Observational Study

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
2025, Vol. 53(5) 1–11

DOI: 10.1177/03000605251340538
journals.sagepub.com/home/imr
Sage

Prevalence of postoperative pulmonary complications in recipients of liver transplantation with abnormal preoperative spirometry

Sunaina Khan, Alishba Zainab, Sapna Amin and Rashid Iqbal

Abstract

Objective: To determine the incidence of postoperative pulmonary complications in liver transplantation recipients with abnormal preoperative spirometry.

Methods: A retrospective observational study was conducted among 210 patients with abnormal preoperative spirometry who underwent living donor liver transplantation between April 2012 and January 2024. Liver transplantation recipients were divided into two groups based on the spirometry diagnosis of restrictive lung disease or obstructive lung disease. The incidence of postoperative pulmonary complications and impact on patient outcomes were assessed in terms of length of stay in the intensive care unit, total length of stay in the hospital, time on the ventilator, duration of surgery, noninvasive ventilator dependence, reintubation rate, hospital-acquired infection, mortality, and arterial blood gas analysis.

Results: The incidence of postoperative pulmonary complications was approximately 91.2% in liver transplantation recipients with abnormal preoperative spirometry. The length of stay in the intensive care unit, total length of stay in the hospital, duration of surgery, noninvasive ventilator dependence, reintubation rate, mortality, and hospital-acquired infections did not notably differ between recipients with restrictive lung disease (n = 189) and obstructive lung disease (n = 21).

Discussion: Abnormal spirometry resulted in an increased incidence of postoperative pulmonary complications. However, the study suggests that the effects of abnormal spirometry were similar after liver transplantation.

Shifa International Hospital Ltd., Pulmonology & Critical Care/SIH, Pakistan

Current affiliation of Rashid Iqbal: National Skills University, Department of Health Sciences Technology, Pakistan

Corresponding author:
Sunaina Khan, Shifa International Hospital Ltd., Pulmonology & Critical Care/SIH, Islamabad, Pakistan.
Email: sunainakhan1235@gmail.com

Conclusion: Preexisting restrictive and obstructive lung diseases are associated with similar risks in liver transplantation recipients. However, as our study had fewer patients with obstructive lung disease, future research should include a comparable number of patients with restrictive and obstructive lung diseases to produce robust data on postoperative complications within this group for liver transplantation.

Keywords
Postoperative complications, liver transplantation, pulmonary complications, pulmonary function tests, spirometry

Date received: 24 October 2024; accepted: 22 April 2025

Introduction

Liver transplantation represents the sole efficacious treatment option for advanced liver failure. Patients are needed to undergo a liver transplantation assessment in cases of fulminant hepatic failure, alcoholic liver disease, cholangiocarcinoma, acute-on-chronic liver failure, systemic complications arising from chronic liver disease, colorectal cancer with metastases to the liver, and metabolic consequences due to liver disorders.[1,2]

Liver transplantation is a major surgery of the upper abdomen, where the lungs are inevitably affected. Hence, pulmonary complications in the postoperative period are frequent and estimated to occur in 35%–50% of liver transplantation recipients. These complications are related to high morbidity and mortality rates.[3] The most common pulmonary complication is pleural effusion (hepatic hydrothorax), which frequently involves the right side of the thorax. Some other common pulmonary complications observed after liver transplantation include atelectasis, pneumonia, pulmonary edema, transfusion-related acute lung injury, and acute respiratory distress syndrome.[4,5] Endotracheal reintubation occurs in 2%–19% of patients throughout the postoperative period of critical care management. Such events caused by respiratory impairment have significant impacts on recovery and are related to higher mortality rates.[6]

Preoperative risk factors associated with a high incidence of postoperative pulmonary complications include, but are not limited to, age, history of smoking, preexisting pulmonary dysfunction, severity of liver disease, portopulmonary hypertension, hypoxemia, hepatopulmonary syndrome, hepatic encephalopathy, comorbidity, and preoperative ventilator dependence.[4] Numerous preoperative investigations are performed to optimize patient care before, during, and after liver transplantation. Pulmonary function tests (PFTs), including spirometry, are part of these investigations that specifically assess pulmonary function before transplantation. Spirometry performed following the American Thoracic Society (ATS) guidelines evaluates the following parameters: (a) forced expiratory volume in 1 second (FEV1); (b) forced vital capacity (FVC); (c) FEV1/FVC; and (d) peak expiratory flow (PEF). The reference values for these parameters are primarily determined via a PFT machine using several factors, such as age, sex, weight, height, race, and history of smoking. Respiratory impairment (restrictive lung

disease (RLD) vs. obstructive lung disease (OLD)) is confirmed after comparing the patient's reported parameters with reference or predicted values.[7,8]

