

The Role of Pre-Operative Spirometry and Chest Radiography in Predicting Post-Operative Pulmonary Complications After Abdominal Surgery

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ABSTRACT

Background: Post-operative pulmonary complications (POPCs) are a major cause of morbidity and prolonged hospital stay following abdominal surgery. In low-resource settings, the predictive utility of routine pre-operative tests like spirometry and chest radiography remains underexplored. This study evaluated the role of these investigations in predicting POPCs in a Nigerian tertiary hospital.

Methods: A prospective observational study was conducted with 100 patients scheduled for elective abdominal surgery. Participants underwent pre-operative spirometry and chest radiography. They were followed for seven days post-operatively for the occurrence of POPCs, defined by standard clinical and radiological criteria.

Results: Over half of the patients (56, 56.0%) had abnormal spirometry, primarily a restrictive pattern (46, 46.0%). Pre-operative chest radiographs were abnormal in 34 (34.0%) of patients. Radiographic findings of fibrosis and hyperinflation were significantly associated with the development of POPCs. Among patients with fibrosis, 6 (75.0%) developed POPCs compared to 33 (35.8%) without ($p=0.033$). Similarly, 5 (83.3%) patients with hyperinflation developed POPCs versus 34 (36.1%) without ($p=0.028$). Patients with fibrosis most frequently developed hypoxemia with infiltrates and pneumonia, while those with hyperinflation commonly had non-productive cough and pneumonia.

Conclusion: Pre-operative spirometry and chest radiography are valuable tools for identifying patients at high risk for POPCs. A restrictive pattern on spirometry, along with radiographic evidence of fibrosis or hyperinflation, are significant predictors. Their routine use in pre-operative assessment can facilitate early risk stratification and guide preventive care, potentially improving surgical outcomes in resource-limited settings.

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BACKGROUND

Post-operative pulmonary complications (POPCs) remain one of the leading causes of perioperative morbidity and mortality worldwide, particularly following major abdominal and thoracic surgeries (Odor et al., 2020; Ashraf et al., 2024). They encompass a range of respiratory conditions including pneumonia, atelectasis, respiratory failure, bronchospasm, and pleural effusion, all of

which can significantly prolong hospital stay, increase healthcare costs and worsen patient outcomes (Miskovic et al., 2017; Lee & Lee, 2025). Globally, POPCs occur in approximately 7 – 30% of patients undergoing major surgery, accounting for nearly one-quarter of all postoperative deaths within the first week after surgery (Kelkar, 2015; Lee & Lee, 2025; Raffa et al., 2025). Their impact is especially pronounced in abdominal procedures,

where factors such as diaphragmatic dysfunction, postoperative pain and impaired cough reflex contribute to compromised pulmonary function (Colucci et al., 2015; Liu et al., 2024).

Pre-operative pulmonary evaluation serves as a critical step in identifying patients at risk for these complications. Spirometry, a simple and cost-effective tool, provides objective quantification of lung function through indices such as the forced expiratory volume in one second (FEV₁) and forced vital capacity (FVC). Studies from high-income countries have consistently shown that reduced spirometric parameters are independently associated with a higher incidence of POPCs, prolonged mechanical ventilation and extended hospital stay (Young & Farmer, 2017; Chang et al., 2023). Similarly, pre-operative chest radiography, though sometimes criticized for overuse, can reveal structural abnormalities like hyperinflation, fibrosis, cardiomegaly and pleural effusion that may predispose patients to postoperative respiratory compromise (Young & Farmer, 2017).

In Africa, where surgical safety infrastructure and perioperative monitoring remain limited, the burden of postoperative complications, including pulmonary events, is disproportionately high. Reports from tertiary hospitals in Ghana and Ethiopia indicate POPC rates ranging from 6% to 25%, with pneumonia and atelectasis being the most frequent (Wulff et al., 2021; Admass et al., 2023). The limited use of objective pre-operative pulmonary assessments, coupled with the high prevalence of undiagnosed chronic lung disease and poorly controlled comorbidities, often hinders early risk stratification in these settings.

