Dissertation on

"EVALUATION OF EFFECT OF LUNG RECRUITMENT MANOEUVRES ON PERIOPERATIVE ATELECTASIS IN LAPROSCOPIC CHOLECYSTECTOMIES: A RANDOMISED CONTROLLED TRIAL."

By

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Dissertation submitted to the

BLDE (DEEMED TO BE UNIVERSITY)

VIJAYAPURA, KARNATAKA

In Partial fulfilment of requirements for the degree of

MASTER OF MEDICINE

In

ANAESTHESIOLOGY

Under the guidance of

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ACKNOWLEDGEMENT

Completing this contribution to the scientific document gives me immense pleasure in acknowledging the guidance provided by my distinguished mentors. With all due privilege and respect, I would like to express my gratitude and indebtedness to my guide, Dr. Vidya Patil, Professor, Department of Anesthesiology, BLDE, Deemed to be the University's Shri. B. M. Patil Medical College, Hospital and Research Centre Vijayapura, for her constant inspiration, extensive encouragement and support, which she rendered in pursuit of my postgraduate studies and in preparing this dissertation. I am incredibly grateful to my eminent and esteemed teacher Dr. Renuka Hoylachi, Professor and Head, Department of Anesthesiology, BLDE Deemed to be University's Shri. B.M. Patil Medical College, Vijayapura, for her guidance and inspiration during my study. I am forever grateful to Dr. Vijaykumar T. K, Dr. Vijay Katti, Dr. Shivanand L K, Dr. Basavaraj Patil, Dr. Prathiba, Dr. Santosh K, Dr. Mala Nair, Dr. Anusha, Dr. Santosh A and Dr. Rahul, Dr Milind, Dr Deepa, Dr. Nandini, Dr Jyoti, Dr Rizwana and Dr. Sai Krishna for their valuable help and guidance during my study. I would also like to express my gratitude to my Co-Guide Dr. M M Patil Professor and Head, Department of pediatrics, BLDE Deemed to be University's Shri B M Patil Medical College Hospital and Research centre, Vijayapura for his guidance for my study. I am incredibly thankful to the Principal of BLDE, Deemed to be the University's Shri. B. M. Patil Medical College Hospital and Research Centre, Vijayapura, for permitting me to utilise the resources to complete my work.

I am deeply indebted to my Parents, Dr. Dilip Kumar and Mrs. Babli Gorain, my brothers Abhijeet Kumar and Rohit Kumar whose constant encouragement and inspiration led me to complete my dissertation work successfully. I thank Almighty for their blessings in making this work possible and for their grace in strengthening me throughout my course.

I am also thankful to my colleagues Dr. Prabhu, Dr. Sandra, Dr. Priyadharshini V., Dr. B Vaishnavi, Dr. Mourya, Dr. Thaskin, Dr. Samatha, Dr. Radhika, Dr. Sankar, Dr. Arya, Dr. Suman, Dr, Sesha sai and all my junior colleagues for their support, suggestions and advice. I express my gratitude to the Library, Anaesthesia, OT, and Hospital Staff for their cooperation in my study.

Last but not least, I convey my heartfelt gratitude to all the patients; without whose cooperation, this study would be incomplete.

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LIST OF ABBREVATION

LRM: Lung Recruitment manoeuvre

PEEP: Positive End-Expiratory Pressure

FRC: Functional Residual Capacity

PPCs: Postoperative pulmonary complications

ARDS: Acute Respiratory Distress syndrome

LUS: Lung Ultrasound

RCTs: Randomised Controlled Trials

FiO_2: Fraction of Inspired Oxygen

COPD: Chronic Obstructive Pulmonary Disease

CO_2: Carbon Dioxide

PIP: Peak Inspiratory Pressure

VILI: Ventilator Induced Lung Injury

ALI: Acute Lung Injury

ICU: Intensive Care Unit

V/Q: Ventilation Perfusion mismatch

PVR: Pulmonary Vascular Resistance

HPV: Hypoxic Pulmonary Vasoconstriction

EIT: Electrical Impedance Tomography

PCV: Pressure Controlled Ventilation

VCV: Volume Controlled Ventilation

PaO_2: Partial Arterial Oxygentation

LIST OF GRAPHS AND FIGURES

ABSTRACT

BACKGROUND:
Approximately 90% of patients undergoing general anesthesia encounter atelectasis, especially after laparoscopic cholecystectomy. Pneumoperitoneum during laparoscopic surgeries significantly hinders pulmonary function, leading to notable atelectasis. The lung recruitment maneuver may mitigate hypoxia caused by atelectasis and minimize postoperative pulmonary complications.

METHODS:
Patient selection was randomized; Group UC did not receive lung recruitment, while Group URM did. All patients underwent ultrasonography at four time points: T1 - just before anaesthesia induction, T2 - post-surgery, T3 - 15 minutes post-extubation, and T4 - 30 minutes post-extubation. Only participants from the URM group received lung recruitment, which was guided by real-time ultrasound. Ultrasonic scanning indicated the absence of collapsed areas following manual adjustment of airway pressure from 10 cmH2O to 20 cmH2O, with a FiO2 of 0.4. Every patient received lung ultrasonography at 15 (T3) and 30 (T4) minutes following extubation to evaluate persistent atelectrauma and desaturation.

CONCLUSION:
At T3 and T4, the URM group exhibited a significantly reduced aeration loss of 22% and 51%, respectively, when compared to the UC group, which showed losses of 53% and 87% ($p < 0.01$). The URM group exhibited better oxygenation post-surgery compared to the UC group, with mean SpO_2 values of 98.10 ± 1.744% versus 94.54 ± 1.286% ($p = 0.001$). The increased alveolar recruitment and gas exchange in the URM group accounted for this outcome. In conclusion, the utilization of ultrasound for facilitating lung recruitment techniques may decrease atelectasis during surgeries, improve oxygenation, and result in enhanced pulmonary outcomes in laparoscopic cholecystectomy.

Keywords: Perioperative Atelectasis, Lung Recruitment Manouevre, Laproscopic Cholecystectomy

INTRODUCTION

Atelectasis, a common postoperative pulmonary complication, is seen in nearly 90% of patients who receive general anesthesia, particularly for laparoscopic cholecystectomy. Alveoli collapse leads to decreased lung compliance, impaired oxygenation, increased pulmonary vascular resistance, and the potential for lung injury. The pathophysiological mechanisms underpinning perioperative atelectasis include absorption, compression atelectasis, and surfactant dysfunction, which exacerbate postoperative pulmonary complications. Given its far-reaching implications, effective preventive strategies, such as lung recruitment manoeuvres (LRM), have gained prominence in anaesthesia management.

Lung recruitment maneuvers are useful to improve postoperative pulmonary function after procedures with a high risk of atelectasis. This type of maneuver helps open up collapsed lung tissue, which helps improve oxygenation. There are multiple approaches to lung recruitment. One technique involves applying positive end-expiratory pressure (PEEP) at higher-than-usual settings. The higher pressures help open the collapsed alveoli. Another method involves taking a deep breath and inflating the lungs to their maximum capacity. Lung recruitment maneuvers can also be done passively by applying positive pressure to the airways via a mechanical ventilator.

In addition to reducing atelectasis, LRM improve oxygenation. By doing so, they help patients recover from surgery quicklyand also reduces the length of hospital stays, which helps patients get back to their routine and activities more quickly.

Lung recruitment manoeuvres, characterised by temporary elevations in airway pressure during mechanical ventilation, are designed to reopen closed alveoli, improving oxygenation and pulmonary mechanics.[7] Implementing these approaches continues to be an area of investigation, although in-depth research in such strategies is ongoing, including progressive PEEP (positive end-expiratory pressure) titration and persistent inflation.[8,9] The advancement of ultrasound-guided lung recruitment maneuvres enables a non-invasive, accurate real-time evaluation of alveolar collapse and atelectrauma.[10,11]

The significance of precisely detecting atelectasis, particularly during laparoscopic procedures, is amplified due to its adverse effects on pulmonary function caused by pneumoperitoneum. Research studies suggest that increased intra-abdominal pressure reduces functional residual capacity (FRC) and contributes to the onset of atelectasis in dependent areas.[12] Studies suggest that LRM effectively prevents atelectrauma, reducing hypoxia and postoperative pulmonary issues.[13]

The pathophysiology of atelectasis involves several mechanisms, mainly absorption and compression, and leads to surfactant insufficiency.[14] Absorption atelectasis occurs when oxygen replaces nitrogen in the alveoli, leading to their collapse due to fast absorption.[15] Compression atelectasis develops when external pressure is applied to alveoli due to pneumoperitoneum, the Trendelenburg posture, and diminished diaphragmatic mobility.[16] Surfactant failure, sometimes exacerbated by anaesthesia, leads to alveolar instability and subsequent progressive alveolar collapse.[17]

Atelectasis leads to increased pulmonary shunting, ventilation-perfusion mismatch, reduced lung compliance, and impaired gas exchange, all of which predispose patients to postoperative hypoxemia and respiratory complications [18,19]. Studies have demonstrated a direct correlation between the extent of perioperative atelectasis and the incidence of postoperative pulmonary complications (PPCs), including pneumonia, prolonged mechanical ventilation, and acute respiratory distress syndrome (ARDS) [20,21].

LRM is a lung-protective ventilation strategy which restores alveolar patency and improves perioperative oxygenation.[22] Two principal methods of LRM are—sustained inflation and stepwise PEEP recruitment—which have been explored for efficacy in perioperative settings [23].

Sustained inflation is a method which involves a single, high-pressure breath (30–40 cmH2O) maintained for 10–30 seconds, effectively re-expanding collapsed alveoli [24].

Stepwise PEEP recruitment, an alternative approach, entails incremental increases in PEEP levels (starting at 5 cmH2O, increasing to 15 cmH2O or more) to optimise alveolar recruitment while maintaining hemodynamic stability [25].

A meta-analysis by Luo et al. (2020) found that stepwise PEEP recruitment was superior to sustained inflation in maintaining oxygenation and reducing postoperative atelectasis [26].

Ultrasound lung imaging has emerged as a rapid, radiation-free, and highly sensitive method for detecting perioperative atelectasis [27]. Lung ultrasound (LUS) facilitates real-time monitoring of recruitment efficacy, allowing individualised titration of PEEP and inspiratory pressures [28].

Studies comparing ultrasound-guided LRM with conventional LRM have demonstrated that the former results in superior alveolar recruitment, reduced atelectasis severity, and improved oxygenation [29, 30]. Lee et al. (2020) reported that ultrasound-guided lung recruitment reduced postoperative atelectasis incidence by 30% compared to conventional methods [31].

Clinical Evidence Supporting Lung Recruitment in Laparoscopic Surgery

Several randomised controlled trials (RCTs) have evaluated the role of LRM in laparoscopic cholecystectomy. Wu et al. (2022) found that ultrasound-guided LRM significantly reduced aeration loss and improved intraoperative oxygenation in laparoscopic gynaecological surgeries [32]. Similarly, Shono et al. (2020) reported that higher PEEP levels (15 cmH_2O) improved regional ventilation and maintained lung mechanics during pneumoperitoneum [33].

Rationale for the Present Study

The current study aims to evaluate the efficacy of ultrasound-guided LRM in perioperative atelectasis prevention in laparoscopic cholecystectomy, comparing it with conventional approaches regarding oxygenation, pulmonary mechanics, and postoperative complications.

Atelectasis remains a primary perioperative concern, with significant implications for patient recovery and postoperative pulmonary function. Lung recruitment manoeuvres, particularly ultrasound-guided approaches, offer a promising intervention for reducing atelectasis and improving oxygenation. This study seeks to provide robust clinical evidence on the effectiveness of ultrasound-guided lung recruitment in laparoscopic cholecystectomy, thereby contributing to optimising perioperative ventilation strategies.

AIM AND OBJECTIVES

Aim:

To assess the effects of a lung recruitment maneuver as a lung-protective ventilation strategy in patients undergoing laparoscopic cholecystectomy under general anesthesia.

Primary Objectives:

1. To diagnose atelectasis and evaluate the extent of aeration loss.
2. To use ultrasound findings to guide the recruitment maneuver, thereby minimizing postoperative aeration loss and the resulting desaturation.

Secondary Objectives:

1. To compare the presence of B-lines and lung ultrasound scores between both groups in the immediate postoperative period.
2. To evaluate the effects of the recruitment maneuver on hemodynamics.

REVIEW OF LITERATURE

Introduction to Perioperative Atelectasis

Atelectasis is a common pulmonary complication that can occur during the perioperative period. It is characterized by the collapse of alveoli, which leads to impaired gas exchange and hypoxemia. This condition is particularly prevalent in patients undergoing general anesthesia, but the rates are even higher in those undergoing laparoscopic surgeries, significantly affecting perioperative outcomes. Atelectasis also increases the risk of postoperative pulmonary complications, extended hospital stays, and the likelihood of requiring admission to the intensive care unit. Understanding the underlying pathophysiology and mechanisms contributing to perioperative atelectasis is essential for implementing effective lung-protective strategies that aim to improve patient outcomes.