Previous studies have shown contradictory results on the concept of preexisting pulmonary dysfunction as a risk factor for pulmonary complications and poor patient outcomes after liver transplantation.[3,9–11] These studies included both normal and abnormal PFT groups and utilized various PFTs. For instance, Kia et al. considered carbon monoxide diffusing capacity (DLCO), lung volume, and spirometry.[9] In contrast, Buggs et al. only utilized DLCO and FEV1/FVC to establish the diagnosis of respiratory impairment.[10] However, in the current study, spirometry was the PFT used to diagnose respiratory impairment, and only abnormal PFT results were considered to assess the impact of RLD and OLD on patient outcomes during the postoperative period. In addition, there are no studies on the pulmonary context of liver transplantation recipients in Pakistan. Therefore, this study was conducted to produce relevant clinical evidence. Abnormal spirometry was hypothesized to manifest as an increased incidence of pulmonary complications after liver transplantation.

The primary objective of this study was to determine the incidence and types of postoperative pulmonary complications in liver transplantation recipients with abnormal preoperative spirometry. Additionally, we aimed to understand the impact of preoperative RLD and OLD on patient outcomes following liver transplantation.

Materials and methods

A retrospective observational study was conducted among living donor liver transplantation recipients (from April 2012 to January 2024) at Shifa International Hospital, Islamabad, Pakistan. A sample size of 384 individuals was calculated using the Open Epi software (Copyright (c) 2002–2003 Geir Landrö, Rollins School of Public Health, Emory University, Atlanta, USA), with a population size of 1 million, an anticipated % frequency (p) of 50%, confidence limit of 5, and a design effect of 1.0.[12] Liver transplantation recipients aged $\geq$6 years with documented preoperative PFT results were included. Recipients with preoperative normal or missing PFT data were excluded. Study approval was obtained from the Institutional Review Board of Shifa International Hospital (IRB number: 0216-23, approved on 20 July 2023). The medical records of all recipients were reviewed selectively using convenient sampling with a structured questionnaire. This study adhered to the principles of the Helsinki Declaration of 2013. The reporting of this study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[13]

A PFT of spirometry was used to establish the diagnosis of RLD and OLD. The spirometry technique complied with the ATS guidelines and was performed using the KoKoPx 4000 (nSpire Health, Inc; Longmont, USA) and MIR Spirolab III Spirometer (MIR srl, Roma, Italy). A normal spirometry result was defined as FEV1 of 80%–120% of the predicted value, FVC of 80%–120% of the predicted value, and FEV1/FVC ratio of 70%–80% of the predicted value. The normal value of PEF was 80% of the predicted value. Any parameter outside the normal range was considered abnormal. OLD was defined as decreased FEV1, normal or decreased FVC, and decreased FEV1/FVC ratio. RLD was characterized by decreased FVC and normal or increased FEV1/FVC.[8,14]

Other preoperative parameters studied were patients' demographics, body mass index (BMI), etiology of liver disease, smoking history, pack years, hepatic encephalopathy, hepatopulmonary syndrome, ejection fraction, mean pulmonary arterial pressure

level, ascites, comorbidities, preoperative chest imaging findings, total bilirubin, albumin level, international normalized ratio (INR), sodium level, creatinine level, model for end-stage liver disease sodium (MELD Na) score, and Child–Pugh score.

For postoperative assessment, chest imaging findings (X-ray, ultrasound, and computed tomography) were used to identify pulmonary complications after transplantation. Primary patient outcomes included mortality, time on ventilator, and reintubation rate. Secondary patient outcomes included total length of stay in the hospital, length of stay in the intensive care unit (ICU), duration of surgery, hospital-acquired infection (HAI), arterial blood gas analysis, and post-extubation noninvasive ventilator (NIV) dependence. Patient outcomes were assessed over a duration of 3 months after transplantation, and arterial blood gas analysis was performed upon arrival to the surgical ICU from the operation theater.

