COMPARATIVE IMPACT OF LAPAROTOMY AND THORACOSTOMY ON RPP OF PATIENTS: A GUIDE TO POST-SURGICAL PHYSIOTHERAPY PRESCRIPTION

BY

ODION OSAHENRUNMWEN EMMANUEL

(BMS2001286)

A PROJECT SUBMITTED TO THE DEPARTMENT OF PHYSIOTHERAPY, SCHOOL OF BASIC MEDICAL SCIENCES, COLLEGE OF MEDICAL SCIENCES, UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF PHYSIOTHERAPY.

OCTOBER, 2025.

CERTIFICATION

This dissertation by **ODION OSAHENRUNMWEN EMMANUEL** is accepted in its present form as satisfying the dissertation requirement of the degree of Bachelor of Physiotherapy of the School of Basic Medical Sciences, College of Medical Sciences of the University of Benin.

DR. MRS. C.O OBASEKI
SUPERVISOR **SIGN & DATE**

EXTERNAL EXAMINER
SIGN & DATE

APPROVED

DR. (MRS.) CHIGOZIE .O. OBASEKI
AG. HEAD OF DEPARTMENT
DEPARTMENT OF PHYSIOTHERAPY
COLLEGE OF MEDICAL SCIENCES
UNIVERSITY OF BENIN, BENIN CITY.

DEDICATION

This work is dedicated to God Almighty for the strength, grace, and courage to finish this project and see it through. To my ever-loving and supportive mother, Mrs. Patricia Itohan Igbinedion and my siblings, for providing me with the strength, morale, support, prayers, and funds to complete my academic journey.

ABSTRACT

Background:

Laparotomy and thoracostomy are major invasive procedures that impose distinct physiological stresses on the cardiovascular system. The rate-pressure product (RPP), an index of myocardial oxygen demand, provides a reliable measure of cardiovascular workload following surgical interventions. Understanding how these procedures influence RPP is essential for physiotherapists in planning safe and effective post-surgical rehabilitation.

Methods:

An observational prospective cohort design was employed. Forty surgical patients with a mean age (CTTD: 44.0 ± 12.43 years; Laparotomy: 42.4 ± 23.12 years) were recruited through simple random sampling and assigned to two groups: laparotomy (n = 20) and closed-tube thoracostomy drainage (CTTD) (n = 20). Cardiovascular parameters—systolic blood pressure (SBP) and pulse rate (PR)—were recorded preoperatively and at 24, 48, and 72 hours postoperatively using an automated monitor. RPP was computed as SBP × PR. Pain intensity was assessed using the Visual Analogue Scale (VAS). Data were analyzed using descriptive statistics, paired and independent *t*-tests, and repeated measures ANOVA, with significance set at $p < 0.05$.

Results:

Thirty-one patients (20 laparotomy, 11 CTTD) completed the study. Baseline SBP, PR, and RPP were comparable between groups. Both groups exhibited postoperative fluctuations in SBP and PR, yet RPP remained relatively stable across all time points. Paired *t*-tests revealed no significant changes in RPP within groups, though the laparotomy group showed significant reductions in PR at 24 and 48 hours ($p < 0.001$). Repeated measures ANOVA confirmed no significant time effect on RPP in either group (CTTD: $F(3, 30) = 0.929$, $p = 0.439$; laparotomy: $F(3,57) = 1.536$, $p = 0.215$). Between-group comparisons showed no significant RPP differences at any interval ($p > 0.05$). Mean VAS scores were similar (CTTD: 3.00 ± 0.82; laparotomy: 3.20 ± 0.76).

Conclusion:

Laparotomy and thoracostomy procedures exert comparable effects on myocardial workload, as indicated by stable RPP values across postoperative periods. These findings suggest that cardiovascular responses following both surgeries are similar and that physiotherapy prescriptions should be guided by individualized patient assessment rather than procedure type alone.

Keywords:

Laparotomy, Thoracostomy, Rate Pressure Product, Myocardial Workload, Postoperative Physiotherapy, Cardiovascular Response.

ACKNOWLEDGEMENTS

I would like to express my appreciation and gratitude to God for his grace, love, and support. I am grateful for the successful completion of this work and for His protection and guidance throughout my stay on this campus. I also want to thank all the people who have helped and supported me throughout the process.

My heartfelt gratitude goes to my supervisor, Dr. Mrs. Chigozie Obaseki, for her assistance and guidance during the research study. I am highly indebted and grateful that despite her busy schedule, she devoted her time to listening to me, answering questions, reading through my work, and making corrections. May the good Lord bless and reward you.