In Nigeria, postoperative pulmonary complications represent a growing challenge in surgical practice, with incidences reported between 33% and 52% in major abdominal surgeries (Ufoaroh et al., 2019; Gebeyehu et al., 2022). Most hospitals rely primarily on routine chest X-rays and clinical evaluation, while pre-operative spirometry remains underutilized due to constraints in equipment availability, time and trained personnel. Yet, evidence suggests that combining spirometric findings with radiographic assessment may enhance predictive accuracy, enabling better patient selection for prehabilitation, chest physiotherapy and intensive postoperative monitoring (Hardatt et al., 2024).

This study, therefore, aimed to evaluate the role of pre-operative spirometry and chest radiography in predicting postoperative pulmonary complications among patients undergoing abdominal surgery in a Nigerian tertiary hospital. The findings will contribute to local evidence supporting the

integration of objective pulmonary evaluation into pre-operative protocols and may guide context-specific recommendations for perioperative respiratory care in low-resource surgical settings

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MATERIALS AND METHODS

Study Design

This was a hospital-based prospective observational study conducted among consenting adult patients scheduled for elective abdominal surgery at the University of Benin Teaching Hospital (UBTH), Benin City over an 8-month period.

Study Area

The University of Benin Teaching Hospital is a 600-bed tertiary hospital located in Benin City, Edo State, South-South Nigeria. It serves as a major referral center for Edo and neighbouring states including Delta, Kogi, Ondo, and Bayelsa, providing tertiary care to a population exceeding 10 million. Elective abdominal surgeries are routinely performed weekly by the general surgery, urology and obstetrics and gynaecology units across four general surgery wards.

Study Population

The study population comprised adult patients (≥ 18 years) booked for elective abdominal surgeries during the study period. Inclusion criteria were consenting adults undergoing elective upper abdominal surgery. Exclusion criteria included emergency procedures, patients with impaired consciousness, obstetric or gynaecologic surgeries, urogenital and extra-abdominal operations.

Sample Size and Sampling Technique

The sample size was calculated using Fisher's formula with a POPC prevalence of 52%, yielding $n = 383.5$. Applying a finite population correction factor ($N = 121$, based on 2021 UBTH surgical register), a minimum sample of 77 was derived. Allowing for 10% attrition increased the target to 84, but 100 participants were ultimately enrolled to enhance study power. Participants were selected using consecutive sampling.

Data Collection

Data were collected using a structured interviewer-administered questionnaire adapted from the Medical Research Council respiratory questionnaire. Information on sociodemographics,

smoking, alcohol use, comorbidities and respiratory symptoms was obtained via a structured questionnaire adapted from the MRC respiratory tool. Clinical parameters (blood pressure, oxygen saturation, respiratory rate, weight and height) were recorded.

Pre-operative spirometry was performed using a Sibelmed Dataspir Mod 120 spirometer following ATS standards. Parameters included FEV₁, FVC, and FEV₁/FVC ratio, categorized as normal, obstructive, restrictive or mixed. Chest radiographs taken within 72 hours before surgery were interpreted by a consultant radiologist for abnormalities such as hyperinflation, fibrosis or effusion. Baseline serum albumin and urea levels were also obtained.

Patients were followed postoperatively for seven days. POPCs were diagnosed based on standard clinical and radiologic criteria, including fever >37.5°C, tachypnea >20/min, hypoxia (SpO₂ <95%) or new chest infiltrates.

Data Analysis

Data were analyzed using SPSS version 26.0. Categorical variables were summarized as frequencies and percentages, while continuous variables were presented as means and standard deviations. Associations between categorical variables were tested using the Chi-square or Fisher's exact test, and continuous variables using Student's t-test. Variables significant at the univariate level were entered into multivariate logistic regression to identify independent predictors of POPCs. Results were reported as odds ratios (OR) with 95% confidence intervals (CI), and statistical significance was set at $p \leq 0.05$.

Ethical Considerations

Ethical approval was obtained from the UBTH Ethics and Research Committee. Written informed consent was secured from all participants. Confidentiality, autonomy and voluntary participation were ensured. All procedures and investigations were conducted at no additional cost to the patients.