Statistical analyses were performed using IBM SPSS Statistics 23 with a p-value of 0.05. All recipient data were de-identified. Appropriate descriptive statistics were used for summarizing the data as follows: mean and standard deviation or median and interquartile range for continuous variables, and frequency and percentages for categorical variables. Comparison of continuous variables was performed using the independent sample *t*-test or Mann–Whitney U test. The chi-square test was used for between-group comparisons of categorical variables.

Results

Patient characteristics before liver transplantation

Abnormal preoperative spirometry was reported in 210 liver transplantation recipients in the preoperative period. The recipients were categorized into RLD and OLD groups based on their spirometry diagnosis. Overall, 90% (n = 189) of the recipients had RLD, whereas 10% (n = 21) had OLD. Baseline characteristics such as age, sex, BMI, smoking history, hepatic encephalopathy, hepatopulmonary syndrome, ejection fraction, mean pulmonary arterial pressure, and Child–Pugh score showed no significant differences between the two groups (Table 1). However, recipients with OLD reported a higher number of pack years ($p = 0.004$). Additionally, a higher number of recipients in the RLD group had ascites (71.8%, $p = 0.023$) and increased MELD Na scores ($p = 0.014$). Notably, although a wide variety of liver disease etiologies were reported in our patients (Table 1), only the prevalence of HCV–HDV coinfection ($p = 0.010$) significantly differed between the two groups, with only one patient in the OLD group reporting this coinfection.

Approximately 62% of the recipients had some comorbidity ($p = 1.000$). Notable comorbidities were hypertension ($p = 0.446$), ischemic heart disease ($p = 0.223$), diabetes mellitus ($p = 0.353$), acute kidney injury ($p = 0.379$), chronic kidney disease ($p = 1.000$), hypothyroidism ($p = 0.576$), asthma ($p = 0.005$), chronic obstructive pulmonary disease ($p = 0.190$), and interstitial lung disease ($p = 1.000$). Approximately 23% of the recipients in the OLD group had asthma (Table 1). Preoperative laboratory parameters, including sodium level, creatinine level, albumin level, total bilirubin, and INR, demonstrated no significant differences between the RLD and OLD groups (Table 1).

Preoperative chest imaging findings (Table 1) such as atelectasis, pleural effusion, and nodules demonstrated no significant differences between the two groups. However, the incidence of pleural effusion with atelectasis ($p = 0.026$) was higher in the RLD group. In addition, other less

Table 1. Baseline patient characteristics (before transplantation).

