

Radiological Predictors of Prolonged Mechanical Ventilation Following Major Abdominal and Thoracic Surgeries: A Retrospective Study

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ABSTRACT

Background: Prolonged mechanical ventilation (PMV) following major abdominal and thoracic surgery is a significant driver of postoperative morbidity, intensive care unit (ICU) resource utilisation, and mortality. Reliable preoperative or early postoperative predictors of PMV are lacking in the Indian tertiary care setting. Radiological parameters — obtained from routinely available preoperative chest X-rays, CT thorax/abdomen, and point-of-care ultrasound — offer objective, quantifiable biomarkers that may complement clinical scoring systems for predicting PMV.

Objectives: To evaluate the association between radiological parameters — including preoperative CT-derived lung density indices and chest AP diameter, perioperative diaphragm excursion and thickening fraction on ultrasound, postoperative lung ultrasound score (LUS), CT-derived psoas muscle index (PMI), and chest X-ray findings (pleural effusion, atelectasis grade, cardiomegaly) — and the occurrence of PMV (>48 hours) in adults undergoing major abdominal or thoracic surgery.

Methodology: A retrospective observational study was conducted from July 2025 to December 2025 at RDJMMCH, Muzaffarpur, Bihar. Medical records of 130 adult patients who underwent elective major abdominal or thoracic surgery under general anaesthesia were reviewed. Preoperative radiological data (CT thorax/abdomen, chest X-ray), perioperative diaphragm ultrasound, and postoperative chest X-ray findings were extracted and correlated with duration of mechanical ventilation. Multivariate logistic regression was used to identify independent radiological predictors of PMV. Data were analysed using SPSS v26.

Results: PMV (>48 hours) occurred in 31 of 130 patients (23.8%). On multivariate logistic regression, diaphragm thickening fraction (DTF) <25% (OR 5.84; 95% CI 2.21–15.42; p<0.001), preoperative CT mean lung density <-850 HU (OR 4.17; 95% CI 1.58–11.03; p=0.004), postoperative LUS >8 (OR 3.92; 95% CI 1.47–10.43; p=0.006), and CT psoas muscle index (PMI) in the lowest sex-specific quartile (OR 3.28; 95% CI 1.19–9.02; p=0.022) were independent predictors of PMV. The combined radiological model yielded AUC 0.904 (95% CI 0.847–0.961).

Conclusion: Radiological parameters — particularly diaphragm thickening fraction, preoperative lung density, postoperative lung ultrasound score, and CT-derived psoas muscle index — are significant independent predictors of PMV after major abdominal and thoracic surgery. Integration of these parameters into a radiological risk-stratification tool could improve perioperative planning and ICU resource allocation at tertiary care centres in north Bihar and comparable settings.

Keywords: prolonged mechanical ventilation, radiological predictors, diaphragm ultrasound, lung ultrasound score, CT lung density, psoas muscle index, postoperative pulmonary complications, abdominal surgery, thoracic surgery, Bihar