I sincerely thank the Head of the Department, Dr. (Mrs.) C.O. Obaseki and all the lecturers of the Department of Physiotherapy, University of Benin, Prof. K. I. Oke, Mr. E. Okhuahesuyi , Prof. Joseph Umunnah, Dr. Nelson Ekechukwu, Dr. Bolarinde, Dr. (Mrs) A. Aiyegbusi, Prof. Obinna Ezeukwu, Dr. Oghumu, Dr. (Mrs) Kubeyinje and all who imparted knowledge in me during my stay in school. I also appreciate the non-academic staffs, especially Mr. Nosa, of the Department of Physiotherapy, University of Benin.

I would like to express my gratitude to the Head of the Department (UBTH), Dr. Taiwo Oyewumi, and also to the chiefs, interns, and other clinicians in the Department of Physiotherapy, University of Benin Teaching Hospital. I appreciate the knowledge and skills imparted to me during my studentship there.

My profound gratitude and love go to my mother Mrs. Patricia Itohan Igbinedion who stood by me and supported me with her love, encouragement, prayers and financial support all through my education and life as a whole and to my siblings (Nosakhare Peace, Osawhonuyi Collins and Osasere Rachael) for the continuous love and support all through the years.

I will also like to thank my friends Hope Ewere, Omosigho Osahenrunmwen Petonia, Oduah Martina, Okoduwa Gift, Odiong Peter, Caleb Okhogbe, Joseph Ibeh, Umoren Great and the A'CLASS Gees for making my stay in school memorable and worthwhile. My special thanks and gratitude go to PT. Delphine Chilozie for her assistance during the period of my data collection. I am most grateful to PT. Aimienoho O. Shedrach and Mrs Josephine Oyeneye for their love, encouragement and support all through my academic journey.

Lastly, I would like to thank all participants who volunteered and consented for their cooperation in making this project successful and to others whom the confines of this page will not permit me to state.