RESULTS

Pulmonary Function by Age and Sex (Table 1)

Among the 100 participants assessed, spirometric indices showed an age-related decline in both sexes.

In males, the mean FEV₁ decreased progressively from 3.12 ± 1.2 L among those aged 31–40 years to 2.06 ± 0.4 L in those above 60 years, while the mean FVC declined from 3.78 ± 0.7 L to 2.75 ± 0.6 L across the same age range. The mean FEV₁/FVC

ratio also reduced slightly from 0.90 ± 0.2 in the youngest group to 0.75 ± 0.1 among those older than 60 years. Also, PEF declined from 458.3 ± 102.1 L/min in the 41–50-year group to 321.0 ± 82.6 L/min after 60 years.

Among females, a similar pattern was observed. The mean FEV₁ decreased from 2.41 ± 0.3 L in those aged 31–40 years to 1.47 ± 0.2 L among participants above 60 years, while FVC declined from 2.94 ± 0.4 L to 1.94 ± 0.4 L. The mean FEV₁/FVC ratio remained relatively stable across age groups ($0.78–0.85$), whereas PEF showed a steady reduction from 365.7 ± 55.4 L/min to 236.0 ± 40.9 L/min beyond 60 years.

Overall, participants aged ≤ 60 years had higher mean FEV₁ (2.25 ± 0.5 L) and FVC (2.77 ± 0.6 L) compared with those aged > 60 years (1.81 ± 0.5 L and 2.43 ± 0.7 L, respectively). The FEV₁/FVC ratio and PEF were also slightly lower among the older age group (0.76 ± 0.1 and 296.1 ± 79.5 L/min, respectively).

Spirometry Pattern of the Participants

Nearly half of the participants (44; 44.0%) demonstrated normal spirometry (FEV₁/FVC > 0.7), while a slightly higher proportion (56; 56.0%) had abnormal spirometric findings. Among those with abnormal results, the restrictive pattern predominated, occurring in 46 (46.0%) of all participants, followed by the obstructive pattern in 6 (6.0%) and a mixed pattern in 4 (4.0%).

Pre-operative Chest Radiograph Findings

Two-thirds of the participants (66; 66.0%) had normal pre-operative chest radiographs, while 34 (34.0%) showed abnormal findings. Among the abnormal films, aortic unfolding was the most common, observed in 19 (55.9%) cases, followed by fibrosis in 8 (23.5%), hyperinflation in 6 (17.6%), and cardiomegaly in 5 (14.7%). Less frequent findings included pleural effusion 4 (11.8%), tracheal deviation 2 (5.9%), hilar opacities 1 (2.9%), cannon ball infiltrate 1 (2.9%), and lung volume loss 1 (2.9%).

Association Between Chest Radiographic Findings and Post-operative Pulmonary Complications

Certain pre-operative radiographic abnormalities were significantly associated with the occurrence of postoperative pulmonary complications (POPCs). Patients with fibrotic changes on chest radiography had a significantly higher rate of POPCs (75.0%) compared to those without (35.8%; $p = 0.033$). Similarly, the presence of hyperinflation was strongly associated with postoperative

complications (83.3% vs. 36.1%; $p = 0.028$). Other findings such as aortic unfolding, cardiomegaly, pleural effusion, tracheal deviation and hilar or cannon ball opacities were not significantly related to POPCs ($p > 0.05$).

Pattern of Post-operative Complications Among Patients with Fibrosis and Hyperinflation

A total of 8 participants (8.0%) had radiographic evidence of fibrosis, while 6 (6.0%) showed hyperinflation. Among those with fibrosis, hypoxemia with crepitations and bilateral infiltrates was the most frequent postoperative

complication, occurring in 3 (3.0%) patients, followed by pneumonia in 2 (2.0%), and productive cough with crepitations in 1 (1.0%). Two patients (2.0%) with fibrosis had no postoperative respiratory symptoms.

In contrast, among patients with hyperinflation, non-productive cough was the predominant postoperative complication 3 (3.0%), followed by pneumonia 2 (2.0%). Only 1 patient (1.0%) with hyperinflation remained asymptomatic postoperatively.

