (per 1,000/mm³)	1.050	0.911–1.210	0.504	NS
NLR	2.627	1.720–4.012	<0.001	***
Platelets (per 10,000/mm³)	0.917	0.847–0.993	0.033	*
BUN (mg/dL)	1.074	1.017–1.134	0.011	*
Serum Creatinine (mg/dL)	26.88	4.63–156.25	<0.001	***
Total Protein (g/dL)	0.057	0.014–0.229	<0.001	***
Albumin (g/dL)	0.029	0.005–0.167	<0.001	***
IL-6 (pg/mL)	1.004	0.987–1.022	0.655	NS
Psoas Muscle Index (per 100 mm²/m²)	0.126	0.039–0.401	<0.001	***
Rectus Diastasis (cm)	0.616	0.078–4.884	0.647	NS
Abd. Muscle Thickness (cm)	0.438	0.061–3.157	0.413	NS
Peritoneal Contamination	3.931	1.034–14.946	0.045	[a]
BMI (kg/m²)	1.087	0.917–1.288	0.337	NS

*OR = Odds Ratio (per unit increase; per 100 mm²/m² for PMI). CI = Confidence Interval. PMI = Psoas Muscle Index. NS = Not Significant. *p < 0.05; **p < 0.01; ***p < 0.001. n = 115 (creatinine n = 114; IL-6 n = 114 due to missing values). [a]Peritoneal contamination: Wald p = 0.045 and likelihood-ratio p = 0.042, but Fisher's exact p = 0.065 (Table 1) and ROC p = 0.055; interpreted as a borderline association.*

Table 3 *Multivariable Firth penalised logistic regression — independent predictors of burst abdomen*

Variable	aOR	95% CI	p-value	Sig.
NLR	2.486	1.306–4.732	0.006	**
Albumin (g/dL)	0.109	0.008–1.444	0.093	NS
Psoas Muscle Index (per 100 mm²/m²)	0.272	0.076–0.975	0.046	*
Peritoneal Contamination	0.665	0.032–13.756	0.792	NS
Model: Firth penalised logistic regression (n = 115; 10 events); the conventional maximum-likelihood model did not converge (complete separation).				

*aOR = Adjusted Odds Ratio from Firth penalised logistic regression (per unit increase; per 100 mm²/m² for PMI). CI = Confidence Interval (Wald). PMI = Psoas Muscle Index. NS = Not Significant after multivariable adjustment. *p < 0.05; **p < 0.01. Model: n = 115 (10 events); conventional maximum-likelihood estimation did not converge because of complete separation.*

Table 4 *ROC curve analysis — AUC, optimal cut-off, sensitivity, and specificity for significant predictors of burst abdomen*

Variable	AUC*	95% CI	Optimal Cut-off	Sens. (%)	Spec. (%)
NLR	0.967	0.927–1.000	≥ 4.3	90.0	97.1
Total Protein (g/dL)	0.956	0.917–0.995	≤ 5.40 g/dL	100.0	84.8
Albumin (g/dL)	0.951	0.909–0.993	≤ 2.82 g/dL	90.0	93.3
Psoas Muscle Index (mm²/m²)	0.921	0.814–1.000	≤ 496 mm²/m²	80.0	97.1
Serum Creatinine (mg/dL)	0.860	0.670–1.000	≥ 1.40 mg/dL	80.0	98.1
Haemoglobin (g/dL)	0.773	0.639–0.906	≤ 11.1 g/dL	80.0	66.7
Platelet count (/mm³)	0.710	0.531–0.890	≤ 145,000	60.0	81.9
BUN (mg/dL)	0.703	0.529–0.877	≥ 33 mg/dL	50.0	88.6

AUC = Area Under ROC Curve. AUC p < 0.05 for all variables. 95% CI by DeLong method. Optimal cut-off by Youden Index; cut-offs and sensitivity/specificity were derived in the study sample and are likely optimistic. Sens. = Sensitivity; Spec. = Specificity.

Figure legends

Fig. 1 Outcome of all emergency laparotomy patients during the study period. Of 509 emergency laparotomies, 394 patients were excluded (no preoperative CECT, n = 360; incomplete preoperative laboratory work-up, n = 12; left against medical advice, n = 22) and 115 were included, of whom 105 had no burst abdomen and 10 developed burst abdomen

Fig. 2 Empirical receiver operating characteristic (ROC) curves of preoperative predictors of burst abdomen. Each curve represents one predictor (NLR, total protein, albumin, psoas muscle index, serum creatinine, haemoglobin, platelet count and BUN; line styles as in the legend); the dashed diagonal is the reference line (AUC = 0.500). AUC values indicate discriminatory power (higher = better)