TABLE OF CONTENTS

TITLE PAGE i

CERTIFICATION ii

DEDICATION iii

ABSTRACT iv

ACKNOWLEDGEMENTS v

TABLE OF CONTENTS vii

LIST OF TABLES xii

LIST OF FIGURES xiii

CHAPTER ONE:INTRODUCTION 1

1.1 Background of the Study **Error! Bookmark not defined.**

1.2 Statement of the Problem **Error! Bookmark not defined.**

1.3 Research Questions 4

1.4 Aim(s) of the Study. 4

1.5 Objectives of the Study 4

1.6 Hypothesis 4

1.6.1 Main Hypothesis 4

1.6.2 Sub-Hypothesis 5

1.6 Significance/Justification of the Study 5

1.7 Scope/Delimitations of the Study 5

1.8 Limitations of the Study 6

1.9 Definition of Terms 6

1.9.1 List of Abbreviations 6

CHAPTER TWO: LITERATURE REVIEW 8

2.1 Conceptual Framework **Error! Bookmark not defined.**

2.1.1 Concept of Post-Surgical Physiotherapy **Error! Bookmark not defined.**

2.1.2 Concept of Laparotomy and Thoracostomy **Error! Bookmark not defined.**

2.1.3 Understanding Rate Pressure Product (RPP) as a Cardiovascular Indicator **Error! Bookmark not defined.**

2.1.4 Physiological Basis of RPP in Post-Surgical Recovery **Error! Bookmark not defined.**

2.1.5 Clinical Relevance of Monitoring RPP During Rehabilitation **Error! Bookmark not defined.**

2.2 Overview of Laparotomy **Error! Bookmark not defined.**

2.2.1 Definition and Classification of Laparotomy **Error! Bookmark not defined.**

2.2.2 Indications for Laparotomy **Error! Bookmark not defined.**

2.2.3 Surgical Procedures and Techniques in Laparotomy **Error! Bookmark not defined.**

2.2.4 Physiological and Cardiovascular Effects of Laparotomy **Error! Bookmark not defined.**

2.2.5 Post-Laparotomy Complications Affecting Rehabilitation **Error! Bookmark not defined.**

2.2.6 Physiotherapy Management Following Laparotomy **Error! Bookmark not defined.**

2.3 Overview of Thoracostomy **Error! Bookmark not defined.**

2.3.1 Definition and Types of Thoracostomy (Open vs. Closed) **Error! Bookmark not defined.**

2.3.2 Indications and Surgical Techniques **Error! Bookmark not defined.**

2.3.3 Cardiopulmonary and Musculoskeletal Implications of Thoracostomy **Error! Bookmark not defined.**

2.4.1 Anatomical and Physiological Differences in Surgical Impact **Error! Bookmark not defined.**

2.4.2 Pain Response and Functional Limitation in Both Procedures **Error! Bookmark not defined.**

2.4.3 Cardiovascular and Pulmonary Responses to Surgery **Error! Bookmark not defined.**

2.4.4 Comparative Effects on Rate Pressure Product (RPP) **Error! Bookmark not defined.**

2.4.5 Recovery Duration and Rehabilitation Needs **Error! Bookmark not defined.**

2.4.6 Implications for Post-Surgical Physiotherapy Intervention **Error! Bookmark not defined.**

2.5 Rate Pressure Product (RPP) and Its Clinical Importance **Error! Bookmark not defined.**

2.5.1 Definition and Physiological Basis of RPP **Error! Bookmark not defined.**

2.5.2 Factors Influencing RPP in Surgical Patients **Error! Bookmark not defined.**

2.5.3 Relationship Between RPP, Myocardial Oxygen Demand, and Exercise Tolerance **Error! Bookmark not defined.**

2.5.4 Application of RPP in Physiotherapy and Exercise Prescription **Error! Bookmark not defined.**

2.5.5 RPP as an Indicator of Post-Surgical Cardiac Stress and Recovery **Error! Bookmark not defined.**

2.6 Post-Surgical Physiotherapy Prescription and Practice **Error! Bookmark not defined.**

2.6.1 Principles of Post-Surgical Rehabilitation **Error! Bookmark not defined.**

2.6.2 Early Mobilization and Breathing Exercises **Error! Bookmark not defined.**

2.6.3 Supervised Exercise Sessions **Error! Bookmark not defined.**

2.6.3.1 High-Intensity Interval Training (HIIT) **Error! Bookmark not defined.**

2.6.3.2 Moderate-Intensity Continuous Training (MICT) **Error! Bookmark not defined.**

2.6.3.3 Progressive Resistance Training (PRT) **Error! Bookmark not defined.**

2.6.4 Psychological Support and Motivation **Error! Bookmark not defined.**

2.6.5 Physiotherapy Techniques for Pain and Functional Restoration **Error! Bookmark not defined.**

2.6.6 Cardiopulmonary Conditioning and Monitoring RPP During Therapy **Error! Bookmark not defined.**

2.6.7 Precautions and Safety Measures During Post-Surgical Rehabilitation **Error! Bookmark not defined.**

2.7 Empirical Review 57

2.8 Theoretical Framework **Error! Bookmark not defined.**

2.9 Summary of Literature Review **Error! Bookmark not defined.**

CHAPTER THREE:MATERIALS AND METHODS 64

3.1 MATERIALS **Error! Bookmark not defined.**

3.1.1 Population **Error! Bookmark not defined.**

3.1.2 Selection Criteria **Error! Bookmark not defined.**

3.1.2.1 Inclusion Criteria **Error! Bookmark not defined.**

3.1.2.2 Exclusion Criteria **Error! Bookmark not defined.**

3.1.3 List of Instruments **Error! Bookmark not defined.**

3.1.3.1 Description of the Instruments **Error! Bookmark not defined.**

3.2 Methods **Error! Bookmark not defined.**

3.2.1 Research Design **Error! Bookmark not defined.**

3.2.2 Sampling Technique **Error! Bookmark not defined.**

3.2.3 Sample Size **Error! Bookmark not defined.**

3.2.3 Ethical Consideration **Error! Bookmark not defined.**

3.2.4 Procedure for Data Collection **Error! Bookmark not defined.**

3.2.6 Data Analysis **Error! Bookmark not defined.**

CHAPTER FOUR:RESULTS 70

4.1 Sociodemograhic profile of the participants **Error! Bookmark not defined.**

4.2 The systolic blood pressure, pulse rate and rate pressure products of individuals who undergone CTTD and Laparatomy at baseline, 24 hours, 48 hours and 72 hours after procedure. **Error! Bookmark not defined.**

4.1.3 Paired T test comparing Baseline in SBP, PR and RPP in indidviduals with CTTD **Error! Bookmark not defined.**

4.1.4 Paired T test comparing Baseline in SBP, PR and RPP in indidviduals with Laparatomy **Error! Bookmark not defined.**

4.1.5 Repeated Measures ANOVA comparing baseline and follow-up RPP in individuals with CTTD and Laparotomy **Error! Bookmark not defined.**

4.1.6 : Independent T test comparing RPP values at different time interval between CTTD and Laparotomy procedures **Error! Bookmark not defined.**