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1. INTRODUCTION

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Mechanical ventilation is an indispensable component of perioperative care following major abdominal and thoracic surgeries. While most patients are successfully extubated within 6–12 hours, a subset require ventilatory support beyond 48 hours — a threshold widely accepted as the definition of prolonged mechanical ventilation (PMV) [1,2]. PMV is associated with substantially higher rates of ventilator-associated pneumonia (VAP), tracheal injury, ICU-acquired weakness, delirium, and mortality, while simultaneously imposing a considerable burden on intensive care resources [3,4]. In resource-constrained tertiary care settings across India, where ICU bed availability is limited and critical care nurse-to-patient ratios are often unfavourable, early and accurate identification of patients at risk of PMV is of particular strategic importance [3]. Postoperative pulmonary complications (PPCs), including atelectasis, pleural effusion, pneumonia, and respiratory failure requiring PMV, occur in 5–33% of patients undergoing major non-cardiac surgery and represent the leading cause of postoperative ICU admission [3,5]. The burden is disproportionately higher after thoracic and upper abdominal procedures, owing to diaphragmatic splinting, phrenic nerve manipulation, pain-induced hypoventilation, and loss of functional residual capacity [5]. In Ethiopia, a multicenter study found PPCs in 33% of abdominal surgery patients, with prolonged ventilatory support being a key outcome predictor [5]. The pathophysiology in north Bihar patients — where late-stage disease presentation, higher rates of undernutrition and sarcopenia, and co-existent chronic lung disease predominate — may amplify this risk further. Conventional clinical predictors of PMV — including ASA grade, pulmonary function test (PFT) values, BMI, and APACHE II score — are routinely employed in preoperative risk stratification. However, they frequently fail to capture parenchymal lung condition, diaphragmatic reserve, and body composition in sufficient granularity [1]. Radiological tools, by contrast, offer direct morphological and functional data: preoperative thoracic CT permits measurement of lung attenuation indices reflecting emphysema and air-trapping; CT-derived psoas muscle index (PMI) at L3 serves as an established surrogate for systemic sarcopenia and frailty [6,12]; perioperative diaphragm ultrasound — measuring diaphragm excursion (DE) and diaphragm thickening fraction (DTF) — provides real-time, non-invasive assessment of respiratory muscle function [7]; and postoperative lung ultrasound score (LUS) on day 1 has been shown to predict PPCs with an AUC of 0.73 in a multicentre prospective study [8]. The landmark case-control study by Canan et al. (2022) from UT Southwestern demonstrated that preoperative CT findings including bronchial wall thickening (OR 4.8), pericardial effusion (OR 5.3), and shorter lung height were independently associated with postoperative mechanical ventilation after major abdominal surgery [9]. Yet, no study from north India — and none specifically from Bihar — has systematically evaluated the composite radiological profile as a predictor of PMV

across both abdominal and thoracic surgical contexts. RDJMMCH, Muzaffarpur, as the principal tertiary referral centre for a population of several million in north Bihar, routinely manages post-surgical patients with complex radiological backgrounds. The present study was therefore designed to retrospectively evaluate the radiological predictors of PMV at this institution, with the objective of generating data that could inform a locally applicable risk-stratification framework.

2. REVIEW OF LITERATURE

The literature on radiological prediction of PMV has grown substantially over the past decade, spanning thoracic CT, diaphragm ultrasound, lung ultrasound, and CT body composition analysis. Canan et al. (2022) published the first matched case-control study specifically examining preoperative thoracic CT as a predictor of postoperative mechanical ventilation after major abdominal or pelvic surgery. Bronchial wall thickening, pericardial effusion, shorter lung height, and greater AP chest diameter were identified as independent predictors, with ORs ranging from 0.8 to 5.3 [9].

On diaphragm ultrasound, Zambon et al. (2016) demonstrated that a diaphragm thickening fraction (DTF) >36% predicted successful weaning with sensitivity 82% and specificity 88% (AUC not stated) [10]. A comprehensive systematic review and meta-analysis by Ferrari et al. (2023) in *Critical Care* assessed 26 studies and confirmed that DTF had pooled sensitivity of 0.85 (95% CI 0.82–0.87) and specificity of 0.75 (95% CI 0.69–0.80) for predicting successful weaning, with an SROC AUC of 0.87 [7]. Similarly, diaphragm excursion (DE) demonstrated sensitivity 0.80 and specificity 0.80 for this outcome. Elfeky et al. (2025), in an ICU-based study from Egypt, validated the composite DE-RSBI index (AUC 0.851) as superior to RSBI alone [7]. The predictive value of preoperative diaphragm ultrasound in predicting postoperative weaning failure was demonstrated specifically in liver transplant patients by a PubMed-indexed study showing that preoperative right hemidiaphragm thickness predicted weaning failure with high accuracy [11].

Lung ultrasound score has emerged as an important perioperative imaging biomarker. Boussier et al. (2024) in a multicentre prospective study (ASILI trial, Paris) found that LUS on postoperative day 1 was significantly higher in patients developing PPCs (median LUS 13 vs 10; Mann-Whitney $p=0.002$; AUC 0.71) after major abdominal surgery [8]. The observational study by Rab et al. (2021) at Semmelweis University showed that postoperative LUS at 24 hours could identify patients at risk of PPCs, with the 24-hour postoperative LUS being the strongest predictor. In a perioperative LUS study in 61 elective abdominal surgery patients in 2024, a higher LUS was associated with longer ventilator time in ICU patients [8]. CT-derived psoas muscle index (PMI) has emerged as a reliable radiological surrogate for sarcopenia and frailty. A prospective observational study from Egypt (Springer Nature, 2025) of 89 major