Table 1: Baseline Lung Function of The Participants

Variable	Frequency (n = 100)	FEV ₁ (L) Mean ± S.D	FVC(L) Mean ± S.D	FEV ₁ /FVC(L) Mean ± S.D	PEF(L) Mean ± S.D
Age (Years)					
Male					
20-30	2	1.83 ± 0.4	2.03 ± 0.1	0.90 ± 0.2	293.00 ± 8.5
31-40	2	3.12 ± 1.2	3.38 ± 0.8	0.82 ± 0.01	432.50 ± 79.9
41-50	7	2.89 ± 0.4	3.78 ± 0.7	0.81 ± 0.1	458.30 ± 102.1
51-60	16	2.16 ± 0.4	2.76 ± 0.6	0.76 ± 0.1	356.50 ± 79.2
> 60	14	2.06 ± 0.4	2.75 ± 0.6	0.75 ± 0.1	321.00 ± 82.6
Female					
20-30	8	2.19 ± 0.5	2.70 ± 0.5	0.85 ± 0.1	333.00 ± 72.8
31-40	15	2.41 ± 0.3	2.94 ± 0.4	0.82 ± 0.1	365.67 ± 55.4
41-50	18	2.14 ± 0.4	2.64 ± 0.7	0.82 ± 0.1	334.8 ± 63.5
51-60	9	1.81 ± 0.2	2.21 ± 0.4	0.79 ± 0.1	279.60 ± 42.2
> 60	9	1.47 ± 0.2	1.94 ± 0.4	0.78 ± 0.1	236.00 ± 40.9
Total					
≤ 60	77	2.25±0.5	2.77±0.6	0.81±0.1	340.93±76.8
> 60	23	1.81±0.5	2.43±0.7	0.76±0.1	296.12±79.5