	RLD (n = 189)	OLD (n = 21)	Total (n = 210)	Missing	p-value
(a)					
PFT, % predicted					
FVC, median (IQR)	66 (55–73)	80 (69–81)	67 (57–74)	N/A	<0.0001
FEV1, median (IQR)	67 (58–76)	70 (48–76)	67 (58–76)	N/A	0.735
FEV1/FVC, median (IQR)	104 (99–113)	88 (70–92)	103 (96–112)	N/A	<0.0001
PEF, mean (SD)	61.4 (19.2)	48.2 (16.1)	60.2 (19.2)	N/A	0.004
Age, years, median (IQR)	49 (42–56)	52 (40–56)	49 (42–56)	N/A	0.746
Sex, n (%)				0	0.138
Male	150 (79.4)	20 (95.2)	170 (81.0)		
Female	39 (20.6)	1 (4.8)	40 (19.0)		
BMI, kg/m^2, mean (SD)	26.0 (4.9)	24.4 (4.3)	25.9 (4.9)	N/A	0.159
Smoking history, n (%)	45 (24.1)	10 (47.6)	55 (26.2)	2	0.059
Pack years, median (IQR)	0 (0–0)	0 (0–15.9)	0 (0–0)	N/A	0.004
Hepatic encephalopathy, n (%)	73 (38.6)	8 (38.1)	81 (38.6)	0	1.000
Ascites, n (%)	135 (71.8)	9 (42.9)	144 (68.9)	1	0.023
Hepatopulmonary syndrome, n (%)	3 (1.6)	0 (0.0)	3 (1.4)	2	0.752
EF (%), median (IQR)	60 (60–60)	60 (60–60)	60 (60–60)	N/A	0.588
Mean pulmonary arterial pressure, mmHg, mean (SD)	15.9 (3.5)	13.2 (3.7)	15.7 (3.6)	N/A	0.057
MELD Na score, median (IQR)	19 (15–24)	14 (10.5–20.5)	19 (15–24)	N/A	0.014
Child–Pugh score, n (%)				6	0.620
A	30 (16.4)	5 (23.8)	35 (17.1)		
B	74 (40.4)	9 (42.9)	83 (40.7)		
C	79 (43.2)	7 (33.3)	86 (42.2)		
Liver disease					
Etiology of liver disease, n (%)				2	0.509
Infectious	141 (75.4)	18 (85.7)	159 (76.4)		
Noninfectious	46 (24.6)	3 (14.3)	49 (23.6)		
HBV, n (%)	15 (8.0)	2 (9.5)	17 (8.2)	2	0.869
HCV, n (%)	91 (48.7)	12 (57.1)	103 (49.5)	2	0.680
HBV–HDV coinfection, n (%)	29 (15.5)	3 (14.3)	32 (15.4)	2	0.884
HBV–HCV coinfection, n (%)	8 (4.3)	2 (9.5)	10 (4.8)	2	0.504
HCV–HDV coinfection, n (%)	0 (0.0)	1 (4.8)	1 (0.5)	2	0.010
ALD, n (%)	12 (6.4)	0 (0.0)	12 (5.8)	2	0.435
NASH, n (%)	4 (2.1)	0 (0.0)	4 (1.9)	2	0.710
AIH, n (%)	3 (1.6)	0 (0.0)	3 (1.4)	2	0.752
Budd–Chiari syndrome, n (%)	5 (2.7)	0 (0.0)	5 (2.4)	2	0.669
Cryptogenic, n (%)	25 (13.4)	3 (14.3)	28 (13.5)	2	0.888
Other, n (%)	4 (2.1)	0 (0.0)	4 (1.9)	2	0.710
HCC, n (%)	55 (29.4)	8 (38.1)	63 (30.3)	2	0.636
(b)					
Comorbidities					
Comorbidity, n (%)	118 (62.4)	13 (61.9)	131 (62.4)	0	1.000
HTN, n (%)	55 (29.1)	4 (19.0)	59 (28.1)	0	0.446
DM, n (%)	76 (40.2)	6 (28.6)	82 (39.0)	0	0.353

(continued)

Table 1. Continued.

	RLD (n = 189)	OLD (n = 21)	Total (n = 210)	Missing	p-value
IHD, n (%)	7 (3.7)	2 (9.5)	9 (4.3)	0	0.223
AKI, n (%)	16 (8.5)	0 (0.0)	16 (7.6)	0	0.379
CKD, n (%)	8 (4.2)	1 (4.8)	9 (4.3)	0	1.000
Hypothyroidism, n (%)	7 (3.7)	1 (4.8)	8 (3.8)	0	0.576
Asthma, n (%)	8 (4.2)	5 (23.8)	13 (6.2)	0	0.005
COPD, n (%)	1 (0.5)	1 (4.8)	2 (1.0)	0	0.190
ILD, n (%)	2 (1.1)	0 (0.0)	2 (1.0)	0	1.000
Others, n (%)	16 (8.5)	2 (9.5)	18 (8.6)	0	0.697
Laboratory findings					
Sodium, mEq/L, median (IQR)	135 (130–138)	138 (133–140)	135 (131–138)	N/A	0.071
Creatinine, mg/dL, median (IQR)	0.8 (0.7–1.2)	0.8 (0.6–1.0)	0.9 (0.7–1.2)	N/A	0.355
Albumin, g/dL, median (IQR)	2.7 (2.4–3.3)	2.8 (2.5–3.6)	2.7 (2.4–3.4)	N/A	0.384
Total bilirubin, mg/dL, median (IQR)	2.5 (1.3–6.1)	1.9 (1.1–3.1)	2.3 (1.3–5.4)	N/A	0.090
INR, median (IQR)	1.4 (1.2–1.7)	1.4 (1.2–1.5)	1.4 (1.2–1.7)	N/A	0.366
Preoperative chest imaging findings					
Atelectasis, n (%)	32 (19.5)	6 (28.6)	38 (20.5)	25	0.122
Pleural effusion, n (%)	25 (15.2)	3 (14.3)	28 (15.1)	25	0.205
Pleural effusion with atelectasis, n (%)	25 (15.2)	0 (0.0)	25 (13.5)	25	0.026
Nodule, n (%)	39 (23.8)	6 (28.6)	45 (24.3)	25	0.182
Other, n (%)	17 (10.4)	5 (23.8)	22 (11.9)	25	0.034