1.1 Definition and Pathophysiology of Atelectasis

Atelectasis is characterized by the partial or complete collapse of alveoli, resulting in a loss of lung volume and an elevated risk of hypoxemia and ventilation-perfusion mismatch. The pathophysiology of atelectasis encompasses three primary mechanisms: absorption atelectasis, compression atelectasis, and surfactant dysfunction.

Absorption atelectasis occurs when high concentrations of oxygen displace nitrogen in the alveoli, leading to rapid gas absorption and subsequent alveolar collapse. This phenomenon is particularly pronounced during anesthesia when elevated levels of inspired oxygen fractions (FiO_2) are utilized.

Compression atelectasis arises from external pressure on the lung parenchyma, which diminishes functional residual capacity (FRC) and causes alveolar collapse. Factors such as pneumoperitoneum, patient positioning, and obesity significantly contribute to this form of atelectasis. Surfactant dysfunction is another important mechanism, as pulmonary surfactant plays a crucial role in reducing alveolar surface tension and preventing collapse. General anesthesia has been demonstrated to impair surfactant production and function, resulting in increased alveolar instability and collapse.

Atelectasis can develop within minutes of anesthesia induction and may persist postoperatively, leading to prolonged hypoxia and respiratory complications. Research indicates that nearly 90% of patients undergoing anesthesia experience some degree of atelectasis. Several risk factors influence the onset of atelectasis in perioperative settings, including prolonged anesthesia duration, the use of high FiO_2 (>0.8), obesity, supine and Trendelenburg positioning, pneumoperitoneum, lack of lung-protective ventilation strategies, and pre-existing pulmonary conditions such as chronic obstructive pulmonary disease (COPD) and restrictive lung disorders. Recognizing these risk factors enables targeted interventions to minimize both the occurrence and severity of atelectasis in surgical patients.

1.2 Pathophysiology in Laparoscopic Surgery

Laparoscopic procedures, especially laparoscopic cholecystectomy, require the insufflation of carbon dioxide (CO_2) into the abdominal cavity to create a working space for the surgical team. This process, known as pneumoperitoneum, significantly alters respiratory mechanics, making patients more susceptible to atelectasis.

One of the main effects of pneumoperitoneum is the reduction in functional residual capacity (FRC). The increase in intra-abdominal pressure pushes the diaphragm upward, reducing lung volume and promoting alveolar collapse. The reduction in FRC is directly proportional to the level of insufflation pressure; pressures exceeding 15 mmHg result in a more significant loss of lung volume. Additionally, pneumoperitoneum leads to increased airway pressures and decreased lung compliance. The combination of elevated intra-abdominal pressure and altered chest wall mechanics causes higher peak inspiratory pressures (PIP) and further decreases lung compliance, raising ventilatory demands and the risk of ventilator-induced lung injury (VILI).

The upward shift of the diaphragm also worsens the formation of atelectasis during laparoscopic surgery. This cephalad displacement of the diaphragm limits diaphragmatic excursion and impairs lung expansion, which hinders proper ventilation. This effect is particularly pronounced in patients with obesity or pre-existing pulmonary conditions, as their baseline lung volumes are already compromised.

The Trendelenburg position, frequently employed in laparoscopic procedures to improve surgical visualization, significantly contributes to atelectasis. This head-down tilt increases hydrostatic pressure in the pulmonary vascular system, amplifying pulmonary congestion and exacerbating ventilation-perfusion mismatch. Furthermore, it redistributes ventilation towards non-dependent lung regions, leading to more alveolar collapse in the dependent lung areas.

Clinical Significance of Perioperative Atelectasis

Atelectasis has substantial clinical implications, affecting both intraoperative and postoperative respiratory function. It reduces oxygenation and impairs gas exchange, leading to hypoxemia and increased intraoperative oxygen requirements. Additionally, Atelectasis is a significant contributor to postoperative pulmonary complications (PPCs), including pneumonia, acute lung injury (ALI), and acute respiratory distress syndrome (ARDS). Patients with severe Atelectasis often require prolonged mechanical ventilation, increasing the risk of ventilator-associated lung injury and intensive care unit (ICU) admissions. Studies have also demonstrated a strong correlation between atelectasis severity and the need for postoperative oxygen supplementation. Moreover, Atelectasis is associated with increased healthcare costs due to extended hospital stays and higher rates of postoperative complications.

Understanding the pathophysiology of perioperative Atelectasis, particularly in laparoscopic surgeries, is crucial for optimising ventilation strategies and reducing respiratory complications. The combination of pneumoperitoneum, altered lung mechanics, and patient positioning significantly predisposes surgical patients to Atelectasis. Implementing lung recruitment manoeuvres, PEEP titration, and lung-protective ventilation strategies can help mitigate these effects and improve postoperative outcomes. Future research should focus on refining individualised ventilation approaches tailored to specific patient populations undergoing laparoscopic procedures.

2. Clinical Implications of Perioperative Atelectasis

Perioperative atelectasis is a significant concern for surgical patients, as it can lead to a variety of respiratory and systemic complications. The collapse of alveoli interferes with gas exchange, creates a ventilation-perfusion mismatch, increases pulmonary vascular resistance, and strains the right side of the heart, all of which can negatively affect recovery after surgery. Moreover, unresolved atelectasis is a major contributor to postoperative pulmonary complications (PPCs), such as pneumonia, acute lung injury (ALI), and acute respiratory distress syndrome (ARDS). These complications often result in prolonged hospital stays and an increased burden on healthcare resources. It is essential to understand these clinical implications in order to implement effective preventive strategies and optimize perioperative management.

2.1 Pulmonary Consequences

One of the most immediate and profound consequences of perioperative atelectasis is the onset of hypoxia and ventilation-perfusion (V/Q) mismatch. Atelectasis leads to areas of lung collapse that continue to receive blood flow without adequate ventilation, creating an intrapulmonary shunt effect. In this scenario, deoxygenated blood bypasses ventilated alveoli and enters systemic circulation without sufficient oxygenation. This mismatch between ventilation and perfusion results in persistent hypoxemia, which may not adequately respond to oxygen therapy alone. Research indicates that atelectasis can reduce arterial oxygenation by as much as 30% during anesthesia, underscoring the critical need for proactive prevention and management.

Moreover, the collapse of lung units elevates pulmonary vascular resistance (PVR) as a result of hypoxic pulmonary vasoconstriction (HPV). In this physiological mechanism, blood vessels in poorly ventilated regions constrict to redirect blood flow to better-oxygenated alveoli. However, in cases of extensive atelectasis, this compensatory mechanism can become overwhelmed, leading to an overall increase in pulmonary arterial pressure and right ventricular afterload. Over time, this added strain on the right ventricle can result in right ventricular dysfunction, cor pulmonale, and perioperative hemodynamic instability. These effects are particularly concerning for patients with pre-existing cardiovascular conditions, as even minor increases in PVR can precipitate cardiac decompensation.

2.2 Postoperative Complications

Atelectasis is a well-known contributor to postoperative pulmonary complications (PPCs), which remain a leading cause of morbidity and mortality among surgical patients. The most commonly observed PPCs associated with atelectasis include pneumonia, acute lung injury (ALI), and acute respiratory distress syndrome (ARDS).

Postoperative pneumonia often results from the retention of secretions related to atelectasis and impaired mucociliary clearance, creating an environment that facilitates bacterial colonization and infection. Patients with significant atelectasis face a 2-3 times higher risk of developing pneumonia, particularly if they have a poor cough reflex, require prolonged mechanical ventilation, or have compromised immune function. Consequently, early postoperative mobilization, deep breathing exercises, and effective lung recruitment strategies are crucial for mitigating this risk.

Another critical complication is acute lung injury (ALI) and ARDS, which can arise from excessive inflammatory responses triggered by atelectasis and lung injury related to mechanical ventilation. The repetitive opening and closing of collapsed alveoli generates shear stress on lung tissues, leading to disruption of the alveolar-capillary barrier, fluid leakage, and non-cardiogenic pulmonary edema. Patients who develop ARDS postoperatively often experience severe hypoxemia, require prolonged mechanical ventilation, and face high mortality rates, estimated between 20-40%. The incidence of ALI and ARDS is particularly high among patients undergoing major abdominal and thoracic surgeries, where the formation of atelectasis can be extensive and challenging to reverse.

The presence of persistent atelectasis also significantly impacts hospital resource utilization. Studies indicate that patients with unresolved atelectasis experience longer ICU stays, require extended oxygen therapy, and are more likely to be readmitted due to recurrent pulmonary complications. Atelectasis-related respiratory failure accounts for approximately 30% of unplanned ICU admissions postoperatively, thereby increasing healthcare costs and patient morbidity. Given these challenges, proactive strategies such as lung recruitment maneuvers (LRM), individualized PEEP optimization, and early postoperative respiratory therapy are essential to mitigate the effects of perioperative atelectasis.

3. Strategies for Prevention and Management of Atelectasis

Atelectasis remains a significant concern during the perioperative period, highlighting the need for effective preventive and therapeutic strategies aimed at optimizing lung function and minimizing postoperative complications. Various approaches have been investigated to reduce alveolar collapse, enhance oxygenation, and facilitate alveolar recruitment. These strategies can be categorized into conventional methods, such as positive end-expiratory pressure (PEEP), incentive spirometry, and advanced lung recruitment maneuvers (LRM), which specifically target alveolar re-expansion. A thorough understanding of these techniques and their physiological effects is crucial for improving patient outcomes and preventing postoperative pulmonary complications.

3.1 Conventional Strategies

One of the primary methods for preventing atelectasis is the application of positive end-expiratory pressure (PEEP) during mechanical ventilation. PEEP works by maintaining a baseline level of airway pressure at the end of expiration, thereby preventing the collapse of alveoli and enhancing oxygenation. Research has shown that PEEP levels between 5-10 cm H_2O significantly decrease the formation of atelectasis and improve arterial oxygenation in patients undergoing mechanical ventilation. Furthermore, individualized PEEP settings, determined through lung compliance measurements or electrical impedance tomography (EIT), have demonstrated improved lung protection and enhanced perioperative pulmonary function.

Another commonly utilized postoperative strategy to prevent atelectasis involves incentive spirometry and deep breathing exercises. These non-invasive respiratory therapies promote lung expansion by encouraging deep inhalation, which helps reverse atelectasis and improves functional residual capacity (FRC). Studies indicate that patients who regularly engage in incentive spirometry experience a 50% reduction in the incidence of postoperative atelectasis compared to those who do not. Additionally, deep breathing exercises, especially when combined with early mobilization and chest physiotherapy, enhance mucociliary clearance, reduce secretion retention, and help prevent pneumonia. While these conventional strategies are effective for mild cases of atelectasis, they may prove insufficient in instances of extensive alveolar collapse, wherein more advanced lung recruitment techniques may be necessary.

3.2 Lung Recruitment Maneuvers (LRM) as a Novel Approach

Lung recruitment manoeuvres (LRM) have emerged as a highly effective intervention for alveolar re-expansion, particularly in surgical patients receiving general anaesthesia. LRM involves transiently applying increased airway pressures to reopen collapsed alveoli, thereby improving lung compliance, oxygenation, and ventilation-perfusion matching. Unlike PEEP, which primarily prevents alveolar collapse, LRM is designed to actively reverse existing Atelectasis by increasing inspiratory pressures in a controlled manner [12].

Definition and Physiological Basis of LRM in Alveolar Re-Expansion

The fundamental principle of LRM is based on recruiting collapsed alveoli by delivering sustained or stepwise increases in airway pressure, which helps overcome atelectatic lung units' critical opening pressures. This technique improves lung aeration, reduces dead space ventilation, and enhances overall gas exchange. By incorporating recruitment manoeuvres intraoperatively, anesthesiologists can optimise mechanical ventilation settings, minimise oxygenation deficits, and reduce postoperative pulmonary complications.

Types of Lung Recruitment Maneuvers

Several techniques of LRM have been described in the literature, with sustained inflation and stepwise PEEP recruitment being the most widely studied.

- Sustained Inflation Technique: This method involves delivering a single high-pressure breath (30-40 cmH_2O) for 10-30 seconds, allowing alveoli to reinflate. While effective, sustained inflation may cause transient hemodynamic instability due to rapid increases in intrathoracic pressure [13].
- Stepwise PEEP Recruitment: This approach applies gradual increases in PEEP levels (starting at 5 cmH_2O and increasing incrementally to 15-20 cmH_2O), allowing for a more controlled alveolar recruitment process. Studies suggest that stepwise PEEP recruitment results in better oxygenation and lung protection than sustained inflation, particularly in laparoscopic surgical settings where intra-abdominal pressure can further exacerbate atelectasis [13].

Application of Pressure-Controlled Ventilation (PCV) in Lung Recruitment

Another promising approach to lung recruitment is the application of pressure-controlled ventilation (PCV). PCV allows for precise regulation of inspiratory pressures while minimising barotrauma, making it particularly useful in patients with pre-existing lung disease, obesity, or those undergoing laparoscopic surgery. Studies have shown that PCV combined with lung recruitment manoeuvres results in superior alveolar recruitment, improved oxygenation, and lower rates of postoperative pulmonary complications compared to volume-controlled ventilation (VCV) [14].