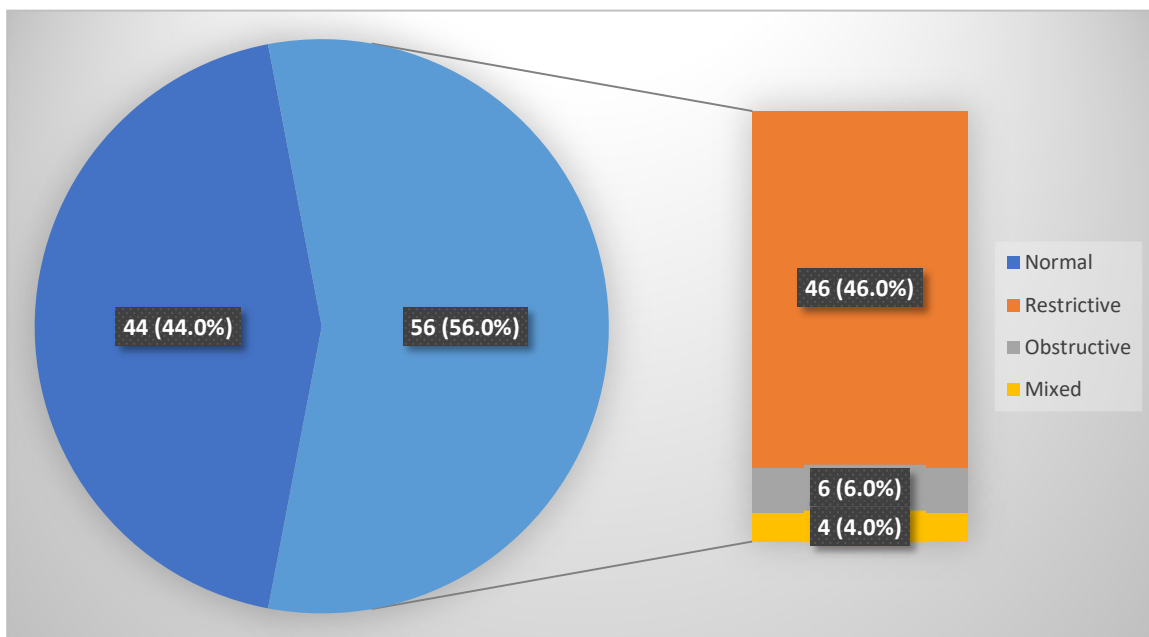


Figure 1: Bar in pie chart showing spirometry pattern of respondents

Table 2: Pre-Operative Chest Radiograph Findings

Findings	Frequency (n = 100)	Percentage (%)
Normal	66	66.0
Abnormal chest radiographic findings* (n = 34)		
Aortic unfolding	19	55.9
Fibrosis	8	23.5
Hyperinflation	6	17.6
Cardiomegaly	5	14.7
Pleural effusion	4	11.8
Tracheal deviation	2	5.9
Hilar opacities	1	2.9
Cannon ball infiltrate	1	2.9
Lung volume loss	1	2.9

*Multiple responses

Table 3: Association Between Chest Radiographic Findings and Post-operative Pulmonary Complications

Features	POCPs		Test of significance	p-value
	Present n (%)	Absent n (%)		
Aortic unfolding				
Yes	10 (52.6)	9 (47.4)	2.131 ^a	0.190
No	29 (35.8)	52 (64.2)		
Fibrosis				
Yes	6 (75.0)	2 (25.0)	5.053 ^b	0.033
No	33 (35.8)	59 (64.2)		
Hyperinflation				
Yes	5 (83.3)	1 (16.7)	7.273 ^b	0.028
No	34 (36.1)	60 (63.9)		
Cardiomegaly				
Yes	2 (40.0)	3 (60.0)	0.009 ^b	0.632
No	37 (38.9)	58 (61.1)		
Pleural effusion				
Yes	3 (75.0)	1 (25.0)	2.421 ^b	0.294
No	36 (37.8)	60 (62.2)		
Tracheal deviation				
Yes	1 (50.0)	1 (50.0)	0.125 ^b	0.618
No	38 (38.7)	60 (61.3)		
Hilar opacities				
Yes	1 (100.0)	0 (0.0)	1.648 ^b	0.380
No	38 (38.3)	61 (61.7)		
Cannon ball infiltrate				
Yes	1 (100.0)	0 (0.0)	1.648 ^b	0.380
No	38 (38.3)	61 (61.7)		
Lung volume loss				
Yes	1 (100.0)	0 (0.0)	1.648 ^b	0.380
No	38 (38.3)	61 (61.7)		

^achi square test, ^bFischer's exact test

Table 4: Pattern of Post-operative Complications Among Patients with Fibrosis and Hyperinflation

Features	Hypoxemia + Crepitation + Bilateral Infiltrates n (%)	Pneumonia n (%)	Productive Cough + Crepitation without pneumonia n (%)	Non- Productive Cough Only n (%)	Productive Cough Only n (%)	None n (%)
Fibrosis	3 (37.5)	2 (12.5)	1 (12.5)	0 (0.0)	0 (0.0)	2 (12.5)
Hyperinflation	0 (0.0)	2 (33.3%)	0 (0.0)	3 (50.0)	0 (0.0)	1 (16.7)

DISCUSSION

This study assessed pre-operative pulmonary function, chest radiographic patterns and their relationship with postoperative pulmonary complications (POPCs) among surgical patients. Nearly half of the participants exhibited abnormal spirometric findings, with restrictive defects predominating. This aligns with reports by Oloyede et al. (2023) in Katsina and Owusu et al. (2024) in South Africa, where restrictive patterns were also the most frequent spirometric abnormality among patients. The finding may reflect underlying chronic lung changes, obesity or reduced physical activity common among middle-aged and elderly populations. Clinically, this highlights the need for preoperative pulmonary evaluation to identify individuals at risk for compromised postoperative recovery.

Radiographically, one-third of patients demonstrated abnormalities, most notably aortic unfolding, fibrosis, and hyperinflation. This is higher than previous studies documented by Akinola et al. in Lagos and van Vugt et al. (2012) in Europe, where chest radiographs revealed incidental findings in 10–20% of respondents. The high proportion of findings and aortic unfolding in this study likely reflects age-related vascular changes rather than active diseases.