RLD: restrictive lung disease; OLD: obstructive lung disease; PFT: pulmonary function test; FVC: forced vital capacity; IQR: interquartile range; FEV1: forced expiratory volume in 1 second; PEF: peak expiratory flow; BMI: body mass index; EF: ejection fraction; MELD Na: model end-stage liver disease sodium; HBV: hepatitis B virus; HCV: hepatitis C virus; HDV: hepatitis D virus; ALD: alcoholic liver disease; NASH: nonalcoholic steatohepatitis; AIH: autoimmune hepatitis; HCC: hepatocellular carcinoma; HTN: hypertension; DM: diabetes mellitus; IHD: ischemic heart disease; AKI: acute kidney injury; CKD: chronic kidney disease; COPD: chronic obstructive pulmonary disease; ILD: interstitial lung disease; IQR: interquartile range; INR: international normalized ratio.

common findings of preoperative chest imaging significantly differed between the two groups, with a higher prevalence in the OLD group ($p = 0.034$).

Patient characteristics after liver transplantation

The incidence of postoperative pulmonary complications was 91.2% in the study population; there was no significant difference in the prevalence between the RLD and OLD groups. The postoperative pulmonary complications observed in the study population were atelectasis, pleural effusion, pleural effusion with atelectasis, infiltrates, consolidation, pneumothorax, pneumoperitoneum, and nodules (Table 2). Pneumoperitoneum ($p = 0.005$) was a notable finding in recipients with OLD ($n = 1$). The most common pulmonary complications were pleural effusion (56.4%, $p = 0.444$) and pleural effusion with atelectasis (25.4%, $p = 0.391$).

Patient outcomes including duration of surgery, time on the ventilator, length of stay in the ICU, total length of stay in the hospital, HAI, postoperative graft survival, NIV dependence, reintubation rate, and mortality are outlined in Table 3.

Table 2. Postoperative pulmonary complications across the RLD and OLD groups.

	RLD (n = 189)	OLD (n = 21)	Total (n = 210)	Missing	p-value
Atelectasis, n (%)	3 (1.9)	0 (0.0)	3 (1.7)	29	0.364
Pleural effusion, n (%)	91 (56.5)	11 (55.0)	102 (56.4)	29	0.444
Pleural effusion with atelectasis, n (%)	40 (24.8)	6 (30.0)	46 (25.4)	29	0.391
Infiltrates, n (%)	11 (6.8)	1 (5.0)	12 (6.6)	29	0.425
Consolidation, n (%)	3 (1.9)	0 (0.0)	3 (1.7)	29	0.364
Pneumothorax, n (%)	1 (0.6)	1 (5.0)	2 (1.1)	29	0.082
Pneumoperitoneum, n (%)	0 (0.0)	1 (5.0)	1 (0.6)	29	0.005
Nodule, n (%)	1 (0.6)	0 (0.0)	1 (0.6)	29	0.419

RLD: restrictive lung disease; OLD: obstructive lung disease.

Table 3. Postoperative patient outcomes across the RLD and OLD groups.