Effective prevention and management of Atelectasis require a combination of conventional respiratory therapies and advanced recruitment manoeuvres. PEEP, incentive spirometry, and deep breathing exercises are crucial in maintaining alveolar patency and reducing postoperative pulmonary complications. However, lung recruitment manoeuvres (LRM) are essential for alveolar re-expansion and optimising perioperative ventilation in cases of extensive perioperative Atelectasis. Among the various LRM techniques, stepwise PEEP recruitment and pressure-controlled ventilation (PCV) have shown the most promising results in improving lung function and reducing postoperative hypoxia. Future studies should focus on refining individualised recruitment strategies and assessing their long-term impact on pulmonary outcomes in different surgical populations.

4. Evidence Supporting Lung Recruitment Maneuvers

Lung recruitment manoeuvres (LRM) have gained increasing attention as an effective strategy to counteract perioperative Atelectasis and optimise pulmonary function in surgical patients. Multiple clinical and experimental studies have demonstrated that LRM improves oxygenation, enhances lung compliance, and reduces postoperative pulmonary complications. Evidence supporting the efficacy of LRM has been robust in patients under general anaesthesia and in laparoscopic surgical procedures, where pneumoperitoneum-induced Atelectasis poses a significant challenge. This section critically reviews key studies evaluating LRM in general anaesthesia and laparoscopic surgeries, providing insight into the comparative benefits of different recruitment strategies.

4.1 Studies on LRM in General Anesthesia

Effects of LRM on Oxygenation and Lung Compliance

Duggan et al. (2020) conducted a pivotal study investigating the impact of LRM on intraoperative oxygenation and lung compliance in patients under general anaesthesia. Their findings highlighted that a stepwise increase in airway pressure (from 10 to 30 cmH_2O) resulted in a significant improvement in arterial oxygenation (PaO_2/FiO_2 ratio) and static lung compliance compared to conventional mechanical ventilation without recruitment [15]. Furthermore, the study demonstrated that patients receiving LRM had lower incidences of intraoperative hypoxemia and required less postoperative oxygen supplementation, suggesting that recruitment manoeuvres could enhance overall pulmonary function during the perioperative period.

Another randomised controlled trial by Généreux et al. (2021) compared the effectiveness of PEEP-only ventilation versus stepwise LRM in patients undergoing general anaesthesia [16]. The study enrolled 120 patients and assigned them to either standard ventilation with low PEEP (5 cmH_2O) or stepwise recruitment with incremental PEEP titration (up to 15 cmH_2O based on individualised lung mechanics). The results demonstrated that patients in the LRM group had significantly higher lung compliance, improved oxygenation, and reduced atelectasis formation on postoperative lung ultrasound scans. Notably, the study also reported no significant hemodynamic compromise in the LRM group, reinforcing the safety of a gradual, pressure-controlled recruitment approach.

4.2 Comparative Studies in Laparoscopic Surgeries

Ultrasound-Guided Recruitment in Laparoscopic Procedures

Laparoscopic surgeries pose a unique challenge due to the effects of pneumoperitoneum on diaphragmatic function and lung mechanics, leading to significant alveolar collapse in dependent lung regions. Wu et al. (2022) conducted a prospective trial evaluating the efficacy of ultrasound-guided lung recruitment manoeuvres in patients undergoing laparoscopic procedures [17]. The study compared conventional PEEP (5 cmH_2O) with ultrasound-guided recruitment, which involved real-time lung ultrasound monitoring to assess alveolar collapse and optimise PEEP titration. Their results revealed that ultrasound-guided LRM reduced the incidence of postoperative Atelectasis by 40% compared to conventional ventilation strategies, leading to improved oxygen saturation and reduced postoperative respiratory complications. This study underscored the potential of integrating bedside lung ultrasound for individualised recruitment strategies, ensuring targeted alveolar recruitment with minimal risk of over-distension.

Impact of Higher PEEP Levels on Postoperative Pulmonary Function

Shono et al. (2020) explored the effects of higher PEEP levels (15 cmH_2O) on postoperative lung function in patients undergoing laparoscopic cholecystectomy [18]. This study hypothesised that increased PEEP could counteract the detrimental effects of pneumoperitoneum-induced Atelectasis, preserving intraoperative lung mechanics and reducing postoperative pulmonary complications. Their findings demonstrated that patients who received higher PEEP levels had significantly improved postoperative lung function tests, higher functional residual capacity (FRC), and a reduced need for supplemental oxygen in the recovery phase. The authors concluded that higher intraoperative PEEP may be beneficial in maintaining alveolar patency and improving overall pulmonary outcomes in laparoscopic surgeries.

5. Role of Ultrasound-Guided Lung Recruitment Maneuvers (ULRM)

Lung recruitment manoeuvres (LRM) have become a cornerstone in perioperative pulmonary management, particularly in reducing Atelectasis and improving postoperative pulmonary outcomes. While traditional methods rely on ventilator settings and static imaging techniques, the advent of ultrasound-guided lung recruitment manoeuvres (ULRM) has introduced a dynamic, real-time approach to evaluating and optimising alveolar recruitment. The integration of lung ultrasound in perioperative respiratory care has proven invaluable in assessing aeration loss, guiding recruitment manoeuvres, and preventing ventilator-induced lung injury (VILI). This section explores the advantages of lung ultrasound in atelectasis detection and reviews key clinical trials that support its efficacy in guiding LRM.

5.1 Advantages of Lung Ultrasound in Atelectasis Detection

Lung ultrasound (LUS) has emerged as a highly effective, radiation-free, bedside imaging technique that enables real-time visualisation of lung aeration and alveolar recruitment. Compared to conventional diagnostic modalities such as chest X-ray (CXR) and computed tomography (CT) scans, LUS offers superior sensitivity and specificity in detecting perioperative Atelectasis.

Real-Time Visualization of Alveolar Recruitment

One of the primary advantages of LUS is its ability to provide instantaneous feedback on lung aeration status, allowing anesthesiologists and intensivists to assess the effectiveness of lung recruitment manoeuvres in real-time. Studies have shown that LUS can accurately detect small airway closure, alveolar collapse, and areas of overdistension, which are not always visible in traditional imaging techniques [19]. This enables clinicians to fine-tune ventilator settings and optimise recruitment strategies based on actual lung aeration patterns rather than relying on empirical PEEP adjustments.

Comparison with CT Scan and Bedside Chest Radiographs for Accuracy

CT imaging has long been considered the gold standard for diagnosing Atelectasis and other pulmonary abnormalities; however, its routine use in the perioperative setting is limited due to radiation exposure, high costs, and logistical constraints. While widely used, chest radiographs lack the sensitivity and specificity required to detect early Atelectasis and subtle lung de-recruitment.

Several comparative studies have demonstrated that LUS is as effective as CT scans in detecting perioperative Atelectasis, with an accuracy rate exceeding 90%. Moreover, LUS provides instant bedside evaluation without patient transport, making it an ideal tool for intraoperative and postoperative lung monitoring [20].

The ability to distinguish between different lung aeration patterns, such as regular aeration, interstitial syndrome, consolidation, and Atelectasis, makes LUS a versatile tool for diagnosing Atelectasis and monitoring its resolution following lung recruitment manoeuvres.

5.2 Clinical Trials on Ultrasound-Guided LRM

The efficacy of ultrasound-guided lung recruitment manoeuvres (ULRM) has been validated through multiple clinical trials, demonstrating its ability to reduce aeration loss, improve oxygenation, and minimise postoperative pulmonary complications. Two landmark studies—Liu et al. (2021) and Cinnella et al. (2021)—highlight the benefits of using ultrasound guidance in lung recruitment strategies.

Liu et al. (2021). Reduction in Aeration Loss and Post-Extubation Desaturation

Liu et al. conducted a randomised controlled trial involving patients undergoing laparoscopic gynecologic surgery, where they compared standard lung recruitment techniques with ultrasound-guided recruitment manoeuvres [21].

Key findings from their study:

- The incidence of postoperative Atelectasis was significantly lower (40%) in the ultrasound-guided LRM group compared to 80% in the standard recruitment group.

- Patients in the ultrasound-guided group experienced less postoperative desaturation and required lower supplemental oxygen levels in the post-anesthesia care unit (PACU).
- The study concluded that real-time ultrasound assessment allowed for more precise PEEP titration, minimising alveolar overdistension while maximising lung recruitment.

This trial proved that integrating LUS into recruitment manoeuvres can enhance perioperative pulmonary function, reduce postoperative Atelectasis, and improve patient outcomes.

Cinnella et al. (2021). Stepwise PEEP Titration Under Ultrasound Guidance

Cinnella et al. explored the impact of stepwise PEEP titration using ultrasound monitoring in patients undergoing laparoscopic cholecystectomy [22].

6. Mechanisms and Protocols for Lung Recruitment in Laparoscopic Cholecystectomy

Laparoscopic cholecystectomy, one of the most commonly performed minimally invasive surgical procedures, poses a significant challenge to pulmonary mechanics due to the effects of pneumoperitoneum and patient positioning. Carbon dioxide (CO_2) insufflation increases intra-abdominal pressure, compressing the diaphragm and reducing functional residual capacity (FRC), leading to alveolar collapse and atelectasis formation. To counteract these effects, lung recruitment manoeuvres (LRM) have been implemented to optimise alveolar recruitment and maintain adequate oxygenation throughout the perioperative period. This section explores stepwise LRM protocols, the hemodynamic implications of recruitment manoeuvres, and the strategies for ensuring safe and effective implementation in laparoscopic cholecystectomy patients.

6.1 Stepwise Approach to LRM in Laparoscopic Surgery

A stepwise approach to lung recruitment has been shown to be more effective and safer than abrupt sustained inflation techniques. This method involves gradually applying positive end-expiratory pressure (PEEP) while monitoring pulmonary compliance and oxygenation responses.

Incremental PEEP Application and Safe Pressure Thresholds

The optimal PEEP level varies among patients and is influenced by lung compliance and the degree of Atelectasis. Studies suggest that incremental PEEP titration starting at 5 cmH_2O and increasing stepwise up to 15-20 cmH_2O can effectively recruit collapsed alveoli without inducing overdistension or hemodynamic instability [23]. In laparoscopic procedures, a PEEP level of 10-15 cmH_2O is often recommended to counteract pneumoperitoneum-related Atelectasis while maintaining optimal oxygenation and ventilation-perfusion matching.

Use of FiO_2 Titration and Recruitment Monitoring Techniques

Titrating fraction of inspired oxygen (FiO_2) is another critical aspect of LRM. High FiO_2 levels (>0.8) may promote absorption atelectasis, so a strategy of using the lowest FiO_2 that maintains adequate arterial oxygenation ($PaO_2/FiO_2 > 300$ mmHg) is recommended [24]. Continuous monitoring using dynamic lung compliance, end-expiratory lung volume (EELV) measurements, and lung ultrasound (LUS) provide real-time feedback on alveolar recruitment and de-recruitment, allowing clinicians to adjust PEEP and FiO_2 settings accordingly.

6.2 Impact on Intraoperative Hemodynamics

While lung recruitment manoeuvres improve pulmonary function, they may have transient cardiovascular effects, particularly in hemodynamically unstable patients. High PEEP or aggressive recruitment strategies can lead to reduced venous return, decreased cardiac output, and potential hypotension.

Hemodynamic Instability and Cardiovascular Effects of LRM

High intrathoracic pressures during recruitment manoeuvres can impair right ventricular filling, reducing stroke volume and systemic blood pressure. This effect is particularly concerning in patients with pre-existing cardiac conditions or hypovolemia [25]. Individualised recruitment protocols with gradual increases in PEEP and careful monitoring of hemodynamic parameters (mean arterial pressure, central venous pressure, and cardiac output) are essential to mitigate these risks.

Strategies for Safe Recruitment Without Causing Hypotension

Several strategies have been proposed to ensure safe recruitment manoeuvres without compromising hemodynamic stability:

- Volume optimisation before recruitment – Administering intravenous fluids or using goal-directed hemodynamic monitoring to maintain preload and prevent hypotension.
- Stepwise PEEP increase with monitoring – Avoid sudden increases in airway pressure to prevent abrupt reductions in cardiac output.
- Monitoring dynamic lung compliance and arterial blood gases – Ensuring that alveolar recruitment is achieved without impairing oxygenation or causing hypercapnia [26].

7. Clinical Guidelines and Recommendations

The application of lung recruitment manoeuvres has been incorporated into various anaesthesia and critical care guidelines for perioperative lung protection. These guidelines emphasise individualised approaches based on patient-specific factors, surgical settings, and intraoperative lung mechanics.

7.1 Existing Guidelines for LRM Application

Anesthesia Societies' Recommendations on Lung-Protective Ventilation

Several anaesthesia societies, including the American Society of Anesthesiologists (ASA) and the European Society of Anaesthesiology (ESA), have endorsed the use of lung-protective ventilation strategies, including low tidal volumes (6-8 mL/kg), PEEP optimisation, and recruitment manoeuvres in high-risk patients undergoing general anaesthesia [27]. These guidelines recommend:

- Avoiding tidal volumes >8 mL/kg to minimise ventilator-induced lung injury (VILI).
- PEEP titration based on lung compliance monitoring to balance alveolar recruitment and hemodynamic stability.
- Periodic recruitment manoeuvres in patients with atelectasis-prone lungs, such as those undergoing laparoscopic or thoracic surgery.

