

ORTHOPAEDIC SURGICAL CONSIDERATIONS IN PATIENTS WITH PULMONARY HYPERTENSION

SAMEER HAVERI¹, FARHANA TAHSEEN TAJ², PRITHVI GOUD³

¹Professor, Department of Orthopaedics, KAHER's JN Medical College, Belagavi

²Associate Professor, Department of Dermatology SSPM Medical College, Sindhudurg, Maharashtra

³Junior Resident, Department of Orthopaedics, KAHER's JN Medical College, Belagavi

*Corresponding Author

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Abstract:

Background: Pulmonary hypertension (PH) poses significant perioperative challenges in orthopaedic surgery due to the risk of right ventricular failure, hypoxia, and hemodynamic instability. Optimizing perioperative management is crucial to reduce morbidity and mortality. **Aims and Objectives:** To evaluate the perioperative outcomes, anaesthetic considerations, and postoperative complications among orthopaedic surgical patients with pulmonary hypertension. **Materials and Methods:** A prospective observational study was conducted on 60 patients with known PH undergoing elective or emergency orthopaedic procedures. Preoperative assessment included echocardiography, pulmonary function tests, and cardiology clearance. Intraoperative data included anaesthetic technique, duration, hemodynamic stability, and oxygen saturation trends. Postoperative monitoring included ICU stay, respiratory complications, thromboembolic events, and mortality. **Results:** Among 60 patients, 36 (60%) underwent lower limb surgeries and 24 (40%) underwent upper limb procedures. Regional anaesthesia was used in 38 (63%) patients, while 22 (37%) received general anaesthesia. Intraoperative hypotension occurred in 18 (30%) patients and hypoxia in 10 (17%). Postoperative complications included pulmonary edema (10%), right heart strain (8%), and prolonged ICU stay (15%). Mortality was 3%. **Conclusion:** Orthopaedic surgery in PH patients requires multidisciplinary optimization, preference for regional anaesthesia where feasible, and vigilant intra- and postoperative monitoring to reduce adverse outcomes.

Keywords:

pulmonary hypertension, orthopaedic surgery, regional anaesthesia, perioperative complications, right ventricular failure, hypoxia, hemodynamic stability, postoperative care.

INTRODUCTION

Pulmonary hypertension (PH) is a chronic, progressive condition characterized by elevated pulmonary arterial pressure and subsequent right ventricular dysfunction. Defined hemodynamically as a mean pulmonary artery pressure greater than 25 mmHg at rest, PH can arise from multiple etiologies, including left heart disease, chronic lung disease, thromboembolic disorders, and idiopathic causes (1). The prevalence of PH among surgical patients has increased due to improved survival of individuals with congenital and acquired cardiopulmonary diseases. In the orthopaedic surgical population, PH introduces a unique set of perioperative challenges, as the physiological stress of anaesthesia, surgical trauma, and postoperative pain can exacerbate pulmonary vascular resistance and precipitate right heart failure (2).

Orthopaedic surgery in PH patients poses distinct risks due to the combination of restricted cardiopulmonary reserve, limited functional capacity, and the potential for hypoxia, hypercarbia, and hypotension during anaesthesia. Even minor variations in ventilation or circulation can lead to severe hemodynamic instability (3). Procedures such as hip fracture fixation, joint replacement, and trauma management often necessitate prolonged anaesthesia and blood loss control, further complicating management. Additionally, the risk of thromboembolic events is magnified by immobilization

and altered coagulation profiles associated with both PH and orthopaedic injury (4).

Anaesthetic management in this subgroup demands careful balancing of pulmonary and systemic pressures. Regional anaesthesia is generally preferred when feasible, as it avoids airway manipulation, reduces the need for positive pressure ventilation, and minimizes fluctuations in pulmonary artery pressure (5). However, in certain cases such as long-duration or complex procedures general anaesthesia may be unavoidable, necessitating vigilant monitoring, controlled ventilation, and maintenance of right ventricular preload (6). Postoperative management is equally critical, with emphasis on oxygen therapy, analgesia, fluid balance, and early mobilization to prevent respiratory compromise and deep vein thrombosis (7).