	RLD (n = 189)	OLD (n = 21)	Total (n = 210)	Missing	p-value
Postoperative pulmonary complications, n (%)	145 (90.1)	20 (100)	165 (91.2)	29	0.136
Duration of surgery, hours, median (IQR)	10 (8–12)	11 (10–13)	10 (9–12)	N/A	0.082
Time on ventilator, hours, median (IQR)	18 (15–25)	20 (16–23)	18 (15–25)	N/A	0.880
Length of ICU stay, days, median (IQR)	6 (5–7)	6 (5–7)	6 (5–7)	N/A	0.676
Total length of stay in hospital, days, median (IQR)	17 (15–19)	16 (14–18)	17 (15–19)	N/A	0.180
HAI, n (%)	80 (47.3)	6 (30.0)	86 (45.5)	21	0.224
Postoperative graft survival, n (%)	168 (98.8)	20 (100.0)	188 (98.9)	20	0.650
NIV dependence, n (%)	15 (9.0)	2 (10.5)	17 (9.1)	24	0.935
Reintubation rate, n (%)	5 (3.0)	1 (5.3)	6 (3.2)	23	0.844
Postoperative mortality, n (%)	2 (1.2)	0 (0.0)	2 (1.0)	19	0.681
Arterial blood gas analysis					
pH, median (IQR)	7.36 (7.34–7.40)	7.36 (7.30–7.40)	7.36 (7.33–7.40)	N/A	0.204
pCO_2, mmHg, median (IQR)	34.4 (31.6–37.0)	37.0 (34.0–39.5)	34.5 (32.0–37.2)	N/A	0.010
SaO_2, %, median (IQR)	99.1 (98.3–99.6)	99.0 (98.5–99.5)	99.1 (98.3–99.6)	N/A	0.806
PaO_2, mmHg, median (IQR)	169.8 (114.9–222.7)	194.6 (135.4–279.6)	172.8 (118.0–229.0)	N/A	0.103
HCO_3^-, mmol/L, mean (SD)	19.6 (2.2)	19.9 (2.4)	19.6 (2.2)	N/A	0.496
Lactate, mmol/L, median (IQR)	4.3 (2.8–6.1)	3.5 (3.1–5.4)	4.17 (2.8–5.9)	N/A	0.536

RLD: restrictive lung disease; OLD: obstructive lung disease; HAI: hospital-acquired Infection; NIV: noninvasive ventilator; pCO_2: partial pressure of carbon dioxide; SaO_2: arterial oxygen saturation; PaO_2: partial pressure of arterial oxygen; HCO_3^-: bicarbonate.

No significant differences were observed in these outcomes between the RLD and OLD groups.

The incidence of HAIs, although higher in the RLD group (n = 80), was not significantly different between the two groups. The prevalence data of pathogens isolated from 83 of the 86 patients with HAI are reported in Figure 1. The most commonly reported pathogen was methicillin-resistant *Staphylococcus epidermidis* (28.9%), followed by cytomegalovirus (20.5%).

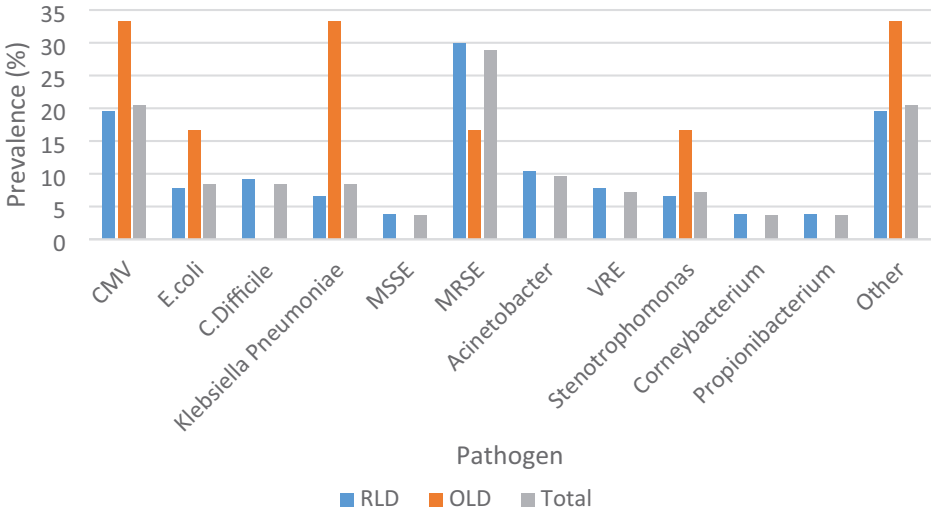

Figure 1. Prevalence of pathogens isolated from 83 patients with hospital-acquired infection (n = 86). CMV: cytomegalovirus; *E. coli*: *Escherichia coli*; *C. difficile*: *Clostridium difficile*; MSSE: methicillin-susceptible *Staphylococcus epidermidis*; MRSE: methicillin-resistant *Staphylococcus epidermidis*; VRE: vancomycin-resistant *Enterococci*; *S. maltophilia*: *Stenotrophomonas maltophilia*.