abdominal surgery patients showed that low PMI at L3 predicted major postoperative complications, ICU admission, and 30-day mortality [6]. In a retrospective study from Japan (2023) on hepatic resection for Klatskin tumors, sarcopenia by CT-derived PMI was associated with ICU admission (77.3% vs 47.9%, $p < 0.001$) and longer ICU stay [12]. Psoas cross-sectional area has been validated as a predictor of complications in colorectal cancer surgery, with sarcopenic patients showing OR 15.4 for major complications [12]. The narrative review by Bhagat (2024) summarised all available evidence on PMV predictors in cardiac surgery, noting that definitions range from >24 to >72 hours, and that COPD, renal failure, and reduced preoperative ejection fraction are the most consistent clinical predictors [1]. Preoperative pulmonary evaluation as a predictor of PPCs was comprehensively reviewed by Adesanya et al. (2023), who affirmed that probability of PMV >48 hours is a key outcome measure within the surgical risk index framework [1]. Admass et al. (2023), in a multicentre follow-up study from Ethiopia on 424 thoracic and upper abdominal surgery patients, found PPCs in 33%, with prolonged surgery duration, emergency surgery, and poor lung function as key predictors [5]. The present study builds on this literature by integrating multiple radiological modalities into a composite predictive framework within the north Bihar tertiary care context.

3. OBJECTIVES

Primary Objective:

To determine whether preoperative and perioperative radiological parameters — including CT-derived lung density, anteroposterior chest diameter, diaphragm thickening fraction (DTF) on ultrasound, postoperative lung ultrasound score (LUS), CT-derived psoas muscle index (PMI), and chest X-ray findings (pleural effusion, atelectasis, cardiomegaly) — are independently associated with prolonged mechanical ventilation (>48 hours) in adult patients undergoing major abdominal or thoracic surgery at RDJMMCH, Muzaffarpur, Bihar.

Secondary Objectives:

- To determine the incidence of PMV (>48 hours) in major abdominal and thoracic surgical patients at RDJMMCH.
- To evaluate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and AUC of individual radiological parameters for predicting PMV.
- To compare the predictive accuracy of the combined radiological model versus conventional clinical risk scores (ASA grade, APACHE II) for PMV.
- To identify the optimal cut-off values for each radiological parameter using ROC curve analysis.
- To characterise the sociodemographic and surgical profile of patients developing PMV at this institution.

4. METHODOLOGY

4.1 Study Design

Retrospective observational analytical study.

4.2 Study Setting

The study was conducted at the Department of Radiodiagnosis & Imaging and the Department of Anaesthesiology and Critical Care, Radha Devi Jageshwari Memorial Medical College & Hospital (RDJMMCH), Muzaffarpur, Bihar, India. RDJMMCH is a tertiary-level teaching hospital functioning as the principal referral centre for north Bihar, including the districts of Muzaffarpur, Sitamarhi, Sheohar, Vaishali, East Champaran, and West Champaran. The surgical ICU at RDJMMCH accommodates both post-abdominal and post-thoracic surgical patients and maintains digital anaesthetic records.

4.3 Study Period

July 2025 to December 2025 (six months).

4.4 Study Population and Sample Size

The target population comprised adult patients (≥ 18 years) who underwent elective major abdominal or thoracic surgery under general anaesthesia with endotracheal intubation at RDJMMCH during the study period and who had undergone preoperative imaging (chest X-ray and/or CT thorax or CT abdomen) within 8 weeks before surgery.

Sample size was calculated using the formula $n = Z^2pq/d^2$, where $Z = 1.96$ (95% confidence level), $p =$ estimated incidence of PMV in comparable surgical populations = 0.20 (20%) [5], $q = 0.80$, $d =$ precision = 0.07. This yielded $n = (1.96)^2 \times 0.20 \times 0.80 / (0.07)^2 \approx 126$. A sample of 130 patients was targeted to account for incomplete records.

4.5 Sampling Method

Consecutive non-probability sampling. All patients fulfilling the inclusion criteria whose complete anaesthetic records, surgical records, imaging archives (PACS/hard copy), and ICU ventilation logs were available were enrolled until the target was reached.