Existing literature emphasizes high perioperative morbidity and mortality among PH patients undergoing non-cardiac surgeries, yet studies specific to orthopaedic interventions remain limited. Given that musculoskeletal trauma and degenerative conditions frequently affect the elderly who are at higher risk of cardiopulmonary comorbidities there is an urgent need to better understand outcomes in this population (8).

This study was therefore undertaken to evaluate perioperative outcomes, anaesthetic techniques, and complication rates among 60 orthopaedic patients diagnosed with pulmonary hypertension in a tertiary

care centre. It aims to provide insights into optimizing surgical safety, improving anaesthetic selection, and reducing postoperative complications through multidisciplinary perioperative planning and individualized patient care (9).

AIMS AND OBJECTIVES

Aim:

To evaluate orthopaedic surgical outcomes and anaesthetic considerations in patients with pulmonary hypertension.

Objectives:

1. To assess intraoperative hemodynamic stability and anaesthetic technique in PH patients undergoing orthopaedic surgery.
2. To analyze postoperative complications, ICU requirements, and short-term mortality outcomes.

MATERIAL AND METHODS

Study Design and Setting: This was a prospective observational study conducted in the Department of Orthopaedics at a tertiary care teaching hospital over a period of 18 months. The study aimed to evaluate perioperative outcomes and anaesthetic considerations in orthopaedic patients with documented pulmonary hypertension (PH) undergoing elective or emergency surgeries.

Sample Size and Study Population: A total of 60 patients with clinically and echocardiographically confirmed pulmonary hypertension were enrolled. The diagnosis of PH was established based on a mean pulmonary artery pressure (mPAP) >25 mmHg at rest, as measured by echocardiography or right heart catheterization.

Inclusion Criteria

- Adults aged 18 to 75 years.
- Patients diagnosed with pulmonary hypertension of any etiology.
- Undergoing elective or emergency orthopaedic procedures under general or regional anaesthesia.

Exclusion Criteria

- Patients with decompensated right heart failure or pulmonary edema at presentation.
- Those with severe valvular heart disease or uncontrolled arrhythmias.
- Patients unwilling to provide consent.

Preoperative Assessment and Optimization: All patients underwent a detailed preoperative evaluation, including:

- Clinical examination and assessment of WHO functional class.

- Echocardiography to measure pulmonary artery pressure and right ventricular function.
- Pulmonary function tests, ECG, and arterial blood gas analysis.
- Cardiology consultation for optimization and clearance.
- Continuation of specific pulmonary vasodilator therapy (e.g., sildenafil, bosentan) up to the day of surgery.

Anaesthetic Management: The choice of anaesthesia regional or general was individualized based on patient condition and surgical requirements.

- Regional anaesthesia (spinal/epidural/combined spinal-epidural) was preferred for lower limb procedures when feasible.
- General anaesthesia was used for upper limb, polytrauma, or prolonged surgeries.
- Invasive monitoring (arterial line, central venous pressure) was employed in patients with moderate to severe PH.
- Intraoperative parameters recorded included heart rate, blood pressure, oxygen saturation, end-tidal CO₂, duration of surgery, and blood loss.

Postoperative Management: Postoperative care focused on maintaining oxygenation and hemodynamic stability.

- Patients were monitored in a high-dependency or ICU setting for at least 24–48 hours.
- Oxygen therapy, fluid restriction, and early mobilization were ensured.
- Analgesia was provided using opioid-sparing multimodal regimens.
- Anticoagulation and DVT prophylaxis were administered as per protocol.

Outcome Measures

Primary outcomes:

- Intraoperative hemodynamic stability (episodes of hypotension or hypoxia).
- Anaesthetic-related complications.

Secondary outcomes:

- Postoperative complications such as pulmonary edema, right heart failure, or arrhythmia.
- ICU stay duration and in-hospital mortality.