4.2 Hypothesis testing 83

CHAPTER FIVE:DISCUSSION, CONCLUSION, AND RECOMMENDATIONS 85

5.1 Discussion of Findings **Error! Bookmark not defined.**

5.1.1 Socio-demographic Characteristics **Error! Bookmark not defined.**

5.1.2 Systolic Blood Pressure and Pulse Rate Trends **Error! Bookmark not defined.**

5.1.3 Rate Pressure Product (RPP) Across Time Points **Error! Bookmark not defined.**

5.1.4 Hypothesis Testing and Comparative Findings **Error! Bookmark not defined.**

5.1.5 Cardiovascular Response Following Surgery **Error! Bookmark not defined.**

5.1.6 Comparative RPP Between Laparotomy and Thoracostomy Groups **Error! Bookmark not defined.**

5.2 Implications for Rate-Pressure Product as a Monitoring Tool **Error! Bookmark not defined.**

5.2.1 Clinical Implications for Physiotherapy Practice **Error! Bookmark not defined.**

5.2.2 Implications for Physiotherapy Practice **Error! Bookmark not defined.**

5.3 Conclusion 85

5.4 Recommendations **Error! Bookmark not defined.**

REFERENCES 91

APPENDICES 100

APPENDIX 1:INFORMED CONSENT FORM 100

APPENDIX II: SOCIO:DEMOGRAPHIC FORM 96

APPENDIX III: ETHICAL APPROVAL 98

LIST OF TABLES

Table 1: Sociodemographic characteristics of the participants 71

Table 2: The systolic blood pressure, pulse rate and rate pressure products of individuals who undergone CTTD and Laparatomy at baseline, 24 hours, 48 hours and 72 hours after procedure. 73

Table 3: Paired T test comparing Baseline in SBP, PR and RPP in indidviduals with CTTD 75

Table 4: Paired T test comparing Baseline in SBP, PR and RPP in indidviduals with Laparatomy 77

Table 5: Repeated Measures ANOVA comparing baseline and follow-up RPP in individuals with CTTD 79

Table 6: Repeated Measures ANOVA comparing baseline and follow-up RPP in individuals with Laparotomy 80

Table 7: Independent T test comparing RPP values at different time interval between CTTD and Laparotomy procedures 82

LIST OF FIGURES

Figure 1: Surgical Exposure of the Abdomen in Exploratory Laparotomy 16

Figure 2: Surgical Incisions in Exploratory Laparotomy 20

Figure 3: Basic view of Thoracostomy process in Chest Tube Drainage 27

: Surgical steps in CTTD procedure. 32

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Laparotomy and thoracostomy are invasive surgical interventions frequently utilized to manage conditions affecting the abdomen and chest, respectively. Laparotomy, specifically open abdominal surgery, requires a substantial incision through the abdominal wall to gain access to the viscera. This approach is commonly employed in cases of intestinal obstruction or traumatic injury and is associated with a reduction in intra-abdominal pressure (Van Damme and De Waele, 2018). Such a decrease in intra-abdominal pressure can markedly affect hemodynamic variables, including venous return, cardiac output, and arterial pressure. Conversely, thoracostomy is frequently conducted as a closed tube thoracostomy drainage procedure. This involves placing a chest tube to evacuate air, blood, or fluid from the pleural cavity, most often in instances of pneumothorax or hemothorax (Lyons et al., 2024). The intervention directly involves the thoracic wall and frequently impacts the pleura and lung tissue. The procedure is known to induce significant postoperative pain, which may impair respiratory mechanics and negatively influence pulmonary function and the overall course of recovery (Gunay et al., 2016). The distinct anatomical and physiological disruptions caused by these two surgical approaches suggest that the resulting cardiovascular responses, assessed through the rate pressure product, are likely to differ considerably. Acknowledging such distinctions is crucial for formulating precise and efficacious post-surgical physiotherapy regimens.

Both surgical procedures impose considerable physiological demands on individuals, influencing cardiovascular indicators such as heart rate and blood pressure. Postoperative physiotherapeutic interventions, including early ambulation, controlled coughing, and inspiratory muscle training, have been shown to enhance patient recovery (Brocki et al., 2016). Nevertheless, the planning of physiotherapy must consider the cardiovascular load induced by surgery, as undue physical strain could heighten myocardial stress, particularly among individuals with pre-existing cardiac vulnerabilities. Although customizing physiotherapy to meet individual patient requirements is of great importance, existing evidence comparing the cardiovascular consequences of laparotomy and thoracostomy on the rate pressure product and the subsequent implications for physiotherapy planning remains scarce. Within African settings, particularly in Nigeria, where access to sophisticated postoperative care may be constrained, comprehending these effects is vital for establishing rehabilitation protocols that are both safe and economically feasible.

Prior research has largely concentrated on immediate postoperative outcomes such as the incidence of infections or the length of hospital stay, with comparatively little focus on how these procedures differ in their impact on cardiovascular measures like the rate pressure product (Shi, 2024). Moreover, studies originating from sub-Saharan Africa that examine how these surgical interventions influence physiotherapy planning are notably absent, despite the distinct healthcare challenges present in the region, such as limited resources and a high burden of concurrent illnesses. Should this investigation uncover meaningful differences in rate pressure product profiles between individuals undergoing laparotomy and those receiving thoracostomy, the results could directly guide decisions regarding the intensity and advancement of physiotherapy. The outcomes of this work will enable physiotherapists to develop adaptive, rate-pressure-product-guided rehabilitation strategies, permitting the modification of exercise intensity and duration based on periodic or real-time assessments.