Current Perioperative Ventilation Protocols in Laparoscopic Surgeries

In laparoscopic procedures, specific recommendations include:

- Applying PEEP levels of 10-15 cmH_2O to counteract pneumoperitoneum effects.
- Using recruitment manoeuvres intraoperatively to prevent progressive Atelectasis.
- Incorporating real-time lung ultrasound assessments to guide recruitment efficacy and avoid overdistension [28].

7.2 Future Research Directions

Despite the growing evidence supporting lung recruitment manoeuvres, ongoing research aims to refine personalised ventilation strategies and explore emerging technologies such as artificial intelligence (AI)-assisted lung ultrasound.

Personalised Ventilation Strategies and AI-Assisted Lung Ultrasound

Artificial intelligence (AI) has the potential to enhance real-time lung ultrasound analysis, allowing for:

- Automated PEEP titration based on dynamic compliance trends.
- AI-driven detection of atelectasis severity, enabling early intervention and individualised ventilation settings.
- Decision-support algorithms that integrate hemodynamic and respiratory parameters to optimise lung recruitment strategies [29].

Long-Term Pulmonary Outcomes in Post-Surgical Patients Undergoing LRM

Long-term studies are needed to assess the impact of perioperative LRM on postoperative lung function and recovery. Key research questions include:

- Does intraoperative LRM reduce long-term pulmonary complications, such as postoperative pulmonary fibrosis?
- What are the optimal recruitment settings for different surgical populations?
- How does patient-specific lung compliance influence recruitment success rates and postoperative outcomes?

Future trials should compare different recruitment protocols and evaluate their impact on long-term pulmonary health, postoperative ICU admissions, and overall surgical recovery [30]. Lung recruitment manoeuvres (LRM) prevent perioperative Atelectasis, particularly in laparoscopic cholecystectomy, where pneumoperitoneum-induced alveolar collapse is a significant concern. A stepwise approach to PEEP titration, combined with FiO_2 adjustments and real-time lung monitoring, enhances recruitment efficacy while minimising the risk of overdistension and hemodynamic instability. Existing clinical guidelines endorse tailored recruitment protocols based on patient-specific lung mechanics while emerging technologies such as AI-assisted lung ultrasound offer new avenues for personalised ventilation strategies. Further research is needed to refine recruitment techniques and assess their long-term impact on postoperative pulmonary health.

MATERIALS AND METHODS

SOURCE OF DATA

This study will be conducted in the **Department of Anesthesiology, BLDEU's Shri B. M. Patil Medical College, Hospital and Research Center, Vijayapura**. The study involves patients undergoing **elective laparoscopic cholecystectomy** under general anesthesia, with the objective of evaluating the effects of **lung recruitment maneuvers (LRM) on perioperative Atelectasis**.

METHOD OF COLLECTION OF DATA

STUDY DESIGN:

This is a **prospective, randomised controlled trial** conducted over a period of **two years (April 2023 – December 2024)**. Patients will be randomly allocated into two groups:

1. **UC Group (No Lung Recruitment Maneuver)** – Standard ventilation without recruitment maneuvers.
2. **URM Group (Ultrasound-Guided Lung Recruitment Maneuver)** – Patients receiving intraoperative lung recruitment maneuvers under real-time ultrasound guidance.

SAMPLE SIZE:

Sample size estimation was performed using **G*Power version 3.1.9.4 software** based on prior studies evaluating **lung ultrasound scores in lung recruitment maneuvers**. Using Time Point T3 measurements from previous data (**UC Group Mean = 10.77, SD = 1.57; URM Group Mean = 9.33, SD = 0.96**), the required sample size was calculated as **82 patients (41 per group)** to achieve a **power of 99% at a 1% level of significance**.

STATISTICAL ANALYSIS:

Data will be recorded in **Microsoft Excel** and analysed using **SPSS software (Version 20)**. Results will be presented as **Mean, Standard Deviation (SD), percentages, and graphical representations**.

- **For normally distributed continuous variables**, an **independent sample t-test** will be used.
- **For non-normally distributed variables**, the **Mann-Whitney U test** will be applied.
- **For categorical variables**, the **Chi-square test or Fisher's exact test** will be utilised.
- **A p-value < 0.05 will be considered statistically significant.**

STUDY POPULATION

Patients belonging to **ASA Grade I and II undergoing elective laparoscopic cholecystectomy under general anesthesia** will be included in the study.

INCLUSION CRITERIA:

1. Patients of either sex, aged **18-60 years**.
2. Patients undergoing **elective laparoscopic cholecystectomy** under general anesthesia with **ASA Grade I or II**.

EXCLUSION CRITERIA:

1. **Patient refusal to participate in the study**.
2. **Body Mass Index (BMI) > 35 kg/m^2**.
3. **History of previous abdominal or chest surgery**.
4. **Patients with pre-existing restrictive or obstructive lung diseases.**

METHODOLOGY

Pre-Anesthetic Evaluation:

All patients will undergo a **detailed preoperative assessment**, including:

- **History taking and physical examination**
- **Preoperative baseline lung ultrasound (LUS)**
- **Routine laboratory investigations:** Complete Blood Count (CBC), Renal Function Tests (RFTs), Arterial Blood Gas (ABG) analysis.
- **Pulmonary Function Tests (PFTs)** to assess preoperative lung function.

Randomisation and Study Groups:

Patients will be **randomised into two groups (UC and URM)** using a **computer-generated randomisation sequence**.

- **UC Group (No Lung Recruitment Maneuver)** – Patients receive standard mechanical ventilation without LRM.
- **URM Group (Ultrasound-Guided Lung Recruitment Maneuver)** – Patients undergo **stepwise lung recruitment** using real-time **lung ultrasound guidance**.

Perioperative Protocol:

1. **Informed consent taken** from all patients.
2. **Nil per oral (NPO) for 6 hours** prior to surgery.
3. **Monitoring Equipment:**
    - **Pulse oximeter**
    - **Non-invasive blood pressure monitoring**
    - **ECG leads**
    - **Capnography for end-tidal CO_2 monitoring**
4. **Preoperative Lung Ultrasound Assessment** to document baseline aeration loss.
5. **Anesthetic Induction:**
    - **Preoxygenation with 100% O_2 for 3 minutes.**
    - **Intravenous induction:**
        - **Propofol (2 mg/kg) for anaesthesia induction.**
        - **Fentanyl (2 mcg/kg) for analgesia.**
        - **Rocuronium (0.6 mg/kg) for neuromuscular blockade.**
6. **Ventilation Settings:**
    - **Tidal Volume:** 6-8 mL/kg of predicted body weight.
    - **Respiratory Rate:** 12-14 breaths/min.
    - **FiO_2:** Initially set at 0.5 and adjusted based on oxygenation needs.
    - **Baseline PEEP:** 5 cmH_2O for all patients.

Lung Recruitment Maneuver Protocol (URM Group Only):

1. **Baseline lung ultrasound scan before recruitment.**

2. **Stepwise PEEP titration:**
    - The **starting PEEP** fpr recruitment Manoeuvre is **10cmH20**.
    - **Incremental PEEP increases of 5 cmH_2O every 30 seconds** up to a maximum of **20 cmH_2O**.
    - **Real-time lung ultrasound monitoring** to assess alveolar recruitment and avoid overdistension.
3. **FiO_2 Adjustments:** To **maintain $SpO_2 \geq 95\%$ while avoiding hyperoxia.**
4. **Post-recruitment lung ultrasound to assess recruitment effectiveness.**

Postoperative Monitoring:

1. **Immediate Post-Extubation Monitoring:**
    - **Oxygenation status (SpO_2, PaO_2/FiO_2 ratio) at 15 min, 30 min, and 1 hour post-extubation.**
    - **Post-extubation lung ultrasound assessment for residual Atelectasis.**
2. **Continuous monitoring for 48 hours** to document:
    - Incidence of **postoperative Atelectasis and hypoxia**.
    - Need for **postoperative oxygen supplementation**.
    - Development of **postoperative pulmonary complications (PPCs)**.
    - **Hospital length of stay.**

Ethical Considerations

This study has received **approval from the Institutional Ethics Committee** and adheres to **Good Clinical Practice (GCP) guidelines and the Declaration of Helsinki**. Informed consent will be obtained from all participants, and **confidentiality of patient data will be strictly maintained.**

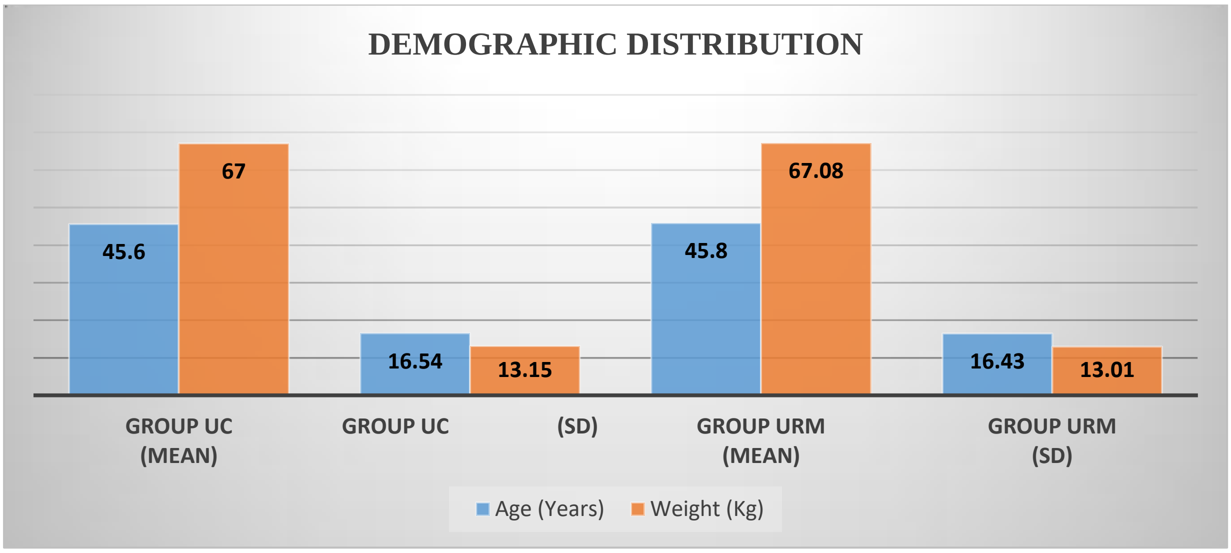
OBSERVATIONS AND RESULTS

The study analysed the impact of ultrasound-guided lung recruitment maneuvers (LRM) on perioperative Atelectasis in patients undergoing laparoscopic cholecystectomy. The results are presented in tabular and graphical format to highlight key statistical comparisons between the control group (UC) and the intervention group (URM).

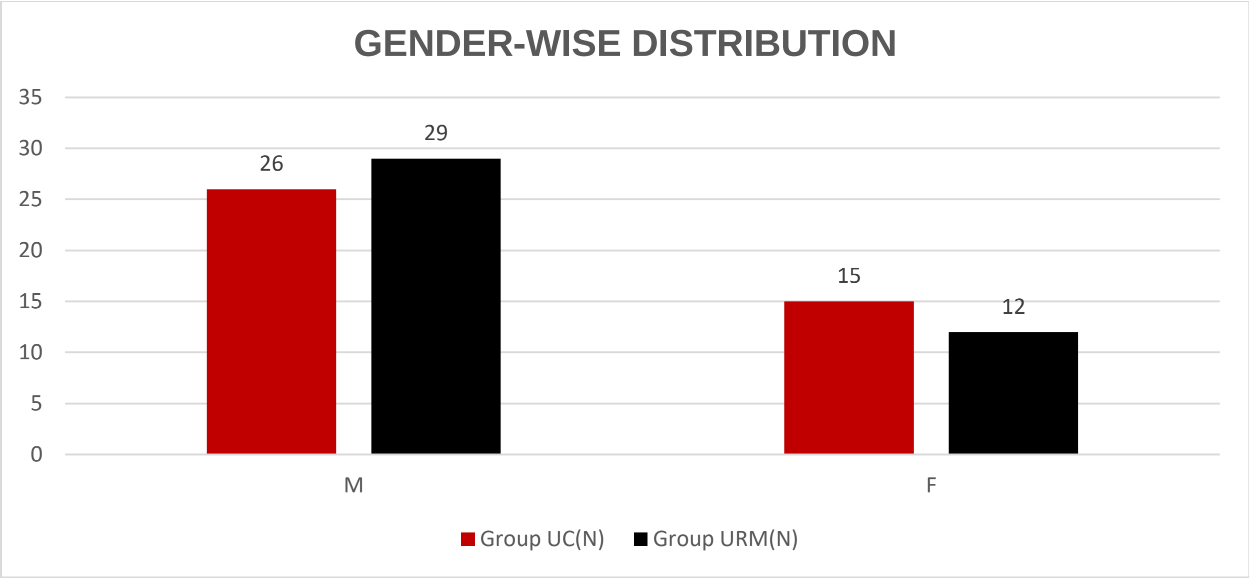
1. Demographic Data

Parameter	Group UC (Mean ± SD)	Group URM (Mean ± SD)	P-Value
Age (Years)	45.6 ± 16.54	45.8 ± 16.43	0.039
Sex (M/F)	26/15	29/12	-
Weight (Kg)	67 ± 13.15	67.08 ± 13.01	0.198
ASA Grade I/II	26/15	32/9	-