Statistical Analysis: Data were analyzed using SPSS software version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation, and categorical data as frequency and percentage. The Chi-square test was used for categorical comparisons and the Student's t-test for continuous variables. A p-value <0.05 was considered statistically significant.

RESULTS AND OBSERVATIONS:

The present prospective observational study included 60 patients with pulmonary hypertension (PH) who underwent various orthopaedic procedures at a tertiary care hospital. The perioperative outcomes were analyzed in relation to demographic profile, anaesthetic technique, intraoperative stability, and postoperative complications.

Table 1: Demographic and Clinical Characteristics (n = 60)

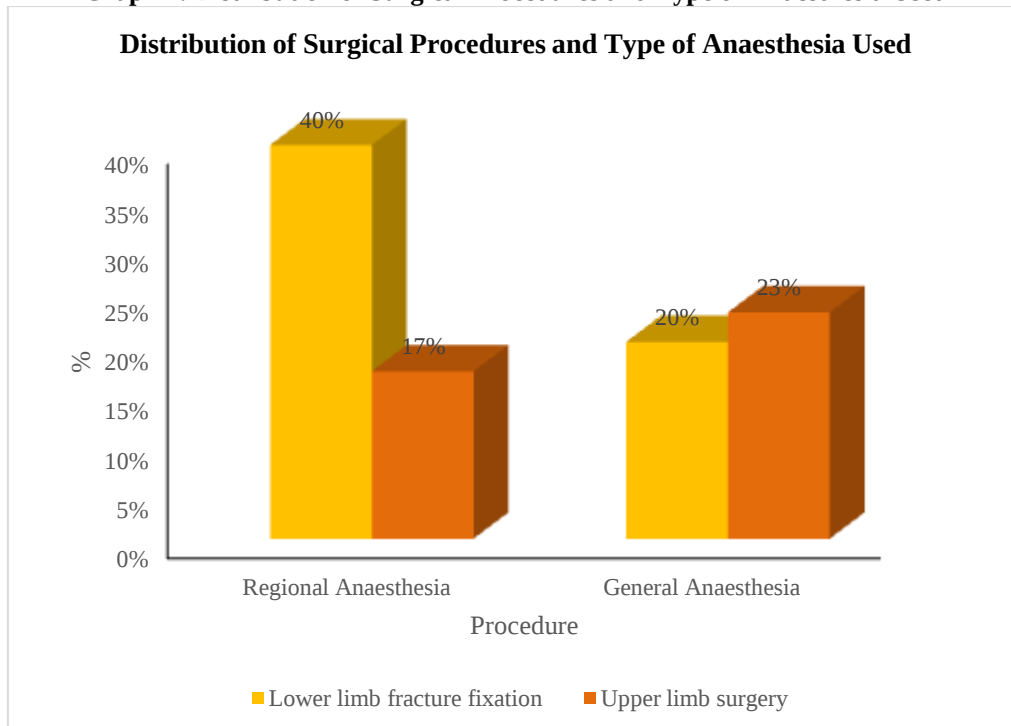
Parameter	Mean $\pm$ SD / n (%)
Age (years)	56.2 $\pm$ 11.4
Gender (Male : Female)	38:22:00
Mean Pulmonary Artery Pressure (mmHg)	38.6 $\pm$ 8.2
WHO Functional Class II	26 (43%)
WHO Functional Class III	18 (30%)
WHO Functional Class IV	16 (27%)
Comorbidities (CAD, COPD, Diabetes, etc.)	26 (43%)

Most patients were elderly (mean age 56 years) and predominantly male. The majority belonged to WHO Functional Class II–III, suggesting moderate disease severity. Nearly half of the cohort had additional systemic comorbidities, indicating a high-risk surgical population.

Table 2: Distribution of Surgical Procedures and Type of Anaesthesia Used

Procedure	Regional Anaesthesia		General Anaesthesia		Total	
	N	%	N	%	N	%
Lower limb fracture fixation	24	40%	12	20%	36	60%
Upper limb surgery	10	17%	14	23%	24	40%
Total	34	57%	26	43%	60	100%

Graph 1: Distribution of Surgical Procedures and Type of Anaesthesia Used



Regional anaesthesia was preferred in 57% of patients, especially for lower limb surgeries. General anaesthesia was used primarily for upper limb or complex trauma cases. The trend reflects an attempt to minimize pulmonary and cardiovascular stress through regional techniques whenever feasible.