Fig. 1

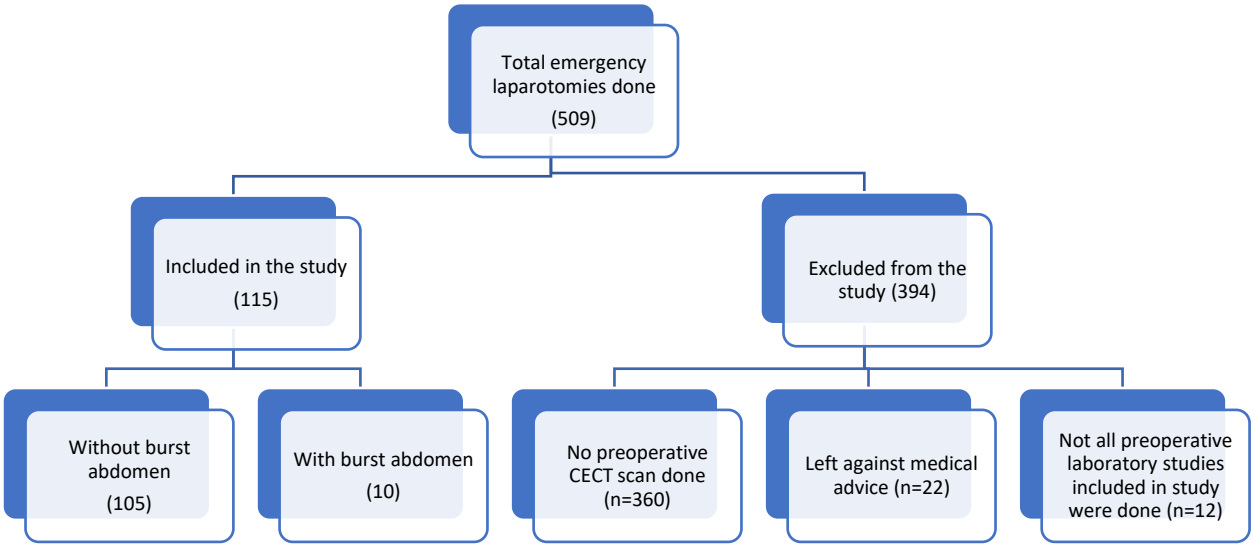
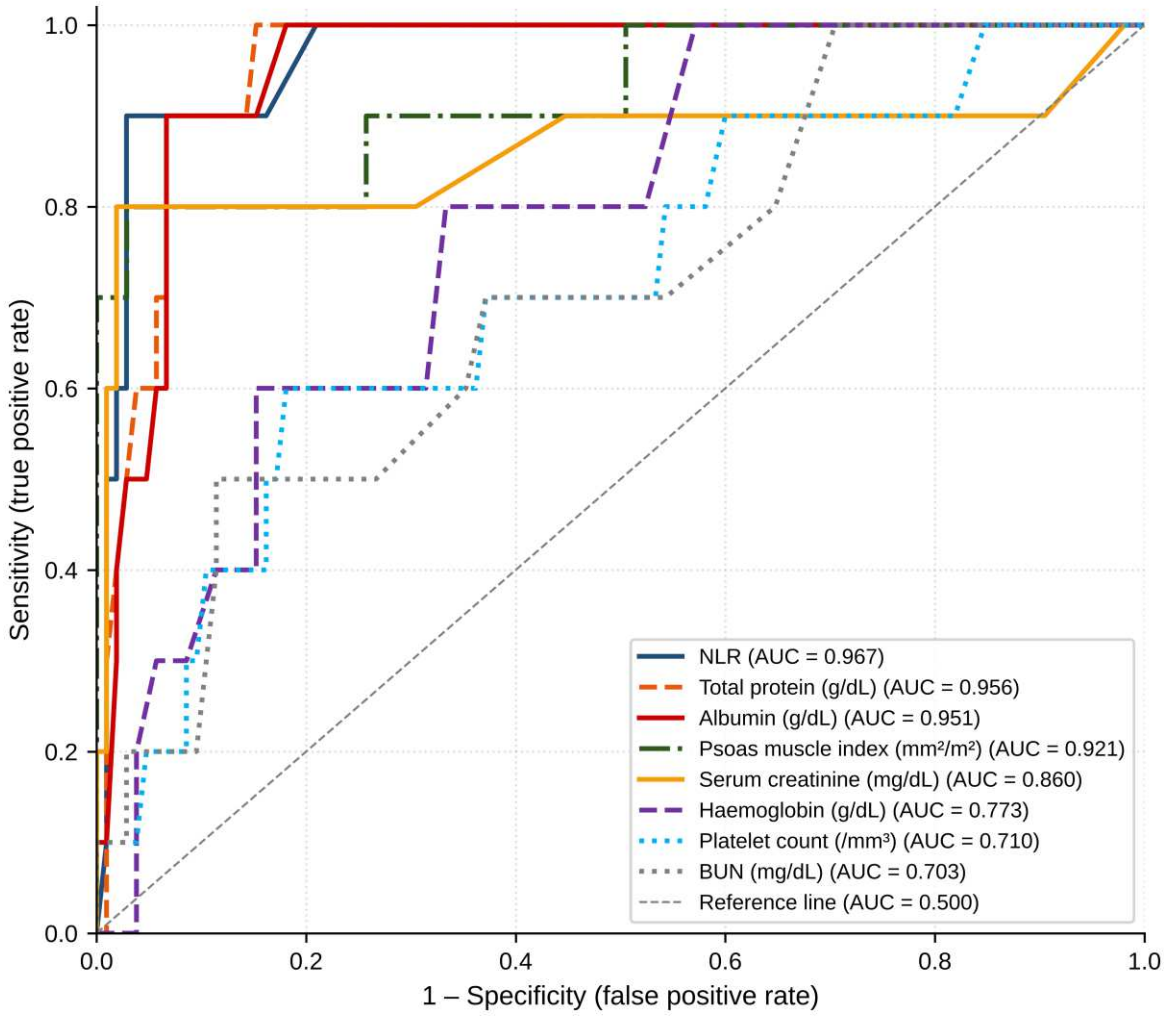


Fig. 2


1.0
0.8
0.6
0.4
0.2
0.0
Sensitivity (true positive rate)
0.0
0.2
0.4
0.6
0.8
1.0
1 – Specificity (false positive rate)
NLR (AUC = 0.967)
Total protein (g/dL) (AUC = 0.956)
Albumin (g/dL) (AUC = 0.951)
Psoas muscle index (mm²/m²) (AUC = 0.921)
Serum creatinine (mg/dL) (AUC = 0.860)
Haemoglobin (g/dL) (AUC = 0.773)
Platelet count (/mm³) (AUC = 0.710)
BUN (mg/dL) (AUC = 0.703)
Reference line (AUC = 0.500)