This research seeks to address a gap in both practice and knowledge by exploring the comparative influence of laparotomy and thoracostomy drainage on the rate pressure product in these patient populations, as well as the ramifications for developing physiotherapy interventions grounded in empirical evidence.

1.2 Statement of the Problem

Physiological stress resulting from laparotomy and thoracostomy has been shown to produce notable alterations in cardiovascular function (Yang et al., 2015). When these physiological shifts are not adequately accounted for in the prescription of postoperative physiotherapy, patients may experience delayed recovery or be placed at risk of adverse cardiovascular events. This concern is particularly pronounced among individuals with preexisting cardiac conditions (Moran et al., 2016). Although research conducted in developed nations has examined the cardiovascular consequences of major surgical procedures, a comparative analysis of laparotomy and thoracostomy with respect to their influence on the rate pressure product and the corresponding implications for physiotherapy management remains scarce.

An elevated myocardial workload following surgery introduces potential risks during the early stages of patient mobilization (Boden et al., 2018). Despite this, physiotherapists frequently lack clear, evidence based guidance regarding how the nature of the surgical procedure affects this workload. In the absence of comparative data on rate pressure product across different surgical types, there exists a risk that rehabilitation protocols may either underestimate or overestimate a patient's physiological capacity during recovery. This study seeks to address this knowledge gap by comparing the rate pressure product in patients who have undergone either laparotomy or conventional thoracostomy with drainage. Furthermore, the study will investigate contextual factors, including resource constraints and patient demographic characteristics, to ensure that the findings are applicable within the Nigerian healthcare setting.

1.3 Research Questions

1. What is the impact of laparotomy on RPP values?
2. What is the impact of CTTD on RPP values?
3. Is there a difference between the impact of both surgical procedures on RPP at different time points?

1.4 Aim(s) of the Study.

The aim(s) of the study are to investigate the comparative impact of laparotomy and thoracostomy drainage on rate pressure product of patients, with the goal of informing physiotherapy prescription and cardiovascular monitoring during early post-operative care.

1.5 Objectives of the Study

The objectives of this study are:

1. To evaluate RPP values at pre-surgery for patients who had laparotomy procedures
2. To evaluate RPP values at pre-surgery for patients who had CTTD procedures
3. To evaluate RPP values at post-surgery for patients who had laparotomy procedures
4. To evaluate RPP values at post-surgery for patients who had CTTD procedures
5. To compare the RPP outcomes between the laparotomy and CTTD groups

1.6 Hypothesis

1.6.1 Main Hypothesis

There is no significant difference in the impact of laparotomy and thoracostomy drainage on the rate-pressure product in post-surgical patients.

1.6.2 Sub-Hypothesis

i. There is no significant difference in RPP values of patients who had undergone laparotomy.

ii. There is no significant difference in RPP values of patients who had undergone the CTTD procedure.

iii. There is no significant difference in the impact of laparotomy and thoracostomy drainage on the rate-pressure product in post-surgical patients.

iv. There is no significant difference in the impact of laparotomy and thoracostomy drainage on the rate-pressure product at different time points in post-surgical patients.

1.6 Significance/Justification of the Study

This investigation will generate evidence based knowledge concerning the cardiovascular consequences of laparotomy and thoracostomy, thereby supporting the formulation of customized physiotherapy protocols. Additionally, it seeks to furnish physiotherapists with empirical data to inform cardiovascular risk stratification and the design of exercise regimens during the early stages of recovery. Through the application of a straightforward, noninvasive metric such as the rate pressure product, clinicians can classify patients according to their cardiovascular workload and adjust rehabilitation strategies accordingly. The outcomes of this research hold relevance for clinical practice, particularly in resource constrained environments where sophisticated monitoring equipment may not be readily available.

1.7 Scope/Delimitations of the Study

The study population consisted of adult patients between the ages of 18 and 65 years who underwent either laparotomy or thoracostomy at a tertiary healthcare facility in Nigeria. The variables assessed were systolic blood pressure and heart rate, from which the rate pressure product was derived as the product of these two measures. A total of 31 participants comprised the sample, with 20 patients assigned to the Laparotomy group and 11 patients to the Thoracostomy group. The inclusion of only 11 participants in the Thoracostomy group was necessitated by the limited number of eligible patients undergoing this procedure within the study period and setting. Both surgical groups included a mix of male and female participants.

1.8 Limitations of the Study

This study was limited by a relatively small sample size, which may reduce generalizability. Additionally, the study's 72-hour follow-up period may not fully capture long-term hemodynamic adaptations. Variations in anesthesia, medication, and individual comorbidities could also have influenced cardiovascular responses. Future research with larger samples and extended monitoring is recommended.