A higher number of recipients required NIV (n = 15, p = 0.935) and reintubation (n = 5, p = 0.844) after transplantation in the RLD group. Furthermore, graft survival and mortality did not differ significantly between the two groups.

Moreover, upon arrival to the ICU after transplantation, arterial blood gas analysis showed lower partial pressure of carbon dioxide (pCO_2) (p = 0.010) in the RLD group than in the OLD group (Table 3). Arterial blood pH, oxygen saturation (SaO_2), partial pressure of oxygen (PaO_2), bicarbonate level (HCO_3^-), and lactate level did not show significant differences.

Discussion

In this study, the incidence of postoperative pulmonary complications was 91.2%, which was remarkably higher than those observed in former studies by Buggs et al. (71.5%), Levesque et al. (88%), and Bozbas et al. (42.1%).[3,10,11] Similar to the reports by Bozbas et al.[11] and Levesque et al.,[3] pleural effusion was the prevalent pulmonary complication following liver transplantation in our study; however, pneumoperitoneum was prominent in the OLD group. Similar to the study by Buggs et al.,[10] this study showed no differences in time on ventilator, length of stay in the ICU, total length of stay in the hospital, graft survival, and mortality between the two groups.[10] However, Kia et al. demonstrated increased length of stay in the ICU, total length of stay in the hospital, and ventilator time in patients with RLD compared with those in normal control patients and those with OLD. Notably, the ventilator time measured by Kia et al. was reported in days, while we reported our ventilator time in hours for precision.[9] Overall, the pulmonary complications and patient outcomes were similar in both RLD and OLD groups, suggesting that postoperative management of these diseases is associated with similar risks.

In this study, the arterial blood gas analysis of the RLD group upon arrival to the

ICU showed lower pCO_2 levels. This could be attributed to intraoperative factors such as intraoperative mechanical ventilation, which was not measured in this study.

All liver transplantation recipients in our study were South Asians, particularly Pakistani. Demographically, Kia et al.[9] and Levesque et al.[3] had higher female representation; however, the present study had more male patients (81%), similar to the study by Buggs et al. (87%).[10] Patient age and BMI were not significantly different between the two groups in our study. Smoking was common in the OLD group, where recipients reported a higher number of pack years. Smoking was also prevalent in the OLD group in the study by Kia et al.,[9] with approximately 26% of recipients reporting a history of smoking. This is remarkably lower than that reported by Bozbas et al. (45.6%)[11] and Kia et al. (66.7%).[9]

Similar to the report by Kia et al. and Levesque et al., a higher number of recipients in the RLD group had ascites ($n = 135$) preoperatively.[3,9] The MELD Na score was also higher in the RLD group. Previous studies have considered the MELD score; Kia et al. reported higher MELD scores in the RLD group.[9] However, Buggs et al. did not observe any substantial difference in the MELD scores between the two groups in their study.[10]

Pleural effusion with atelectasis was a common finding in preoperative chest imaging in the RLD group. However, previous studies have reported only pleural effusion to be prevalent in patients with RLD preoperatively.[3,9] Other less common findings (interstitial changes, congestion, bronchiectasis, and hyperinflation) on chest imaging were more frequent in liver transplantation recipients with OLD. Additionally, as asthma is an OLD, it was a common comorbidity in the OLD group, similar to the report by Kia et al.[9] Contrary to the studies by Kia et al. and Levesque et al., the preoperative albumin level, total bilirubin, and INR did not significantly differ between the OLD and RLD groups.[3,9]

This was a single-center study. Therefore, the lack of diversity may have greatly limited our study results. The use of convenient and selective sampling could have introduced bias during data collection. As in previous studies by Kia et al. and Levesque et al., the representation of patients with OLD was considerably lower.[3,9] Therefore, further studies are needed on liver transplantation recipients with obstructive lung disease to truly assess the impact of obstruction on postoperative pulmonary complications and patient outcomes.

This study established the evidence regarding the effects of abnormal preoperative spirometry on the outcomes of liver transplantation recipients in Pakistan. However, more research is warranted to assess the impact of abnormalities in spirometry and other PFTs after liver transplantation.