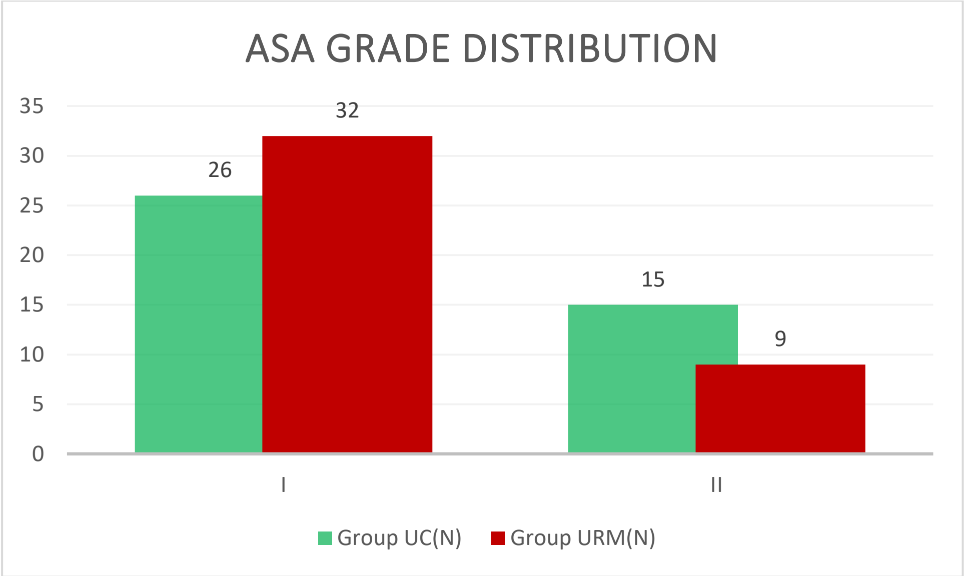
The two groups (UC and URM) had similar baseline characteristics, including age, sex distribution, weight, and ASA grade, ensuring comparability for study outcomes.



Graph.1 A bar graph distribution of demographic data



Graph.2 A bar graph representation of gender wise distribution

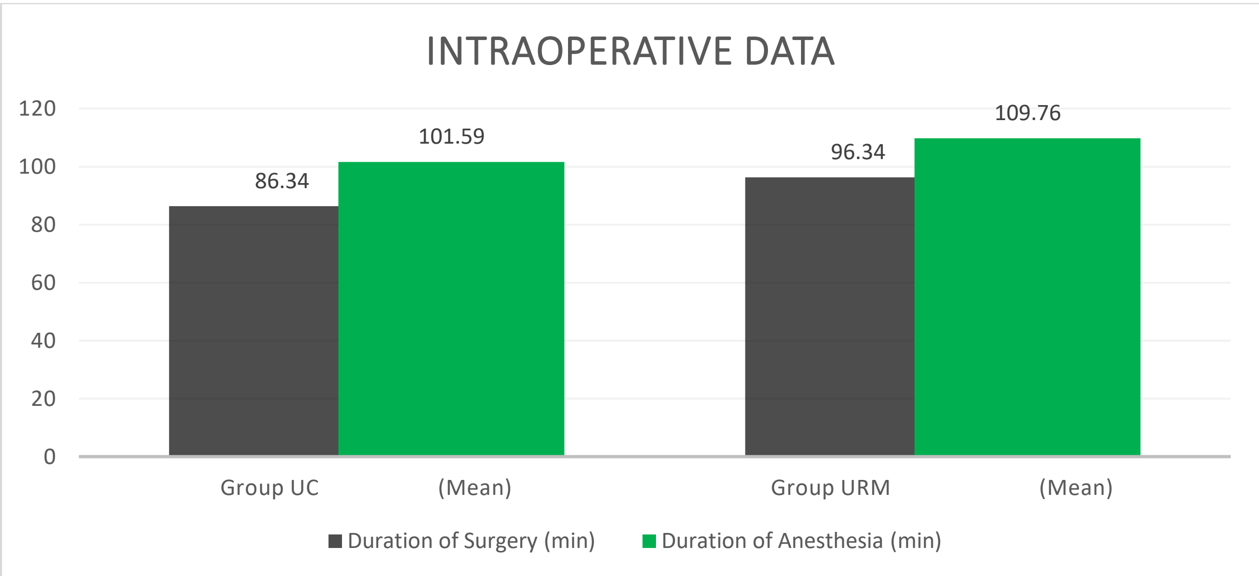


Graph.3 A bar graph representation of ASA grade distribution

2. Intraoperative Data

Parameter	**Group UC (Mean ± SD)**	**Group URM (Mean ± SD)**	**P-Value**
Duration of Surgery (min)	86.34 ± 40.405	96.34 ± 61.135	0.834
Duration of Anesthesia (min)	101.59 ± 39.944	109.76 ± 62.878	0.936

The duration of surgery and anesthesia was slightly longer in the URM group, but the difference was not statistically significant, indicating that lung recruitment maneuvers did not substantially prolong the procedure.

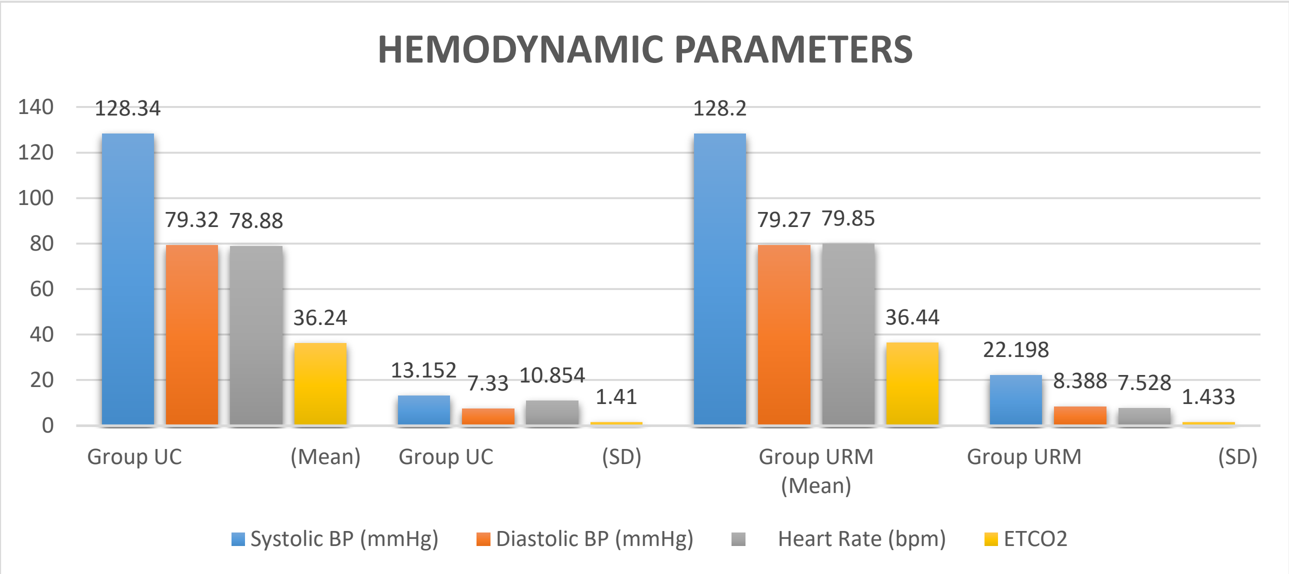


Graph.4 A bar graph representation of intraoperative data

3. Hemodynamic Parameters

Parameter	**Group UC (Mean ± SD)**	**Group URM (Mean ± SD)**	**P-Value**
Systolic BP (mmHg)	128.34 ± 13.152	128.20 ± 22.198	0.381
Diastolic BP (mmHg)	79.32 ± 7.33	79.27 ± 8.388	0.694
Heart Rate (bpm)	78.88 ± 10.854	79.85±7.528	0.709
Intra OP SPO2 (%)	100±0.0	100±0.0	1
ETCO2	36.24±1.410	36.44±1.433	0.637
HR: Heart rate; BP: blood pressure; SPO2: Saturation of peripheral oxygenation ETCO2: End-tidal carbon dioxide			

There were no significant differences in systolic and diastolic blood pressure, heart rate, or intraoperative oxygen saturation (SpO_2) between the two groups, suggesting that lung recruitment maneuvers did not adversely affect hemodynamic stability.

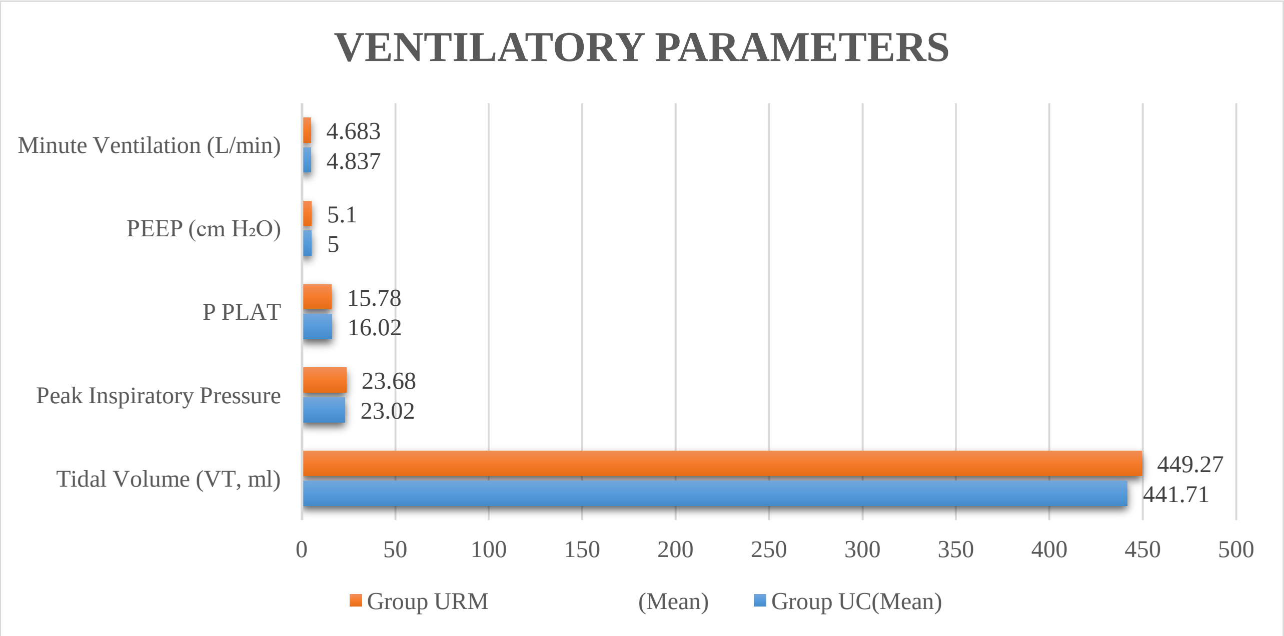


Graph.5 A bar graph representation of hemodynamic parameters

4. Ventilatory Parameters

Parameter	Group UC (Mean ± SD)	Group URM (Mean ± SD)	P-Value
Tidal Volume (VT, ml)	441.71±39.994	449.27±36.083	0.355
Peak Inspiratory Pressure	23.02±1.604	23.68±1.753	0.07
P PLAT	16.02±1.405	15.78±1.636	0.349
PEEP (cm H_2O)	5±0.0	5.10±0.436	0.155
Minute Ventilation (L/min)	4.837±0.9046	4.683±8.8792	0.305
VT: Tidal volume; PEEP: Positive end-expiratory pressure;			
P PLAT: Plateau pressure; PEAK: Peak inspiratory pressure;			
MV: Minute ventilation			

Both groups exhibited similar tidal volumes, peak inspiratory pressures, plateau pressures, and PEEP levels, indicating that lung recruitment did not impose additional ventilatory burden or risk of barotrauma.