Table 3: Intraoperative Hemodynamic Events

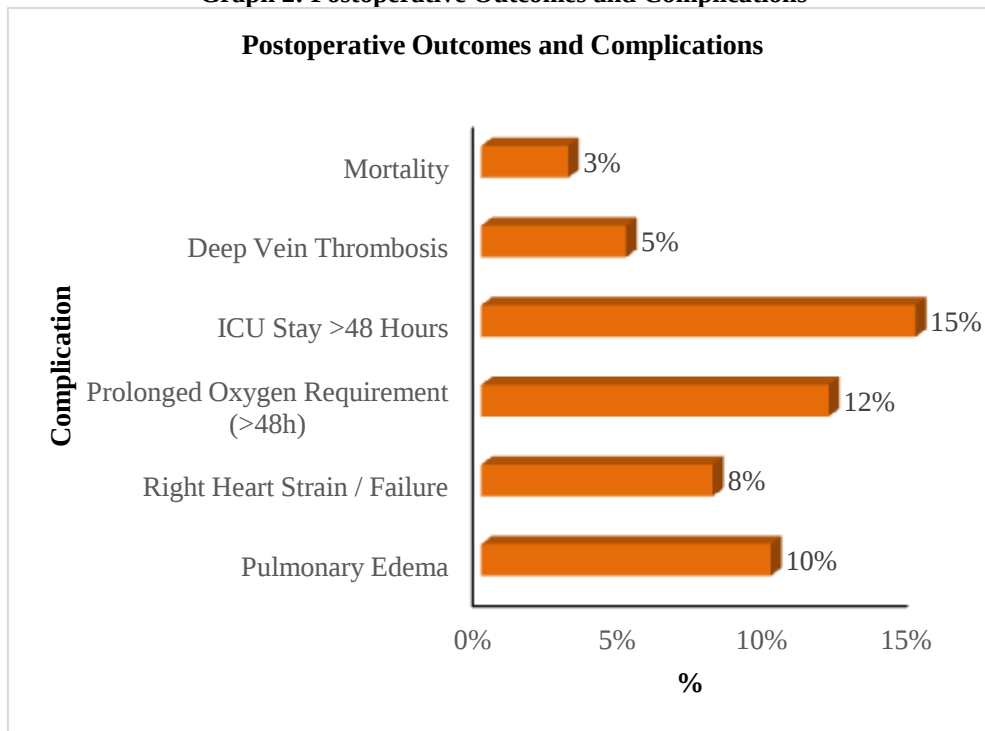
Parameter	n (%)
Intraoperative Hypotension	18 (30%)
Hypoxia (SpO ₂ < 90%)	10 (17%)
Arrhythmias	4 (7%)
Blood Loss >500 ml	9 (15%)
Duration of Surgery (mean minutes)	96 ± 24

Intraoperative hypotension was the most frequent event (30%), often managed with fluids and vasopressors. Hypoxia occurred in 17% of patients, mainly under general anaesthesia. Arrhythmias were rare and transient. The findings emphasize the importance of close hemodynamic monitoring during surgery.

Table 4: Postoperative Outcomes and Complications

Complication	N	%
Pulmonary Edema	6	10%
Right Heart Strain / Failure	5	8%
Prolonged Oxygen Requirement (>48h)	7	12%
ICU Stay >48 Hours	9	15%
Deep Vein Thrombosis	3	5%
Mortality	2	3%