4.6 Radiological Parameters Assessed

The following radiological measurements were extracted by trained radiologists blinded to outcome data:

(a) Preoperative CT Thorax Parameters

- Mean lung density (MLD, Hounsfield units [HU]): measured in the upper, mid, and lower lobes bilaterally; mean calculated. Lower HU (more negative) indicates hyperinflation/emphysema.
- Anteroposterior (AP) chest diameter (cm): measured at the level of T7 vertebra.
- Bronchial wall thickening: graded as present or absent per radiologist consensus.
- Pericardial effusion: present or absent.

(b) CT Abdomen Parameters

- Psoas muscle index (PMI, cm^2/m^2): bilateral psoas cross-sectional area measured at the level of the third lumbar vertebra (L3), summed and normalised by height

squared. Sarcopenia defined as PMI $<6.36 \text{ cm}^2/\text{m}^2$ in men and $<3.92 \text{ cm}^2/\text{m}^2$ in women (sex-specific cut-offs validated by Cruz-Jentoft criteria).

(c) Perioperative Diaphragm Ultrasound

- Diaphragm excursion (DE, cm): measured in the right hemidiaphragm in the zone of apposition using M-mode in the anterior axillary line during a spontaneous breathing trial or within 6 hours of extubation readiness assessment.
- Diaphragm thickening fraction (DTF, %): $\text{DTF} = [(\text{end-inspiratory thickness} - \text{end-expiratory thickness}) / \text{end-expiratory thickness}] \times 100$. Measured at the right zone of apposition (7th–9th intercostal space, anterior axillary line).

(d) Postoperative Chest X-Ray Parameters (Day 1)

- Pleural effusion: present/absent; if present, graded as small, moderate, or large.
- Atelectasis: graded as absent, subsegmental, segmental, lobar, or complete lung collapse.
- Cardiomegaly: cardiothoracic ratio >0.5 .
- Pulmonary infiltrates: bilateral, unilateral, or absent.

(e) Postoperative Lung Ultrasound Score (LUS, Day 1)

- A validated 12-zone lung ultrasound scoring system was applied: each zone scored 0 (normal A-lines), 1 (≥ 3 B-lines or small subpleural consolidation), 2 (confluent B-lines or multiple subpleural consolidations), or 3 (dense consolidation with aerobronchograms). Maximum score = 36.

4.7 Outcome Definition

Prolonged mechanical ventilation (PMV): requirement for invasive mechanical ventilation via endotracheal tube for >48 hours postoperatively, or need for re-intubation within 48 hours of initial extubation, consistent with the definition used in the ACS-NSQIP and international literature [1,2].

4.8 Statistical Analysis

Data were entered in Microsoft Excel 2021 and analysed using SPSS v26.0. Continuous variables were expressed as mean \pm standard deviation (SD) and categorical variables as frequency (n) and percentage (%). Independent samples t-test and Mann-Whitney U test were used for comparison between PMV and non-PMV groups, as appropriate. Chi-square and Fisher’s exact tests were used for categorical comparisons. Interobserver agreement for radiological measurements between two blinded radiologists was assessed using the intraclass correlation coefficient (ICC). ROC curve analyses were performed to determine optimal cut-offs and AUC for each radiological predictor. Multivariate

binary logistic regression (backward conditional method) was used to identify independent predictors of PMV. A p-value <0.05 was considered as statistically significant.

4.9 Ethical Clearance

Ethical approval was obtained from the Institutional Ethics Committee of RDJMMCH. Since this was a retrospective record-review study with no direct patient intervention, individual informed consent was waived per IEC conditions. Data were anonymised prior to analysis, and the study was conducted in accordance with the Declaration of Helsinki (2013 revision).

5. INCLUSION AND EXCLUSION CRITERIA

5.1 Inclusion Criteria

- Adult patients ≥ 18 years of either sex
- Elective major abdominal surgery (procedures involving the GI tract, liver, pancreas, spleen, or major vessels) or thoracic surgery (lung resection, oesophagectomy, mediastinal procedures) under general anaesthesia
- Preoperative chest X-ray and/or CT thorax/abdomen within 8 weeks prior to surgery available in the PACS or radiology archive
- Perioperative diaphragm ultrasound performed by the anaesthesiology/critical care team and documented in the ICU record
- Postoperative ICU admission with mechanical ventilation records available
- ASA physical status grade I–IV

5.2 Exclusion Criteria

- Emergency, trauma, or unplanned surgery
- Cardiac or neurosurgical procedures
- Patients requiring preoperative mechanical ventilation or with tracheostomy in situ
- Patients on long-term home oxygen therapy or NIV preoperatively
- CT imaging unavailable or of inadequate quality for psoas measurement
- Paediatric patients (<18 years) or pregnant patients
- Patients who died intraoperatively or within the first 6 hours postoperatively (before PMV classification was possible)
- Incomplete ICU ventilation duration records

6. RESULTS AND ANALYSIS

6.1 Sociodemographic and Clinical Profile

A total of 130 patients satisfying the inclusion criteria were enrolled. PMV (>48 hours) occurred in 31 patients (23.8%); 99 patients (76.2%) were extubated within 48 hours (non-PMV group). Table 1 presents the demographic and clinical profile.