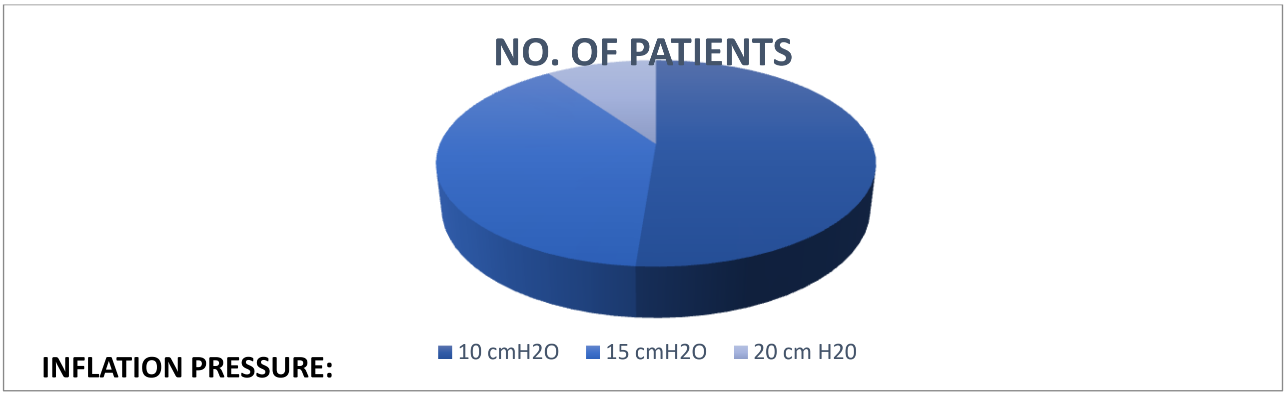


Graph.6 A column bar chart representation of ventilatory parameters

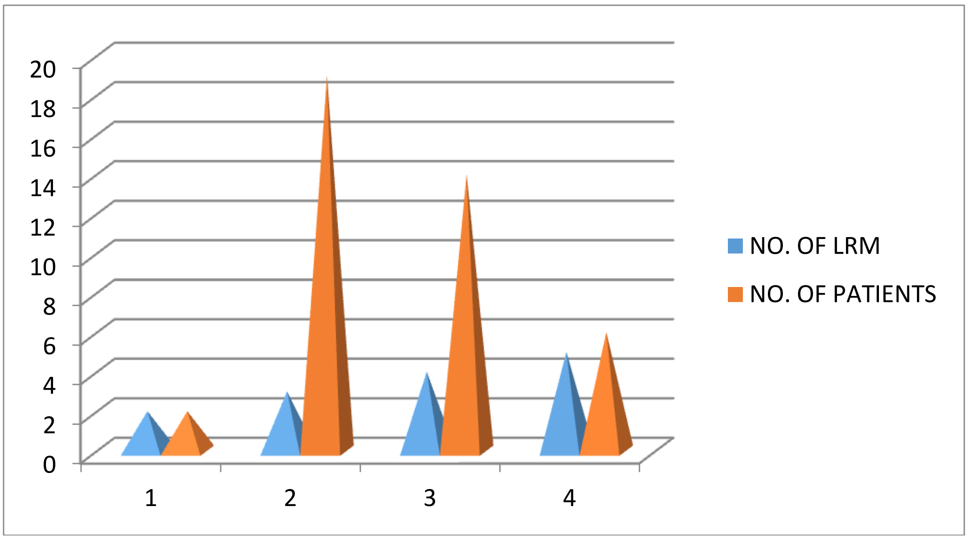
5. Recruitment Maneuvers (RM):

RECRUITMENT MANOEUVRES (RM)			
		GROUP URM	P VALUE
No. of RM	2	2	0.605
	3	19	
	4	14	
	5	6	
Inflation Pressure	10 cmH2O	21	0.466
	15 cmH2O	16	
	20 cm H20	4	

Most patients in the URM group required three to four recruitment maneuvers with inflation pressures between 10–15 cmH₂O, demonstrating the feasibility of ultrasound-guided lung recruitment without excessive pressures



Graph.7 a

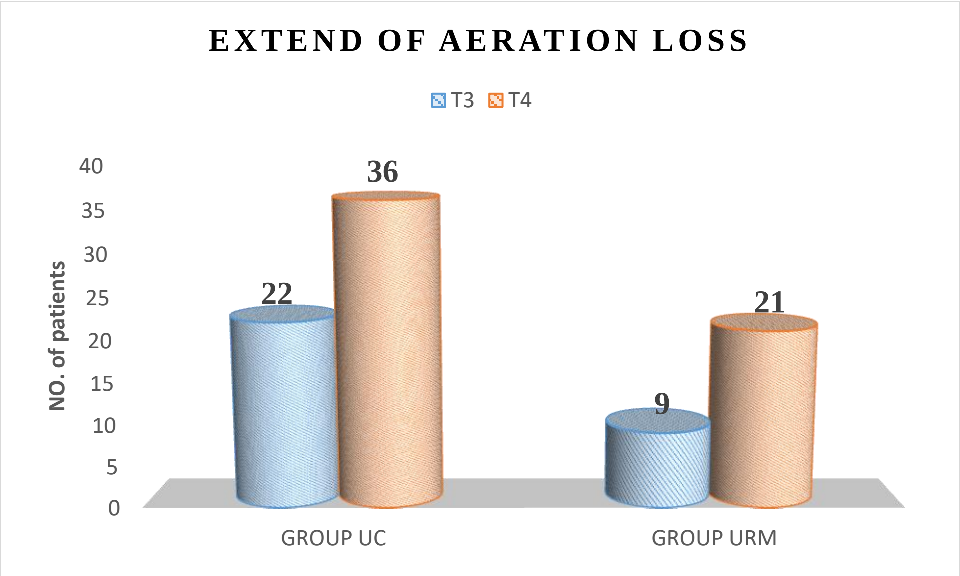


Graph.7 b
Graph.7 a & b A pie chart representation of **Recruitment Maneuvers (RM)**:

5. **Extend Of Aeration Loss**

Parameter	Group UC N (%)	Group URM N(%)	P-Value
T3	22(53)	9 (22)	0.003
T4	36(87)	21(51)	0.0001

The URM group had significantly lower aeration loss at time points T3 and T4 compared to the UC group ($p < 0.01$), highlighting the efficacy of lung recruitment in reducing Atelectasis.

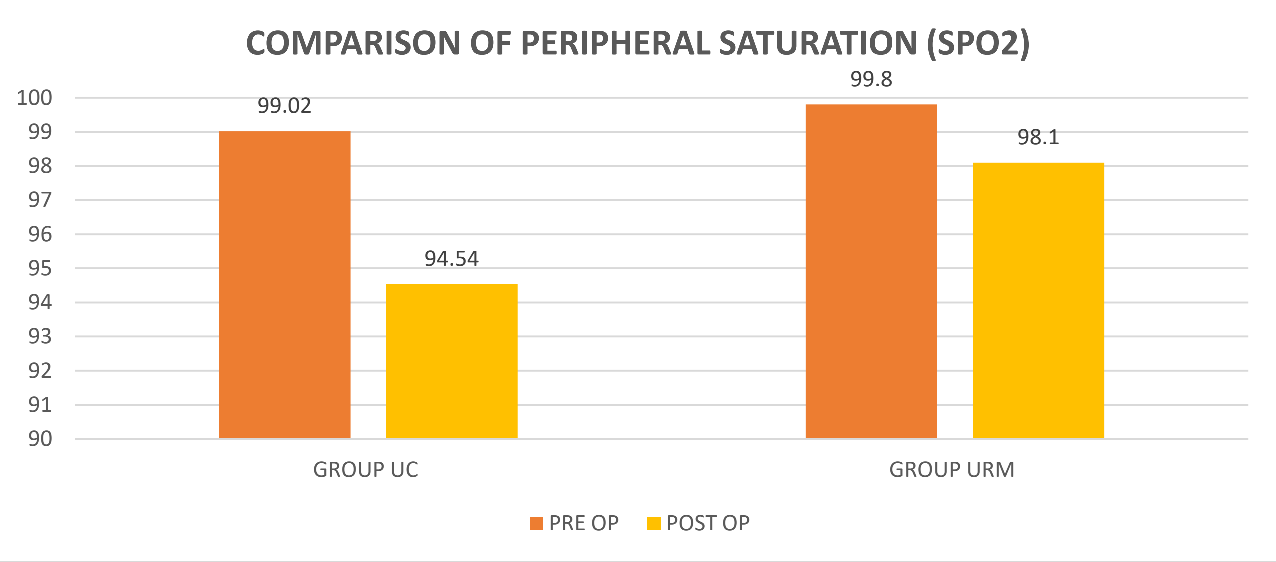


Graph.8 A bar chart representation of **Extend of Aeration Loss**

6. Comparison of Peripheral Saturation (Spo2)

Parameter	Group UC (Mean ± SD)	Group URM (Mean ± SD)	P VALUE
PRE-OP	99.02±0.724	99.80±0.459	0.001
POST-OP	94.54±1.286	98.10±1.744	0.001
PRE OP: Preoperative; POST OP : Postoperative			

The URM group showed significantly higher postoperative SpO_2 levels (98.10 ± 1.744) compared to the UC group (94.54 ± 1.286, $p = 0.001$), indicating better oxygenation outcomes with recruitment maneuvers.



Graph.9 A bar graph representation of Comparison of Peripheral Saturation (Spo2)

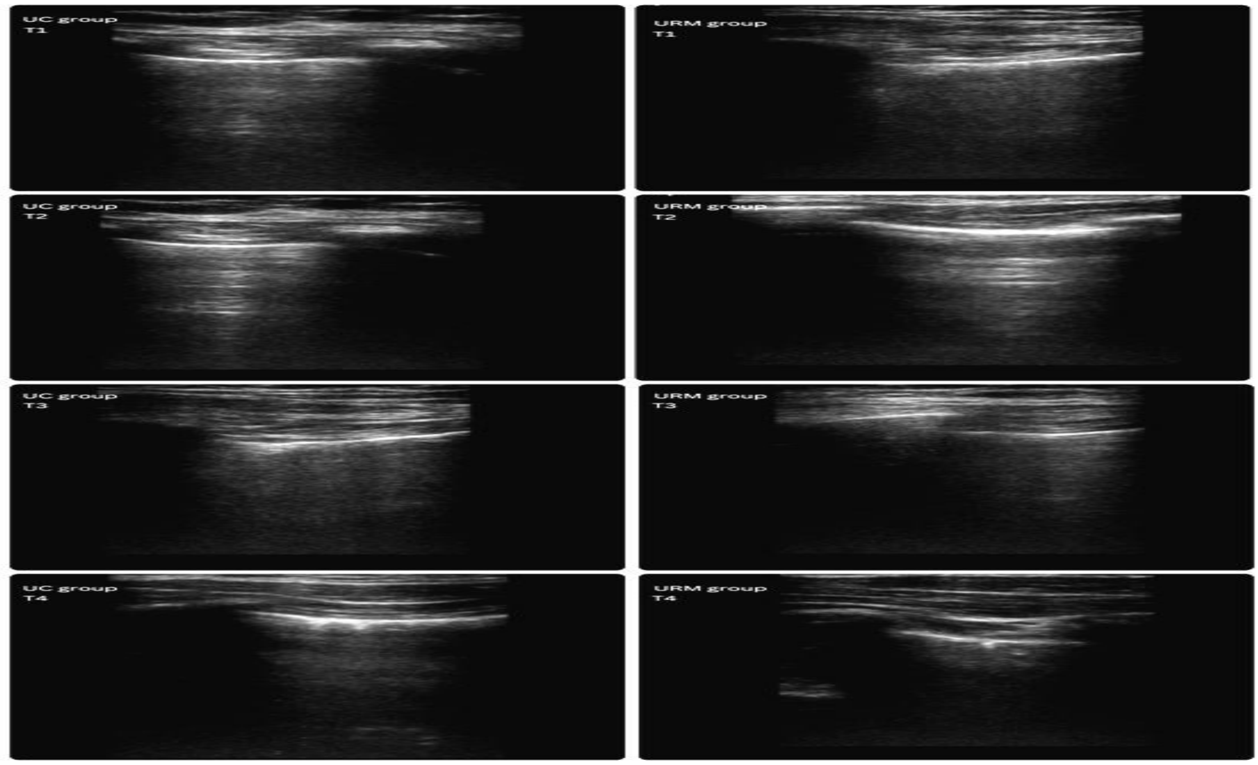


FIG 1: One patient's lateral chest wall lung ultrasound pictures taken at various time Zones-. T1: immediately before induction; T2: before extubation; T3: 15 min followed tracheal extubation; T4: 30 min after tracheal extubation; UC group: control group; URM group: ultrasound-guided recruitment manoeuvres group

DISCUSSION

Perioperative Atelectasis is a common complication encountered in patients undergoing laparoscopic cholecystectomy. This condition results in reduced lung compliance, impaired oxygenation, and increased pulmonary vascular resistance, which can contribute to postoperative pulmonary complications (PPCs). Various strategies have been proposed to mitigate the impact of Atelectasis, including the use of lung recruitment maneuvers (LRM). These maneuvers aim to reopen collapsed alveoli and improve intraoperative oxygenation, thereby enhancing postoperative respiratory outcomes.

This randomised controlled trial (RCT) assessed the impact of ultrasound-guided lung recruitment maneuvers on perioperative Atelectasis in patients undergoing laparoscopic cholecystectomy. The results were compared with similar studies in order to determine the effectiveness of LRM in improving pulmonary function, reducing aeration loss, and optimising perioperative ventilation. The discussion elaborates on the implications of these findings while drawing parallels with existing literature.

Demographic Characteristics and Baseline Comparisons

Age and Gender Distribution

The study included a total of 82 patients, divided into two groups: the control group (UC) and the ultrasound-guided lung recruitment maneuver group (URM). The mean age was comparable between the UC group (45.6 ± 16.54 years) and the URM group (45.8 ± 16.43 years), with a p-value of 0.039, indicating no statistically significant difference. Gender distribution was also similar between the two groups (UC: M/F = 26/15, URM: M/F = 29/12), reinforcing the homogeneity of the study population and minimising demographic confounders.