A key observation in this study was the strong association between preoperative fibrosis and hyperinflation with POPCs, where 75.0% and 83.3% of affected patients respectively developed complications. Comparable findings were reported by Shafiek et al. (2016) in Spain, who identified chronic lung changes as independent predictors of postoperative pulmonary morbidity. The presence of fibrosis or hyperinflation likely represents reduced pulmonary reserve, impaired gas exchange and poor mucociliary clearance, all of which predispose to hypoxemia, pneumonia, and prolonged hospital stay.

Among those with fibrosis, hypoxemia with bilateral infiltrates and pneumonia were predominant postoperative complications, mirroring findings from Liu et al. (2021) in the United States and China. In patients with hyperinflation, nonproductive cough and pneumonia were common, consistent with the obstructive physiology typically associated with chronic airflow limitation. These complications are clinically significant, as even mild respiratory compromise can delay recovery and increase perioperative risk.

Overall, the study emphasizes that simple preoperative spirometry and chest radiography remain valuable screening tools, particularly in

low-resource settings. Routine interpretation of these tests by anaesthetists and surgeons could facilitate early identification of high-risk patients and enable targeted preventive strategies such as preoperative physiotherapy, bronchodilator optimization and careful postoperative monitoring.

CONCLUSION

Restrictive spirometric patterns, pulmonary fibrosis, and hyperinflation were identified as strong predictors of postoperative pulmonary complications in this cohort. Routine preoperative spirometry and chest radiography provide valuable, low-cost methods for detecting patients at high risk of respiratory complications. Their incorporation into preoperative protocols could significantly enhance surgical safety, particularly in elderly and comorbid populations.

RECOMMENDATIONS

1. Preoperative pulmonary function testing and chest radiography should be routinely performed in elective surgical patients, especially those above 50 years or with a smoking history.
2. Patients with identified pulmonary abnormalities should receive preoperative respiratory physiotherapy, optimization of comorbidities, and enhanced postoperative monitoring.
3. Future studies with larger, multicenter cohorts and extended postoperative follow-up are recommended to validate these findings and assess long-term pulmonary outcomes.

LIMITATIONS

This study was limited by its relatively small sample size and single-centre design, which may limit generalizability. Also, postoperative follow-up was confined to the immediate perioperative period, and longer-term outcomes such as late-onset pulmonary dysfunction were not assessed. Despite these limitations, the study provides useful data emphasizing the predictive value of simple preoperative assessments in identifying at-risk surgical patients.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