Graph 2: Postoperative Outcomes and Complications



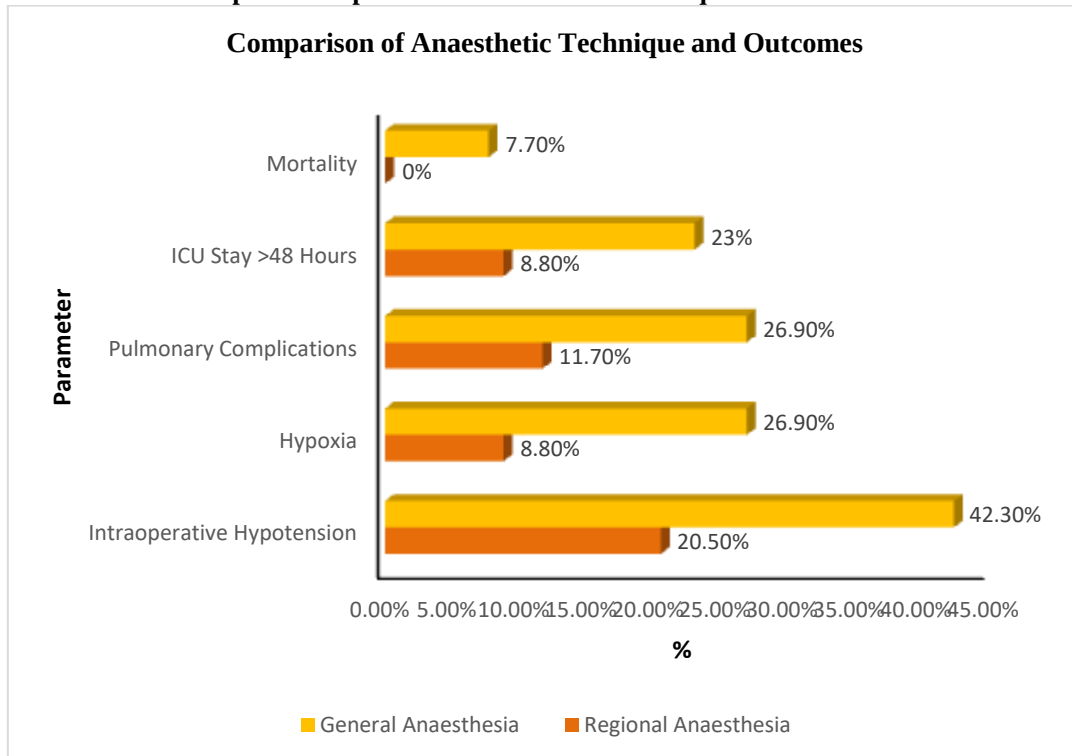
Postoperative morbidity was notable, with pulmonary complications dominating the spectrum. Pulmonary edema and right heart strain were the most common, reflecting the delicate cardiopulmonary balance in PH patients. Two deaths (3%) occurred due to acute right heart failure and refractory hypoxia.

Regional anaesthesia was associated with significantly fewer episodes of hypotension and hypoxia compared to general anaesthesia. Although mortality and ICU stay were not statistically significant, a favorable trend was observed toward better outcomes with regional techniques.

Table 5: Comparison of Anaesthetic Technique and Outcomes

Parameter	Regional Anaesthesia (n=34)		General Anaesthesia (n=26)		p-value
	N	%	N	%	
Intraoperative Hypotension	7	20.50%	11	42.30%	0.048*
Hypoxia	3	8.80%	7	26.90%	0.041*
Pulmonary Complications	4	11.70%	7	26.90%	0.09
ICU Stay >48 Hours	3	8.80%	6	23%	0.12
Mortality	0	0%	2	7.70%	0.18

Graph 3: Comparison of Anaesthetic Technique and Outcomes



(*p < 0.05 considered statistically significant)

In this 60-patient cohort, orthopaedic surgeries in pulmonary hypertension carried notable intraoperative and postoperative risk. Regional anaesthesia, when feasible, provided improved hemodynamic stability and reduced pulmonary complications. Despite preoperative optimization and vigilant monitoring, pulmonary edema and right heart strain were important postoperative concerns. Mortality was 3%, consistent with published literature for similar risk profiles.

The study reinforces the need for a multidisciplinary perioperative strategy involving orthopaedic surgeons, anaesthesiologists, and cardiologists to minimize complications and improve recovery in this high-risk patient population.