Conclusion

PFTs are preoperative investigation methods to help assess the postoperative risk of complications in major abdominal surgeries, such as liver transplantation. The incidence of pulmonary complications was 91.2% after liver transplantation in patients with abnormal preoperative spirometry. The pulmonary complications identified in the study population were atelectasis, pleural effusion, pleural effusion with atelectasis, infiltrates, consolidation, pneumothorax, pneumoperitoneum, and nodules. Patients with RLD and OLD experienced similar effects in terms of pulmonary complications and patient outcomes. This suggests that both diseases can be managed similarly in clinical practice, especially in the Pakistani population. However, as the OLD group was underrepresented in this study, further

research is needed to determine the effects of OLD on liver transplantation outcomes.

Acknowledgements

The authors thank Dr. Aftab Akhtar (Consultant Pulmonology and Principal Investigator) and Dr. Hajira Bukhari (Fellow Critical Care Medicine and Supervisor), the Liver Transplantation department, and Medical Record of Shifa International Hospital, Islamabad, Pakistan.

Author contributions

Rashid Iqbal: supervision, design of the research methodology, review and editing; Sunaina Khan: data analysis, draft writing, abstract writing, and manuscript preparation; Alishba Zainab: data collection, data entry, review and editing; and Sapna Amin: draft writing and data collection.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Data availability statement

The data were collected via a review of medical records. As individual consent could not be obtained, the study data cannot be shared, respecting the privacy and confidentiality of patient data.

Declaration of conflicting interests

Authors declare that there is no conflict of interest related to this study.

Ethical considerations

This study was approved by the Shifa International Hospitals Ltd. Institutional Review Board & Ethics Committee (approval no. 0216-23) on 20 July 2023.

Funding

This research did not receive any financial support from any source.

ORCID iD

Sunaina Khan https://orcid.org/0009-0002-2051-022X

References

1. O'Leary JG, Lepe R and Davis GL. Indications for liver transplantation. *Gastroenterology* 2008; 134: 1764–1776.
2. Zanetto A, Shalaby S, Gambato M, et al. New indications for liver transplantation. *J Clin Med* 2021; 10: 3867.
3. Levesque E, Hoti E, Azoulay D, et al. Pulmonary complications after elective liver transplantation—incidence, risk factors, and outcome. *Transplantation* 2012; 94: 532–538.
4. Feltracco P, Carollo C, Barbieri S, et al. Early respiratory complications after liver transplantation. *World J Gastroenterol* 2013; 19: 9271–9281.
5. Cardoso FS and Karvellas CJ. Respiratory complications before and after liver transplant. *J Intensive Care Med* 2019; 34: 355–363.
6. Glanemann M, Kaisers U, Langrehr JM, et al. Incidence and indications for reintubation during postoperative care following orthotopic liver transplantation. *J Clin Anesth* 2001; 13: 377–382.
7. Graham BL, Steenbruggen I, Miller MR, et al. Standardization of spirometry 2019 update. An official American thoracic society and European respiratory society technical statement. *Am J Respir Crit Care Med* 2019; 200: e70–e88.
8. Stanojevic S, Kaminsky DA, Miller MR, et al. ERS/ATS technical standard on interpretive strategies for routine lung function tests. *Eur Respir J* 2022; 60: 2101499.
9. Kia L, Cuttica MJ, Yang A, et al. The utility of pulmonary function testing in predicting outcomes following liver transplantation. *Liver Transpl* 2016; 22: 805–811.
10. Buggs J, LaGoy M, Ermekbaeva A, et al. Cost utilization and the use of pulmonary function tests in preoperative liver transplant patients. *Am Surg* 2020; 86: 996–1000.
11. Bozbas SS, Eyuboglu FO, Sevmis S, et al. Pulmonary complications and mortality after liver transplant. *Exp Clin Transplant* 2008; 6: 264–270.

12. Sullivan KM, Dean A, Soe MM, et al. OpenEpi: a web-based epidemiologic and statistical calculator for public health. *Public Health Rep* 2009; 124: 471–474.
13. Vandenbroucke JP, von Elm E, Altman DG; STROBE Initiative, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. *PLoS Med* 2007; 4: e297.
14. Haynes JM. Basic spirometry testing and interpretation for the primary care provider. *CJRT* 2018; 54: 92–98.