REFERENCES

- Admass BA, Ego BY, Tawye HY, Ahmed SA (2023). Post-operative pulmonary complications after thoracic and upper abdominal procedures at referral hospitals in Amhara region, Ethiopia: a multi-center study. *Frontiers Surg*; 10. doi:10.3389/fsurg.2023.1177647.
- Akinola RA, Akhighe AO, Mohammed A, Omotayo OO Evaluation of routine chest X-rays performed in a tertiary institution in Nigeria. *Cardiovasc Res J* 2014; 8(2): 2. doi:10.4172/2324-8602.1000178.
- Ashraf N, Zargar OU, Albina A, Ahmed S (2024). Study of incidence and factors associated with postoperative pulmonary complications in patients undergoing abdominal surgery. *Int J Res Med Sci*; 12(11):4129-4135. doi:10.18203/2320-6012.ijrms20243360.
- Chang PC, Chen PH, Chang TH, et al (2023). Incentive spirometry is an effective strategy to improve the quality of postoperative care in patients. *Asian J Surg*; 46(9):3397-3404. doi:10.1016/j.asjsur.2022.11.030.
- Colucci DBB, Fiore JF, Paisani DM, et al (2015). Cough Impairment and Risk of Postoperative Pulmonary Complications After Open Upper Abdominal Surgery. *Respiratory Care*; 60(5):673-678. doi:10.4187/respcare.03600.
- Gebeyehu G, Eshetu A, Aweke S (2022). Incidence and Associated Factors of Postoperative Pulmonary Complications after Abdominal Surgery in the Public Hospital, Addis Ababa, Ethiopia. *Anesthesiol Res Pract*; 2022:1-8. doi:10.1155/2022/8223903.
- Hardatt D, Singh G, Kaur N, Pethekar AJ, Gupta S, Dhanawat M (2024). To Shed Light on the Association between Poor Ergophthalmologic Practices and Computer Vision Syndrome. *Current Indian Sci*; 02. doi:10.2174/012210299X247199231128100613.
- Lee HJ, Lee HW (2025). Comprehensive Strategies for Preoperative Pulmonary Risk Evaluation and Management. *Tuberculosis and Respiratory Diseases (Seoul)*; 88(1):90-108. doi:10.4046/trd.2024.0118Liu F, Wen Q, Yang Y, et al (2024). Diaphragmatic dysfunction is associated with postoperative pulmonary complications in aged patients who underwent radical resection of esophageal cancer: a prospective observational study. *J Thoracic Dis*; 16(6):3623-3635. doi:10.21037/jtd-24-197
- Liu K, Scott JB, Jing G, Li J (2021). Management of Postoperative Hypoxemia. *Respiratory Care*; 66(7):1136-1149. doi:10.4187/respcare.08929
- Kelkar K (2015). Post-operative pulmonary complications after non-cardiothoracic surgery. *Indian J Anaesthesia*; 59(9):599. doi:10.4103/0019-5049.165857
- Miskovic A, Lumb AB (2017). Postoperative pulmonary complications. *Br J Anaesthesia*. 2017;118(3):317-334. doi:10.1093/bja/aex002
- Odor PM, Bampoe S, Gilhooly D, Creagh-Brown B, Moonesinghe SR (2020). Perioperative interventions for prevention of postoperative pulmonary complications: systematic review and meta-analysis. *BMJ*; 368:m540. doi: 10.1136/bmj.m540.
- Oloyede T, Tekobo G, Gbadamosi H, et al (2023). Indication for Spirometry and Pattern of Lung Functions among Patients in a Tertiary Health Institution in Northwest Nigeria: A Three-Year Review. *West Nig J Med Sci*; 6(1):29-34.
- Owusu SK, Mapani MK, Visagie A, et al (2024). Pulmonary function assessments and clinical correlates in children with sickle cell disease in Cape Town, South Africa. *J Pan African Thoracic Soc*; 5:33. doi:10.25259/JPATS_30_2023
- Raffa RB, Pergolizzi JV, Dungan GC, Miller TL (2025). Mortality 30, 60, and 90 Days After Discharge Is Greater in Patients Who Experienced Postoperative Respiratory Depression and Pulmonary Complication. *Cureus J Med Sci*; doi:10.7759/cureus.79913.
- Shafiek H, Valera JL, Togores B, Torrecilla JA, Sauleda J, Cosío BG (2016). Risk of postoperative complications in chronic obstructive lung diseases patients considered fit for lung cancer surgery: beyond oxygen consumption. *Euro J Cardio-Thoracic Surg*; 50(4):772-779. doi:10.1093/ejcts/ezw104.
- Shin SH, Shin B, Kang D, et al (2019). Restrictive Spirometric Pattern and Postoperative Pulmonary Complications Following Non-cardiothoracic Surgery. *Scientific Rep*. 2019;9(1):12750. doi:10.1038/s41598-019-49158-1.
- Ufoaroh CU, Ele PU, Anyabolu AE, et al (2019). Pre-operative pulmonary assessment and risk factors for post-operative pulmonary complications in elective abdominal surgery in Nigeria. *Afr Health Sci*; 19(1):1745. doi:10.4314/ahs.v19i1.51.
- Wulff I, Duah HO, Osei Tutu H, et al (2021). Postoperative Pulmonary Complications in Complex Pediatric and Adult Spine Deformity: A Retrospective Review of Consecutive Patients Treated at a Single Site in West Africa. *Global Spine J*; 11(8):1208-1214. doi:10.1177/2192568220942482.
- Young EM, Farmer JD (2017). Preoperative Chest Radiography in Elective Surgery: Review and Update. *South Dakota Med*; 70(2):81-87.
- van Vugt S, Broekhuizen L, Zuithoff N, et al (2012). Incidental Chest Radiographic Findings in Adult Patients With Acute Cough. *Ann Fam Med*; 10(6):510-515. doi:10.1370/afm.1384