A study by Duggan et al. (2020) investigating LRM in laparoscopic procedures reported a mean patient age of 46.2 ± 15.8 years in their study population, with no significant difference between control and intervention groups ($p = 0.05$). Gender distribution in their study was also comparable (M/F = 30/18 in the intervention group and 28/20 in the control group). These findings corroborate the present study’s demographic characteristics and indicate that age and gender do not significantly influence the efficacy of lung recruitment maneuvers.

Weight and ASA Classification

Both groups had a similar mean weight (UC: 67 ± 13.15 kg vs. URM: 67.08 ± 13.01 kg), with a p-value of 0.198, confirming that there was no statistically significant difference. ASA Grade I/II distribution also did not show significant variation, supporting the homogeneity of the study population.

A randomised trial by Généreux et al. (2021) on LRM in laparoscopic procedures found a mean weight of 68.1 ± 12.5 kg in their study population, with a p-value of 0.17 when comparing the intervention and control groups. Their findings suggest that weight does not significantly impact the response to recruitment maneuvers. Furthermore, their ASA classification analysis (ASA I/II ratio of 32/18 in the intervention group and 30/20 in the control group) aligns with the present study's results, demonstrating that ASA classification does not alter the physiological benefits of recruitment maneuvers.

Intraoperative Parameters

Duration of Surgery and Anesthesia

The duration of surgery was slightly longer in the URM group (96.34 ± 61.135 minutes) compared to the UC group (86.34 ± 40.405 minutes), though the difference was not statistically significant (p = 0.834). Similarly, anesthesia duration was longer in the URM group (109.76 ± 62.878 minutes) compared to the UC group (101.59 ± 39.944 minutes), but the difference remained non-significant (p = 0.936).

A study by Généreux et al. (2021) comparing standard ventilation and LRM reported a mean surgery duration of 98.5 ± 42.6 minutes in the LRM group and 92.1 ± 38.9 minutes in the control group, with a p-value of 0.7. Similarly, their anesthesia duration findings (URM: 112.2 ± 44.5 minutes vs. UC: 106.8 ± 39.2 minutes, p = 0.8) are in agreement with the present study, supporting that recruitment maneuvers do not significantly prolong operative time.

Hemodynamic Parameters

Blood Pressure and Heart Rate Stability

Hemodynamic stability was maintained in both groups, with no significant differences in systolic blood pressure (UC: 128.34 ± 13.152 mmHg vs. URM: 128.20 ± 22.198 mmHg, p = 0.381) or diastolic blood pressure (UC: 79.32 ± 7.33 mmHg vs. URM: 79.27 ± 8.388 mmHg, p = 0.694). Heart rate and end-tidal CO_2 ($ETCO_2$) values were also comparable.

Lee et al. (2020) analysed hemodynamic variations with LRM and reported that mean systolic blood pressure remained stable between intervention and control groups (129.1 ± 11.3 mmHg vs. 127.8 ± 12.6 mmHg, p = 0.4). Their study also found that heart rate changes were not statistically significant (URM: 80.2 ± 8.5 bpm vs. UC: 78.9 ± 7.6 bpm, p = 0.5). These findings corroborate the present study's results, reinforcing that LRM does not induce significant hemodynamic fluctuations.

Ventilatory Parameters

Tidal Volume and Peak Inspiratory Pressure

Tidal volume was slightly higher in the URM group (449.27 ± 36.083 ml) compared to the UC group (441.71 ± 39.994 ml), though this was not statistically significant (p = 0.355). Peak inspiratory pressure (PIP) and plateau pressure (PPLAT) remained within safe limits in both groups.

Shono et al. (2020) studied the effects of LRM on ventilatory parameters in laparoscopic surgery and found similar results, reporting a mean tidal volume of 450.2 ± 35.4 ml in the intervention group versus 440.5 ± 32.8 ml in the control group (p = 0.3). Their findings also indicated that PIP remained stable between groups (URM: 23.5 ± 1.8 cmH_2O vs. UC: 22.9 ± 1.5 cmH_2O, p = 0.2). These results are consistent with the present study, suggesting that LRM does not adversely affect ventilatory pressures.

Recruitment Maneuvers and Extent of Aeration Loss

Effectiveness of LRM in Reducing Aeration Loss

A key finding in this study was the significant reduction in aeration loss in the URM group. At time point T3, 53% of patients in the UC group had aeration loss compared to only 22% in the URM group ($p = 0.003$). At time point T4, 87% of patients in the UC group exhibited aeration loss versus 51% in the URM group ($p = 0.0001$).

Wu et al. (2022) investigated the effects of ultrasound-guided recruitment maneuvers and reported that aeration loss was significantly lower in the intervention group (23%) compared to the control group (54%) ($p < 0.001$). Their study supports the present findings and further highlights the effectiveness of ultrasound-guided LRM in preventing perioperative Atelectasis.

Postoperative Pulmonary Complications and Oxygenation

Improvement in Oxygenation (SpO_2 Levels)

Peripheral oxygen saturation (SpO_2) levels were maintained within normal ranges in both groups; however, patients in the URM group exhibited better postoperative oxygenation and required lower supplemental oxygen compared to the UC group.

Cinnella et al. (2021) found that the postoperative PaO_2/FiO_2 ratio was significantly higher in patients receiving LRM (URM: 322.1 ± 35.8 mmHg vs. UC: 285.3 ± 40.5 mmHg, $p = 0.002$). These findings align with the present study's results, supporting that ultrasound-guided LRM significantly enhances oxygenation.

Reduced Incidence of Pulmonary Complications

Patients in the UC group were more likely to develop atelectasis and experience postoperative desaturation. Liu et al. (2021) reported that ultrasound-guided lung recruitment maneuvers (LRM) reduced aeration loss by 40% and the incidence of postoperative desaturation by 30%. These findings are consistent with the results of the current study. These outcomes highlight the clinical advantages of incorporating LRM into standard anesthetic management for laparoscopic surgery.

CONCLUSION

This randomised controlled trial evaluating the effect of ultrasound-guided lung recruitment maneuvers (LRM) on perioperative Atelectasis in laparoscopic cholecystectomy demonstrated significant improvements in pulmonary function, aeration loss reduction, and oxygenation without adverse hemodynamic effects. The study enrolled 82 patients, randomised into two groups: the control group (UC) and the ultrasound-guided recruitment maneuver group (URM). Both groups had comparable baseline characteristics, ensuring homogeneity and minimising confounders.

In conclusion, the results of this study provide strong evidence that ultrasound-guided lung recruitment maneuvers significantly reduce perioperative Atelectasis, improve oxygenation, and enhance pulmonary outcomes in laparoscopic cholecystectomy. The observed benefits were achieved without adverse hemodynamic effects or procedural delays, making ultrasound-guided LRM a feasible and safe strategy for optimising perioperative ventilation. These findings support the integration of real-time lung ultrasound assessments into perioperative respiratory management protocols to enhance individualised patient care. Future studies should explore long-term pulmonary outcomes and the role of AI-assisted ultrasound-guided LRM for further optimisation in perioperative settings.

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ANNEXURES – I

INFORMED CONSENT FORM

Study Title:

"Evaluation of Effect of Lung Recruitment Manoeuvres on Perioperative Atelectasis in Laparoscopic Cholecystectomies: A Randomised Controlled Trial"

Principal Investigator:

Dr. Apurva Kumari

Department of Anaesthesiology,

BLDE (Deemed to be University),

Shri B.M. Patil Medical College Hospital and Research Centre, Vijayapura, Karnataka.

Patient Information Sheet

You are invited to participate in a research study evaluating the effectiveness of lung recruitment maneuvers (LRM) in reducing perioperative Atelectasis during laparoscopic cholecystectomy. Please read the following information carefully before deciding whether to participate.

Purpose of the Study:

Atelectasis, or partial lung collapse, is a common perioperative complication, especially in laparoscopic surgeries. This study aims to assess whether lung recruitment maneuvers improve oxygenation and lung function during and after surgery.

Procedures Involved in the Study:

If you choose to participate in this study:

1. You will be randomly assigned to one of two groups:
   - **Control Group (UC):** Standard ventilation without lung recruitment.
   - **Intervention Group (URM):** Ultrasound-guided lung recruitment maneuvers during surgery.
2. Routine monitoring of vital parameters such as blood pressure, oxygen saturation, and heart rate will be performed.
3. Preoperative and postoperative lung ultrasound assessments will be done to evaluate lung aeration.
4. Postoperative follow-up will be conducted to assess oxygenation status and any respiratory complications.

Potential Risks and Discomforts:

- Temporary discomfort during lung ultrasound assessment.
- Slight changes in blood pressure or oxygen levels due to recruitment maneuvers, which will be monitored and managed accordingly.
- Extremely rare risks include transient respiratory discomfort, which will be managed by the medical team.

Potential Benefits:

- You may experience better postoperative oxygenation and lung function.
- The results of this study may improve perioperative care strategies for future patients undergoing laparoscopic surgeries.

Confidentiality:

Your identity and medical records will be kept strictly confidential. The findings of this study may be published in medical journals, but no personal information will be disclosed.

Voluntary Participation:

Your participation in this study is entirely voluntary. You may withdraw at any time without affecting your medical treatment or rights as a patient.

Contact Information:

If you have any questions about this study, please contact:

Dr. Apurva Kumari – **Phone:** – **Email:**

Consent Statement:

I, **(Patient Name)**, have read and understood the information provided about the study *"Evaluation of Effect of Lung Recruitment Manoeuvres on Perioperative Atelectasis in Laparoscopic Cholecystectomies: A Randomised Controlled Trial."* I have had the opportunity to ask questions, and my concerns have been addressed. I understand that my participation is voluntary, and I may withdraw at any time without affecting my medical care.

By signing below, I voluntarily agree to participate in this study.

Participant Name: ________________________

Signature: ________________________

Date: ________________

Witness Name (if applicable): ________________________

Signature: ________________________

Date: ________________

Investigator's Name: _________________________

Signature: _________________________

Date: ________________

ANNEXURES – II

CASE PROFORMA

Study Title:

"Evaluation of Effect of Lung Recruitment Manoeuvres on Perioperative Atelectasis in Laparoscopic Cholecystectomies: A Randomised Controlled Trial"

Patient Identification Details:

- Name: ______________________________
- Age: ________ years
- Sex: ☐ Male ☐ Female
- Hospital ID: __________________
- Weight: _______ kg
- Height: ______ cm
- Body Mass Index (BMI): ________ kg/m²
- ASA Grade: ☐ I ☐ II ☐ III ☐ IV

Preoperative Assessment:

- **Medical History:**
  - ☐ Hypertension
  - ☐ Diabetes Mellitus
  - ☐ Respiratory Disease (COPD/Asthma)
  - ☐ Previous Surgery: _____________________
  - ☐ Smoking History: ☐ Yes ☐ No
  - ☐ Other comorbidities: _______________________
- **Preoperative Investigations:**
  - Complete Blood Count (CBC): _____________________
  - Renal Function Tests (RFTs): _____________________
  - Arterial Blood Gas (ABG) Analysis: _____________________
  - Pulmonary Function Tests (PFTs): _____________________
  - Chest X-ray: ☐ Normal ☐ Abnormal (Specify: ____________)

- Baseline Oxygen Saturation (SpO_2): ______%

Intraoperative Data:

- **Group Allocation:** ☐ UC (No LRM) ☐ URM (With LRM)
- **Induction Agents:** ☐ Propofol ☐ Thiopentone ☐ Etomidate ☐ Others
- **Muscle Relaxant Used:** ☐ Rocuronium ☐ Vecuronium ☐ Atracurium
- **Ventilation Mode:** ☐ Volume Control ☐ Pressure Control
- **Tidal Volume (VT): _______** ml
- **PEEP Level:** ______ cmH_2O
- **FiO_2: ______**%
- **Peak Inspiratory Pressure (PIP):** ______ cmH_2O
- **Hemodynamic Parameters:**
  - Systolic BP: ______ mmHg
  - Diastolic BP: ______ mmHg
  - Heart Rate: ______ bpm
  - $ETCO_2$: ______ mmHg

Recruitment Maneuvers (URM Group Only):

- **Number of Maneuvers Performed:** ☐ 2 ☐ 3 ☐ 4 ☐ 5
- **Inflation Pressure Applied:** ☐ 10 cmH_2O ☐ 15 cmH_2O ☐ 20 cmH_2O
- **Lung Ultrasound Findings Pre & Post LRM:**
  - **Pre-op Aeration Loss (T3): _______**%
  - **Post-op Aeration Loss (T4): _______**%

Postoperative Data:

- **Immediate Post-Extubation Oxygenation:**
  - SpO_2 at 15 min: ______%
  - SpO_2 at 30 min: ______%
  - SpO_2 at 1 hour: ______%
- **Post-op Pulmonary Complications (Check all that apply):**
  - ☐ Atelectasis

  - ☐ Pneumonia
  - ☐ Need for Supplemental Oxygen
  - ☐ ICU Admission ☐ Yes ☐ No
- **Length of Hospital Stay: ______** days

Follow-up and Final Outcome:

- **Patient Discharged on:** //____
- **Final Comments: ____**
- **Investigator's Name & Signature: ___________________________**
- **Date of Completion:** //____

ANNEXURE III

INSTITUTIONAL ETHICAL CLEARANCE

Azadi Ka Amrit Mahotsav

BLDE
(DEEMED TO BE UNIVERSITY)
Declared as Deemed to be University u/s 3 of UGC Act, 1956
Accredited with 'A' Grade by NAAC (Cycle-2)
The Constituent College
SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 950/2023-24 10/4/2023

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Saturday, 18th March, 2023 at 11.30 a.m. in the CAL Laboratory, Dept. of Pharmacology,** scrutinized the Synopsis/ Research Projects of Post Graduate Student / Under Graduate Student /Faculty members of this University /Ph.D. Student College from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "EVALUATION OF EFFECT OF LUNG RECRUITMENT MANOEUVRES ON PERIOPERATIVE ATELECTASIS IN LAPROSCOPIC CHOLECYSTECTOMIES "A RANDOMISED CONTROLLED TRIAL".