Table 1: Sociodemographic and Clinical Profile of Study Participants (n=130)

Variable	PMV Group (n=31)	Non-PMV Group (n=99)
Age, years (mean \pm SD)	58.6 \pm 12.4	47.3 \pm 13.8

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Variable	PMV Group (n=31)	Non-PMV Group (n=99)
Sex: Male	22 (71.0%)	61 (61.6%)
BMI (kg/m ² , mean ± SD)	24.2 ± 5.4	25.8 ± 4.8
ASA Grade III–IV	23 (74.2%)	29 (29.3%)
History of smoking/COPD	17 (54.8%)	31 (31.3%)
Abdominal surgery	20 (64.5%)	67 (67.7%)
Thoracic surgery	11 (35.5%)	32 (32.3%)
Mean surgery duration (min)	248.3 ± 61.4	189.7 ± 54.2
APACHE II score (mean ± SD)	18.4 ± 4.7	11.2 ± 3.9
Mean ICU stay, days (mean ± SD)	9.8 ± 4.6	3.1 ± 1.7
In-hospital mortality	7 (22.6%)	4 (4.0%)

PMV: Prolonged mechanical ventilation (>48 hours); APACHE: Acute Physiology and Chronic Health Evaluation; ASA: American Society of Anesthesiologists; COPD: Chronic obstructive pulmonary disease; BMI: Body mass index.

6.2 Comparison of Radiological Parameters

Table 2 presents the comparison of all radiological parameters between the PMV and non-PMV groups. Significant differences were observed across all principal CT, ultrasound, and CXR parameters.

Table 2: Comparison of Radiological Parameters Between PMV and Non-PMV Groups

Radiological Parameter	PMV (n=31) Mean±SD or n(%)	Non-PMV (n=99) Mean±SD or n(%)	p-value
Mean lung density, HU	-864.3 ± 48.7	-812.6 ± 41.3	0.001*
AP chest diameter, cm	27.4 ± 3.8	24.1 ± 3.2	0.002*
Bronchial wall thickening (present)	19 (61.3%)	28 (28.3%)	0.001*
Pericardial effusion (present)	10 (32.3%)	12 (12.1%)	0.011*
PMI (cm ² /m ²)	4.81 ± 1.42	6.74 ± 1.89	<0.001*
Sarcopenia by PMI	22 (71.0%)	31 (31.3%)	<0.001*
DTF (%)	19.4 ± 6.3	31.8 ± 7.4	<0.001*
DTF <25% (present)	26 (83.9%)	28 (28.3%)	<0.001*
DE, cm	0.94 ± 0.31	1.62 ± 0.48	<0.001*
LUS score (Day 1)	14.7 ± 4.2	8.3 ± 3.7	<0.001*
LUS >8 (present)	28 (90.3%)	42 (42.4%)	<0.001*
Postoperative pleural effusion	21 (67.7%)	27 (27.3%)	<0.001*
Lobar/complete atelectasis (CXR)	18 (58.1%)	21 (21.2%)	<0.001*
Cardiomegaly (CTR >0.5)	14 (45.2%)	22 (22.2%)	0.014*

*Statistically significant ($p < 0.05$). HU: Hounsfield units; AP: Anteroposterior; PMI: Psoas muscle index; DTF: Diaphragm thickening fraction; DE: Diaphragm excursion; LUS: Lung ultrasound score; CTR: Cardiothoracic ratio; CXR: Chest X-ray.

6.3 ROC Curve Analysis

Table 3 summarises the ROC curve analysis for each continuous radiological predictor. DTF demonstrated the highest AUC among single predictors (0.879), followed closely by LUS score on Day 1 (0.856).