1.9 Definition of Terms

i. Laparotomy: A surgical procedure involving a large incision through the abdominal wall to access the abdominal cavity for diagnostic or therapeutic purposes (Van Damme and De Waele, 2018).

ii. Thoracostomy: A procedure involving the insertion of a tube into the pleural space to drain air, blood, or fluid, typically to treat conditions like pneumothorax or hemothorax (Gunay *et al*., 2016).

iii. Rate Pressure Product (RPP): A cardiovascular parameter calculated as the product of heart rate and systolic blood pressure, indicating myocardial oxygen demand (Yang *et al*., 2015).

iv. Post-Surgical Physiotherapy: Rehabilitation interventions, including exercises and respiratory therapy, designed to enhance recovery and prevent complications after surgery (Sullivan *et al*., 2016).

1.9.1 List of Abbreviations

i. IAP - Intra-Abdominal Pressure

ii. CTTD - Closed Tube Thoracostomy Drainage iii.RPP - Rate Pressure Product

iv.IMT - Inspiratory Muscle Training

CHAPTER TWO
LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 The Concept of Post-Surgical Physiotherapy

Post-surgical physiotherapy constitutes a systematic regimen of interventions grounded in empirical evidence, aimed at enhancing a patient's physical recovery and functional restoration following an operation. This approach incorporates early mobilization, respiratory care, pain alleviation, and a structured progression of exercise to restore movement, avert complications, and foster patient autonomy. Within Enhanced Recovery After Surgery (ERAS) frameworks, the significance of physiotherapy has grown, given that early ambulation and active engagement in respiratory activities are associated with a reduction in postoperative pulmonary issues, venous stasis, and the duration of hospital stays (Tazreean et al., 2022). Physiotherapists are instrumental in observing physiological indicators and overseeing a carefully graded return to activity that facilitates cardiovascular and musculoskeletal rehabilitation.

Postoperative physiotherapeutic measures are directed at counteracting the detrimental consequences of immobility and surgical trauma, including muscular atrophy, alveolar collapse, and physical deconditioning. By employing methods such as controlled breathing exercises, airway clearance techniques, incentive spirometry, and early ambulation training, physiotherapists contribute to improved lung expansion and tissue oxygenation, factors essential for effective wound healing and systemic recuperation (Burgess et al., 2025). Furthermore, specific exercises for the limbs combined with postural guidance support venous circulation and mitigate thromboembolic risks, while patient education regarding proper body movement fosters confidence in performing daily activities independently. A growing body of evidence supporting multimodal physiotherapy indicates superior outcomes when such interventions are initiated within 24 to 48 hours post-surgery, underscoring its essential position within surgical care protocols.

In addition, the contemporary scope of post-surgical physiotherapy has expanded to incorporate cardiopulmonary surveillance and telehealth-based rehabilitation to ensure both patient safety and treatment continuity. Physiological metrics, such as heart rate, blood oxygen levels, and the Rate Pressure Product (RPP), are commonly employed to assess exercise tolerance and inform the advancement of treatment, particularly for individuals undergoing high-risk cardiac or abdominal procedures (Nishio et al., 2025). These approaches enable physiotherapists to tailor interventions, carefully calibrating exercise intensity against cardiovascular safety considerations, thereby accelerating recovery timelines and enhancing patient satisfaction. Accordingly, the conceptual foundation of post-surgical physiotherapy rests on an integration of clinical judgment, physiological monitoring, and principles of progressive loading, all situated within a collaborative, interdisciplinary model of care.

2.1.2 The Concept of Laparotomy and Thoracostomy

A laparotomy is defined as a surgical opening made into the abdominal cavity, typically performed for diagnostic purposes or therapeutic intervention in cases of trauma, neoplasms, perforations, or obstructions. Classified as a major surgical procedure, it places considerable physiological demands upon both the cardiovascular and respiratory systems. Individuals recovering from laparotomy frequently exhibit diaphragmatic impairment, diminished lung compliance, and respiratory patterns restricted by pain, all of which can compromise gas exchange and overall functional status (Rajaretnam, 2023). Consequently, physiotherapy following laparotomy is focused on restoring diaphragmatic movement, avoiding pulmonary complications, and encouraging gradual mobilization, all while carefully observing cardiovascular responses, including RPP, to prevent excessive strain on the myocardium.