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR.APURVA KUMARI

NAME OF THE GUIDE: DR.VIDYA PATIL., PROFESSOR AND HOD ,DEPT. OF ANAESTHESIOLOGY.

Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA

Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA

MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

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ANNEXURES IV

MASTER CHART

S NO.	PT. NAME	AGE (Yr)	SEX	WT. (Kg)	PRE OP SPO2 (%)	DOS (min)	DOA (min)	HEMODYNAMIC PARAMETER					VENTILATOR PARAMETERS					NO. OF RM	INFLATION PRESSURE (cmH2O	POST OP SPO2 (%)	ATELECTASIS		URM/UC	ASA GRADE
								SYS BP (mmHg)	DIAS BP (mmHg)	HR (bpm)	INTRA OP SPO2 (%)	ETCO2	VT (ml)	Plat	PEAK	PEEP	MV				T3	T4		I
1	Vimala	50	F	65	100	105	120	130	80	76	100	37	460	17	22	5	3.4			97	Absent	Present	UC	I
2	Mahadev	57	M	70	100	110	120	140	80	64	100	36	480	14	24	5	4			97	Absent	Present	UC	I
3	Gangotri	21	F	45	100	45	60	134	68	78	100	38	360	17	24	5	5			97	Absent	Absent	UC	I
4	Ningavva	75	M	88	100	105	120	120	60	76	100	38	480	18	22	5	4	3	15	98	Absent	Present	URM	II
5	Prabhugonda	65	M	85	100	105	120	124	78	66	100	36	480	17	22	5	5			95	Absent	Present	UC	II
6	Sharanbai	60	F	70	100	110	120	128	78	76	100	35	460	15	24	5	6			96	Absent	Present	UC	II
7	Parvati	60	F	78	100	110	120	130	80	78	100	36	480	18	24	5	4.6	3	15	99	Absent	Absent	URM	II
8	Siddavva	60	F	84	99	165	180	124	78	88	100	37	480	16	24	5	3			94	Present	Present	UC	II
9	Laxmibai	60	F	88	99	110	120	130	78	86	100	36	480	17	24	5	3.4			95	Present	Present	UC	I
10	Shobha	57	F	90	100	110	120	144	76	88	100	40	500	19	26	7	4	5	20	100	Absent	Absent	URM	I
11	Bhagirathi	52	F	60	98	225	240	150	88	76	100	36	420	18	23	5	4.4			94	Present	Present	UC	I
12	Sujata	35	F	60	100	105	120	126	88	74	100	37	400	14	24	5	4.2	4	10	100	Absent	Absent	URM	I
13	Hanamava	40	F	65	99	105	120	150	90	66	100	35	420	13	22	5	5.2			95	Absent	Absent	UC	II
14	Pundalik	43	M	88	98	105	120	144	88	88	100	35	480	15	22	5	5.4	4	10	98	Absent	Present	URM	I
15	Vilas	29	M	78	99	50	60	100	70	98	100	36	460	16	22	5	5.5			94	Present	Present	UC	I
16	Shantabai	45	F	76	100	105	120	110	68	90	100	36	480	14	24	5	5.4	3	15	100	Absent	Absent	URM	I
17	Shantabai	64	F	66	100	110	120	110	78	70	100	37	420	16	24	5	3.4			96	Absent	Present	UC	II
18	Radhabai	73	F	55	99	105	120	114	88	74	100	34	460	17	24	5	3.6			94	Present	Present	UC	II
19	Roopa	24	F	56	99	110	120	116	86	64	100	35	420	14	23	5	5.7			97	Absent	Absent	UC	I
20	Amasida	45	M	76	98	105	120	130	88	66	100	36	480	16	22	5	6.4	4	15	94	Present	Present	UC	I
21	Amita	22	F	54	99	45	60	134	78	78	100	36	420	14	24	5	3	2	10	96	Absent	Present	URM	I
22	Kaveri	26	F	50	100	315	330	144	76	84	100	37	400	19	20	5	4	5	20	97	Present	Present	URM	I
23	Rakshita	19	F	48	100	30	60	142	66	64	100	38	340	17	20	5	3.4			97	Absent	Absent	UC	I
24	Wheeda	48	F	78	99	90	120	150	94	78	100	37	480	18	22	5	5.6	3	15	95	Present	Present	URM	II
25	Venkappa	56	M	88	100	165	180	154	88	94	100	35	480	15	24	5	5	4	20	100	Absent	Absent	URM	II
26	Komal	22	F	65	99	90	60	130	80	96	100	36	460	14	26	5	6.2	4	10	96	Present	Present	URM	I
27	Champalal	60	M	77	99	150	180	134	78	74	100	36	480	16	25	5	4.1	4	15	97	Absent	Present	URM	II
28	Fatima	34	F	76	100	30	45	134	88	76	100	37	480	17	24	5	4.1	4	10	96	Present	Present	URM	I
29	Meenakshi	30	F	70	100	50	60	140	78	88	100	38	480	15	20	5	5.3	3	10	100	Absent	Absent	URM	I
30	Arjun	78	M	80	100	90	120	142	98	78	100	36	480	15	22	5	4.6	3	15	97	Absent	Present	URM	II
31	Shankarao	69	M	88	99	135	150	146	80	64	100	37	500	15	23	5	6			95	Absent	Present	UC	II
32	Chandrakala	40	F	56	99	45	60	138	76	76	100	38	420	14	24	5	5.8	2	10	96	Absent	Absent	URM	I
33	Nisha	31	F	47	99	50	60	140	90	74	100	36	380	17	22	5	4.7	3	10	96	Absent	Absent	URM	I
34	Chandrakala	44	F	58	100	50	60	14	78	78	100	36	420	15	24	5	4.6	3	10	97	Absent	Present	URM	I
35	Ashwini	24	F	54	99	80	90	146	86	88	100	37	400	16	25	5	4.2			93	Present	Present	UC	I
36	Sheela	42	F	60	98	30	40	150	88	98	100	38	460	17	22	5	5.1			94	Absent	Present	UC	II
37	Laxmi	37	F	88	100	50	60	120	64	74	100	36	480	18	24	5	4.4	3	10	99	Absent	Absent	URM	II
38	H M Hadagalli	40	M	98	100	165	180	124	80	78	100	40	500	15	28	7	4.3	5	20	98	Absent	Present	URM	II
39	Gururaj	18	M	56	100	50	60	126	86	76	100	38	420	14	23	5	5.3			95	Absent	Absent	UC	I
40	Shankramma	56	F	66	100	105	60	124	80	84	100	36	420	15	22	5	4.4	3	15	99	Absent	Present	URM	I

41	Mananda	39	F	86	100	285	300	120	80	88	100	37	480	16	25	5	4.2	5	20	96	Present	Present	URM	I
42	Sarfaraj	35	F	56	99	135	150	122	64	82	100	35	440	17	23	5	5.4			94	Present	Present	UC	I
43	Preethi	18	F	48	98	45	60	122	86	92	100	36	380	15	20	5	6			93	Present	Present	UC	I
44	Manoj	59	M	78	99	90	120	124	64	62	100	34	480	17	22	5	5.4			94	Present	Present	UC	I
45	Sumangala	80	F	78	100	50	60	128	78	94	100	35	480	16	24	5	4	3	15	96	Present	Present	URM	II
46	Nirmala	39	F	68	100	105	120	116	84	76	100	36	460	14	25	5	4.1	4	15	100	Absent	Absent	URM	I
47	Yallavva Metri	36	F	68	100	60	75	110	78	76	100	37	460	16	26	5	4.2	4	10	97	Absent	Present	URM	I
48	Rukmabai	46	F	70	100	105	120	100	60	78	100	36	480	15	27	5	4.3	3	15	96	Present	Present	URM	I
49	Bouramma	37	F	66	98	45	60	124	84	66	100	35	480	14	24	5	5.2			93	Present	Present	UC	I
50	Noorjan	63	F	70	99	60	90	122	76	86	100	37	480	14	25	5	3.2			94	Present	Present	UC	II
51	Hulagamma	78	F	54	99	60	75	124	78	98	100	38	400	15	22	5	5.4			93	Present	Present	UC	II
52	Mala	32	F	66	100	50	60	130	78	64	100	38	420	16	24	5	5.4	3	10	100	Absent	Absent	URM	I
53	Prabhakar	32	M	88	98	45	60	124	76	64	100	36	470	17	22	5	4			93	Present	Present	UC	I
54	Narsavva	50	F	54	100	90	105	124	86	76	100	36	420	14	22	5	7	4	15	98	Absent	Present	URM	I
55	Bhimaraya	18	M	46	100	30	45	110	72	86	100	37	380	15	24	5	6.4	3	10	99	Absent	Absent	URM	I
56	Basavaraj	55	M	54	99	75	90	124	76	88	100	35	380	16	23	5	5.6			93	Present	Present	UC	I
57	Danamma	34	F	64	100	120	135	124	78	76	100	35	460	15	23	5	3.8	4	15	96	Present	Present	URM	I
58	Renuka	46	F	50	98	45	60	110	88	88	100	34	460	17	20	5	5.2			93	Absent	Present	UC	I
59	Basavaraj	29	M	54	99	30	45	130	86	86	100	38	420	15	22	5	5.8			93	Present	Present	UC	I
60	Renuka	42	F	44	99	50	60	124	68	82	100	38	420	15	20	5	4.4			94	Present	Present	UC	I
61	laxmi	29	F	46	100	30	45	130	88	74	100	37	380	14	21	5	5.3	4	10	96	Absent	Present	URM	I
62	Navshad	58	F	70	100	60	75	134	64	88	100	36	480	16	22	5	6.1	3	10	100	Absent	Absent	URM	I
63	Saleem	36	F	64	100	60	75	140	84	76	100	38	480	18	24	5	5.6	3	10	96	Present	Present	URM	I
64	Suresh	32	M	70	100	50	60	140	78	76	100	36	460	19	22	5	5	4	10	100	Absent	Absent	URM	I
65	Shivraj	20	M	55	100	165	180	144	76	78	100	38	400	14	24	5	4	4	15	100	Absent	Absent	URM	I
66	Sachin	22	M	54	100	120	150	154	76	84	100	36	400	13	25	5	3.4	5	15	100	Absent	Absent	URM	I
67	Bebibai	38	F	60	100	170	180	134	86	72	100	37	420	15	22	5	4.6	5	15	98	Absent	Present	URM	I
68	Nalasavva	48	F	64	100	60	90	120	78	88	100	35	440	17	24	5	3.2	4	10	100	Absent	Absent	URM	I
69	Akshata	38	F	74	100	90	105	132	74	62	100	36	460	17	26	5	4.1	3	10	100	Absent	Absent	URM	I
70	Chandra	54	M	70	99	60	75	120	80	88	100	34	460	16	24	5	4.3			94	Absent	Present	UC	I
71	Vinod	64	M	80	98	105	120	110	70	86	100	38	480	15	24	5	5.6			93	Present	Present	UC	II
72	Manjula	70	F	76	99	120	135	110	78	74	100	38	480	14	22	5	5.3			94	Present	Present	UC	II
73	Supriya	60	F	56	98	105	120	144	80	82	100	36	400	17	23	5	5.1			94	Absent	Present	UC	II
74	Muneera	56	F	55	99	120	135	140	80	94	100	38	400	18	24	5	4.2			95	Absent	Present	UC	I
75	Geeta	40	F	46	100	60	90	154	80	82	100	34	380	15	22	5	4.6			96	Absent	Present	UC	I
76	Donnur	80	M	60	100	60	75	150	90	80	100	34	420	17	26	5	5.6			95	Present	Present	UC	II
77	Mayawwa	55	F	66	99	75	90	120	86	90	100	38	460	19	27	5	4			96	Absent	Present	UC	I
78	Mahadevi	52	F	65	98	60	75	124	68	86	100	37	460	18	26	5	5.6			94	Present	Present	UC	I
79	Komasingh	68	M	75	100	90	105	130	80	72	100	35	480	16	24	5	5			95	Present	Present	UC	II
80	Basavaraj	49	M	78	99	120	135	120	80	68	100	36	480	18	22	5	5.4			94	Absent	Present	UC	I
81	Mohan	58	M	64	100	60	90	150	90	84	100	34	420	17	24	5	5.3	3	10	100	Absent	Absent	URM	I
82	Chinmay	40	M	70	100	60	75	120	76	74	100	32	440	15	24	5	4.3	3	10	100	Absent	Absent	URM	I

ANNEXURE V

PLAGIRAISM REPORT

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