Table 3: ROC Curve Analysis — Radiological Predictors of PMV

Parameter	Cut-off	AUC (95% CI)	Sens (%)	Spec (%)	p-value
DTF (%)	<25%	0.879 (0.807–0.951)	83.9	71.7	<0.001
LUS Score (Day 1)	>8	0.856 (0.779–0.933)	90.3	57.6	<0.001
Mean Lung Density (HU)	<-850 HU	0.822 (0.736–0.909)	74.2	78.8	<0.001
PMI (cm ² /m ²)	Sex-specific low quartile	0.793 (0.698–0.888)	71.0	68.7	<0.001
DE (cm)	<1.1 cm	0.811 (0.723–0.900)	77.4	72.7	<0.001
AP Chest Diameter (cm)	>26 cm	0.745 (0.646–0.844)	64.5	74.7	<0.001
Combined Radiological Model	Composite	0.904 (0.847–0.961)	87.1	82.8	<0.001

DTF: Diaphragm thickening fraction; LUS: Lung ultrasound score; HU: Hounsfield units; PMI: Psoas muscle index; DE: Diaphragm excursion; AUC: Area under receiver operating characteristic curve; Sens: Sensitivity; Spec: Specificity.

6.4 Multivariate Logistic Regression

Table 4 presents the independent radiological predictors of PMV identified by multivariate logistic regression. DTF <25% emerged as the strongest independent predictor (OR 5.84), followed by LUS >8 (OR 3.92), mean lung density <-850 HU (OR 4.17), and PMI in lowest quartile (OR 3.28).

Table 4: Independent Radiological Predictors of PMV — Multivariate Logistic Regression

Predictor	OR	95% CI	AUC	p-value
DTF <25%	5.84	2.21–15.42	0.879	<0.001
Mean lung density <-850 HU	4.17	1.58–11.03	0.822	0.004
LUS >8 (Day 1 postoperative)	3.92	1.47–10.43	0.856	0.006
PMI lowest sex-specific quartile	3.28	1.19–9.02	0.793	0.022
Bronchial wall thickening	2.91	1.08–7.83	0.712	0.035
ASA Grade III–IV (clinical)	2.44	0.91–6.57	0.684	0.078 (NS)
APACHE II score (clinical)	1.24 per point	1.09–1.41	0.741	0.001

NS: Not significant. Combined radiological model (DTF + LUS + lung density + PMI + bronchial wall thickening) AUC: 0.904. Radiological model + APACHE II AUC: 0.921. OR: Odds ratio; CI: Confidence interval.

7. DISCUSSION AND INTERPRETATION

This retrospective study from a north Bihar tertiary care institution comprehensively evaluated multiple radiological modalities as predictors of prolonged mechanical ventilation (>48 hours) following major abdominal and thoracic surgery. The principal finding is that a composite radiological model incorporating

diaphragm thickening fraction, postoperative lung ultrasound score, mean CT lung density, and psoas muscle index achieves an AUC of 0.904 for PMV prediction — substantially exceeding individual clinical variables such as ASA grade or APACHE II score used in isolation.

The 23.8% incidence of PMV in our cohort is higher than rates of 6–15% reported in developed-country settings [3,4] but consistent with the 20–30% range observed in comparable south Asian and African tertiary care surgical populations [3,5]. The higher burden likely reflects the complex case mix at RDJMMCH — including late-presenting gastrointestinal malignancies, oesophageal carcinoma requiring major resection, and thoracic surgical patients with established COPD — as well as the high prevalence of sarcopenia and pre-existing nutritional deficiency in north Bihar.

The dominant predictor in our model was DTF <25% (OR 5.84). This finding aligns with the systematic review by Ferrari et al. (2023), which confirmed that DTF is the most diagnostically accurate single ultrasound index for predicting weaning outcome, with pooled sensitivity 85% and SROC AUC 0.87 [7]. The mechanistic basis is straightforward: a reduced DTF indicates impaired diaphragmatic contractile reserve, which directly compromises the ability to sustain spontaneous ventilation following withdrawal of ventilatory support. In our cohort, 83.9% of PMV patients had DTF <25%, compared to only 28.3% of non-PMV patients ($p < 0.001$). The DTF cut-off of 25% in our study is consistent with the threshold of ≥ 20 –30% proposed in the international literature for predicting weaning success [7,10].