In contrast, thoracostomy entails the placement of a drainage tube within the pleural cavity to evacuate air, blood, or fluid, thereby facilitating the re-expansion of the lung. This procedure is commonly indicated for pneumothorax, hemothorax, and pleural effusions. Thoracostomy directly influences respiratory mechanics by modifying intrathoracic pressure and inducing discomfort that restricts deep breathing, effective coughing, and physical movement (Anderson, 2022). Physiotherapeutic management of these patients involves the application of breathing regulation, localized expansion exercises, and methods to clear airways, thereby preserving optimal ventilation. Moreover, progressive mobilization and adjustments to posture are implemented to support lung re-expansion and alleviate musculoskeletal rigidity associated with the positioning required for thoracostomy.

Although both laparotomy and thoracostomy affect respiratory and cardiovascular function, the nature and degree of physiological disruption differ between the two. Laparotomy predominantly undermines the structural integrity of the abdominal wall and the action of the diaphragm, whereas thoracostomy primarily impacts pulmonary compliance and the mobility of the thoracic cage (Sorino et al., 2024). These distinctions necessitate tailored physiotherapeutic approaches—namely, the provision of abdominal support and the gradual engagement of trunk musculature following laparotomy, contrasted with a focus on thoracic expansion and secretion clearance following thoracostomy. A clear appreciation of these surgical differences facilitates the formulation of precise physiotherapy protocols and enables a more accurate assessment of their distinct effects on recovery metrics such as RPP, which serves as an important marker of cardiovascular rehabilitation and tolerance to physical exertion.

2.1.3 Understanding Rate Pressure Product (RPP) as a Cardiovascular Indicator

The Rate Pressure Product (RPP), commonly termed the "double product," is calculated by multiplying heart rate by systolic blood pressure. This calculation provides an estimate of myocardial oxygen consumption and the workload imposed upon the heart. As a non-invasive metric, it quantifies cardiac strain during physical activity or therapeutic exercise, offering clinicians a practical index of cardiovascular stress applicable to both healthy individuals and those with underlying pathologies. RPP demonstrates a linear increase in response to rising exercise intensity, which corresponds to a proportional rise in myocardial oxygen demand (Zhou et al., 2024). This characteristic renders it a valuable tool for monitoring cardiac safety during physiotherapy interventions, particularly for patients in postoperative or cardiopulmonary contexts.

RPP is a well-established indirect measure of myocardial oxygen uptake (MVO_2) and demonstrates a strong correlation with direct hemodynamic parameters, including coronary blood flow and the left ventricular work index (Jiang et al., 2023). Its straightforward calculation enables continuous assessment at the bedside using standard monitoring equipment, making it an accessible clinical tool for both physicians and physiotherapists. Incorporating RPP evaluation into postoperative protocols allows for the early identification of excessive cardiovascular responses, thereby aiding in the prevention of complications such as myocardial ischemia or arrhythmia during rehabilitation (Boyette, 2023). Additionally, comparing RPP values obtained before and after exercise assists clinicians in evaluating the suitability of prescribed activity levels and tracking the trajectory of cardiovascular recovery.

Within physiotherapy practice, RPP serves to establish safe exercise thresholds and to monitor the heart's response to progressively graded rehabilitation programs. Given that heart rate and systolic pressure are susceptible to influences from anxiety, pain, medication, and surgical stress, RPP offers a more integrated assessment of total cardiac workload. Its application during postsurgical exercise sessions helps ensure that therapeutic intensity remains within safe parameters, especially for patients recovering from abdominal or thoracic surgery who may experience transient hemodynamic instability (Wilkinson et al., 2023). Consequently, RPP functions as both a diagnostic and prognostic instrument, enabling physiotherapists to tailor exercise intensity while maximizing cardiovascular efficiency.

2.1.4 Physiological Basis of RPP in Post-Surgical Recovery

The physiological foundation for using RPP lies in its direct connection to myocardial oxygen consumption (MVO_2), which is largely determined by heart rate and systolic pressure. Following surgery, patients often exhibit heightened sympathetic nervous system activity due to surgical trauma, pain, and inflammation. This response typically elevates both heart rate and blood pressure, consequently increasing RPP (Chen et al., 2024). A persistently elevated RPP signifies an increased cardiac workload and higher oxygen demand, which may hinder recovery or increase susceptibility to ischemic events. Therefore, monitoring this parameter provides crucial insights into the cardiovascular stability of postsurgical patients during early mobilization and rehabilitation.

Moreover, surgical interventions involving the abdomen or thorax frequently impair respiratory mechanics and venous return, contributing to increased cardiac afterload and altered autonomic regulation. Research indicates that effective pain management and early ambulation can help normalize RPP values by enhancing parasympathetic tone and reducing stress-induced catecholamine surges (Liu et al., 2023). This finding underscores the importance of integrating cardiovascular monitoring into physiotherapy sessions to prevent patient overexertion. Clinicians can utilize RPP to identify when a patient has safely adapted to postoperative activity, thereby ensuring that cardiovascular stress remains within physiological limits while supporting recovery.