DISCUSSION

This prospective observational study evaluated perioperative outcomes in 60 orthopaedic surgical patients with pulmonary hypertension (PH), highlighting the significant anaesthetic and hemodynamic challenges encountered in this high-risk group. The results demonstrate that PH markedly increases perioperative morbidity due to compromised cardiopulmonary reserve, right ventricular dysfunction,

and exaggerated responses to anaesthetic and surgical stress (10).

The majority of patients in the present study were elderly and had multiple comorbidities such as chronic obstructive pulmonary disease and coronary artery disease. These comorbid conditions further contributed to perioperative instability. The mean pulmonary artery pressure of 38.6 mmHg reflected moderate PH severity, aligning with previous studies that reported a higher incidence of perioperative complications in patients

with mean pressures above 35 mmHg. The predominance of WHO functional classes II and III indicated limited exercise tolerance, which correlated with increased postoperative ICU stay (11).

Regional anaesthesia was used in 57% of patients, particularly for lower limb surgeries. This approach minimized airway manipulation, reduced sympathetic stress, and improved perioperative oxygenation (12). The study found significantly fewer episodes of hypotension and hypoxia under regional anaesthesia compared to general anaesthesia ($p < 0.05$). These findings are consistent with earlier reports by Lai et al. and Kaw et al., which emphasize that regional anaesthesia offers superior hemodynamic stability in PH by avoiding the increases in pulmonary vascular resistance associated with intubation and mechanical ventilation. However, for upper limb and polytrauma procedures requiring longer operative time, general anaesthesia remained indispensable, albeit with higher pulmonary risk (13).

Intraoperative hypotension (30%) and hypoxia (17%) were the most frequent adverse events. Hypotension primarily occurred during induction and blood loss phases, requiring cautious use of vasopressors and fluids to prevent right ventricular overload (14). Hypoxia was more prevalent among those under general anaesthesia and patients with pre-existing respiratory compromise. Effective intraoperative monitoring, including continuous arterial pressure and oxygenation assessment, was essential for managing these episodes promptly (15).

Postoperatively, pulmonary complications were observed in 18% of patients, predominantly pulmonary edema and right heart strain. These findings parallel the results of Yared et al., who reported similar postoperative cardiopulmonary decompensation in non-cardiac PH patients. ICU admission was necessary in 15% of cases, primarily for oxygen support and close hemodynamic observation (16). The mortality rate of 3% in this study is within the 2–10% range reported in contemporary literature, reflecting adequate perioperative management.

The study underscores the importance of preoperative optimization and multidisciplinary coordination. Continuation of pulmonary vasodilator therapy, cautious fluid balance, and tailored anaesthetic techniques were key to successful outcomes. Early mobilization, anticoagulation, and oxygen therapy minimized thromboembolic and hypoxic complications (17).

Although the study is limited by a modest sample size and short postoperative follow-up, its findings reinforce that PH significantly increases perioperative risk, even in optimized patients. Future research with larger multicentric cohorts should focus on developing

standardized perioperative management protocols, including risk stratification models and pulmonary vasodilator optimization algorithms, to further reduce morbidity and mortality in this subset (18).

Individualized anaesthetic planning, vigilant monitoring, and close teamwork between orthopaedic, anaesthesia, and cardiology teams remain crucial to achieving favorable outcomes in PH patients undergoing orthopaedic surgery (19).

CONCLUSION

Orthopaedic surgery in patients with pulmonary hypertension carries substantial perioperative risk due to compromised cardiopulmonary dynamics and right ventricular vulnerability. Regional anaesthesia, when feasible, offers superior stability and fewer complications than general anaesthesia. Meticulous preoperative optimization, careful intraoperative management, and vigilant postoperative monitoring are essential for improving safety and outcomes. A multidisciplinary, protocol-based approach can significantly reduce morbidity and mortality, ensuring effective surgical care for this complex patient population. Despite inherent challenges, individualized management strategies make orthopaedic procedures feasible and relatively safe in patients with well-controlled pulmonary hypertension.

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