Mean CT lung density <-850 HU was the second strongest predictor (OR 4.17). More negative HU values in the lung parenchyma indicate significant air-trapping and emphysematous changes — a pattern associated with elevated intrinsic PEEP, impaired gas exchange, and increased work of breathing in the postoperative state. This is consistent with the preoperative CT findings reported by Canan et al. (2022), who found that bronchial wall thickening (a surrogate of obstructive lung disease) had an OR of 4.8 for postoperative mechanical ventilation [9]. Our data extend this observation by showing that parenchymal density — not just airway wall changes — independently contributes to PMV risk.

Postoperative LUS >8 on day 1 (OR 3.92) is consistent with the ASILI trial by Boussier et al. (2024), the largest prospective multicentre study on this topic, which showed that LUS on day 1 discriminated between PPC and non-PPC patients with Mann-Whitney $p = 0.002$ [8]. LUS captures both alveolar (consolidation, atelectasis) and interstitial (pulmonary oedema, B-lines) lung pathologies simultaneously and is therefore a sensitive composite marker of post-surgical lung injury. Its superiority over chest X-ray is well documented for detecting atelectasis and pleural effusions, as confirmed by the prospective study from the Netherlands on 51 major abdominal surgery patients [13].

CT-derived sarcopenia by PMI was an independent predictor (OR 3.28), consistent with Nassar et al. (2025) from the Egyptian Journal of Radiology, who found that low PMI at L3 predicted ICU admission and major complications in 89 major abdominal surgery patients [6], and with the hepatic resection study by Nishimura et

al. (2023) where sarcopenic patients had significantly higher ICU admission rates (77.3% vs 47.9%) [12]. In the north Bihar context, where overt or subclinical malnutrition is common among patients presenting with gastrointestinal or oesophageal malignancies, preoperative PMI screening from available CT scans offers a no-cost, no-radiation-exposure biomarker for surgical risk stratification.

8. CONCLUSION

Radiological parameters — specifically diaphragm thickening fraction on ultrasound, mean CT lung density, postoperative lung ultrasound score, CT-derived psoas muscle index, and preoperative bronchial wall thickening — are significant independent predictors of prolonged mechanical ventilation (>48 hours) following major abdominal and thoracic surgery at a tertiary referral centre in north Bihar. A combined radiological model integrating these parameters achieved an AUC of 0.904, outperforming conventional clinical risk scores used alone.

These findings have direct clinical implications for preoperative planning, ICU resource allocation, and patient counselling at RDJMMCH and similar tertiary institutions in north India. Implementation of routine diaphragm DTF measurement in the perioperative period, systematic extraction of PMI from available staging CT scans, and standardised postoperative LUS assessment on day 1 are pragmatic, low-cost steps that can be introduced without additional capital expenditure. The proposed cut-off values (DTF <25%, LUS >8, lung density <-850 HU, and sex-specific PMI thresholds) require prospective multicentre validation before formal incorporation into institutional ventilation weaning protocols.

Future studies should evaluate whether targeted prehabilitation — including pre-surgical inspiratory muscle training, nutritional optimisation, and diaphragm-strengthening protocols — in patients identified as high-risk by this radiological profile reduces PMV rates and ICU length of stay in the north Bihar surgical population.

9. LIMITATIONS OF THE STUDY

- The retrospective single-centre design inherently limits causal inference and introduces selection bias, as only patients with adequate preoperative imaging and complete ICU records were included.
- Diaphragm ultrasound measurements were performed by different operators during the study period; despite blinding to outcomes, interoperator variability in DTF measurement — though assessed by ICC — may introduce measurement heterogeneity not fully correctable in a retrospective setting.
- CT scans were acquired for diverse clinical indications (pre-surgical staging, trauma assessment, vascular work-up) using variable scan protocols; this may have introduced heterogeneity

in lung density measurements across patients and scanners.

- Postoperative LUS was assessed on a single time point (Day 1); dynamic LUS trajectories over the first 72–96 hours — which may be more predictive — were not captured in this retrospective design.
- The sample size (n=130) while adequate for primary multivariate analysis, limits the power of subgroup analyses by surgery type (abdominal vs thoracic) and by specific surgical procedure, which may have different PMV risk profiles.
- Pulmonary function test (PFT/spirometry) data were not consistently available for all patients, preventing a full comparison of radiological predictors with objective spirometric parameters such as FEV1 and FEV1/FVC ratio.

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