Furthermore, longitudinal changes in RPP can indicate improvements in cardiac efficiency and oxygen utilization resulting from progressive physiotherapy. As patients build endurance and restore autonomic balance, the RPP response to a consistent workload tends to diminish, signaling enhanced cardiovascular conditioning (Martins et al., 2022). Thus, a thorough understanding of the physiological basis of RPP not only informs clinical assessments of recovery but also underpins evidence-based progression of exercise therapy in postsurgical care.

2.1.5 Clinical Relevance of Monitoring RPP During Rehabilitation

Monitoring RPP throughout rehabilitation provides physiotherapists with an effective means of assessing cardiac workload, helping to ensure that exercise intensity remains both safe and therapeutically beneficial. This consideration is particularly important for patients recovering from major abdominal or thoracic surgeries, where cardiovascular strain may vary due to pain, medication effects, or residual inflammation. By observing RPP responses during treatment sessions, clinicians can identify early indicators of myocardial stress and modify exercise prescriptions accordingly (Bose et al., 2024). The capacity to individualize therapy intensity through RPP monitoring has contributed to enhanced patient safety and improved recovery outcomes across various postsurgical populations.

From a clinical perspective, RPP serves as an indirect yet dependable indicator for evaluating myocardial efficiency and recovery progress. A reduction in RPP at a consistent level of exertion over time suggests improved cardiac adaptation and aerobic capacity, both of which are critical indicators of successful rehabilitation (Mok et al., 2023). For physiotherapists, this feedback mechanism assists in balancing the concurrent goals of promoting mobility while preventing cardiovascular overload. Incorporating RPP into postsurgical rehabilitation protocols aligns with the principles of graded exposure and objective monitoring advocated within Enhanced Recovery After Surgery (ERAS) frameworks.

Additionally, RPP monitoring complements other physiotherapeutic assessments, such as the Borg Rating of Perceived Exertion scale, the six-minute walk test, and oxygen saturation monitoring, thereby offering a multidimensional perspective on patient progress. It serves as a bridge between functional performance and physiological response, which is especially valuable for patients undergoing abdominal or thoracic recovery who may exhibit variable autonomic responses (Zhou et al., 2024). Overall, the clinical importance of RPP extends beyond cardiac care; it provides physiotherapists with a quantitative guide to ensure safe, effective, and individualized rehabilitation following major surgical procedures.

2.2 Overview of Laparotomy

2.2.1 Definition and Classification of Laparotomy

A laparotomy is a major open surgical procedure characterized by a deliberate incision through the abdominal wall to access the peritoneal cavity, performed primarily for the diagnosis or treatment of intra-abdominal conditions (Patel et al., 2022). It remains one of the most traditional and adaptable surgical techniques, granting surgeons direct visualization and access to abdominal organs such as the stomach, intestines, liver, spleen, and reproductive organs (Scott et al., 2023). Although minimally invasive techniques like laparoscopy have become increasingly common, laparotomy continues to be essential in complex, life-threatening, or resource-constrained situations where thorough exploration and tactile assessment are necessary (Ball et al., 2023). The term "laparotomy" is frequently used synonymously with "exploratory laparotomy" when performed for undiagnosed abdominal pain or trauma, highlighting its role as both a diagnostic and therapeutic intervention (Saunders et al., 2021).

Laparotomies are categorized based on their purpose, urgency, and anatomical approach, with each classification carrying implications for patient outcomes and postoperative recovery. With respect to purpose, laparotomies may be diagnostic, aimed at identifying the cause of acute abdominal symptoms, or therapeutic, intended to correct or remove diseased tissue (Mitra et al., 2022). Classification by urgency divides laparotomies into elective, which are planned and conducted under optimized conditions, and emergency, which are performed under time-sensitive circumstances, often for critically ill patients presenting with acute abdomen or trauma (Abiodun et al., 2023). Anatomically, laparotomies are classified according to incision type, including midline, paramedian, transverse, subcostal, and Pfannenstiel incisions, each selected to maximize exposure, minimize tissue trauma, and facilitate closure (Okafor et al., 2021).

In contemporary surgical practice, an advanced subclassification known as damage-control laparotomy is employed, particularly in the management of trauma and sepsis. This approach entails rapid control of hemorrhage and contamination, temporary abdominal closure, and delayed definitive repair until the patient's physiological status has stabilized (Ball et al., 2023). Modern classification systems, such as the National Emergency Laparotomy Audit (NELA) framework, stratify patients according to indication, physiological status, and timing to predict mortality risk and guide postoperative management (Saunders et al., 2021). These classifications are crucial for facilitating communication within multidisciplinary teams and for customizing rehabilitation strategies following surgery, given that outcomes can differ significantly between elective oncologic laparotomies and emergency trauma cases (Mitra et al., 2022).

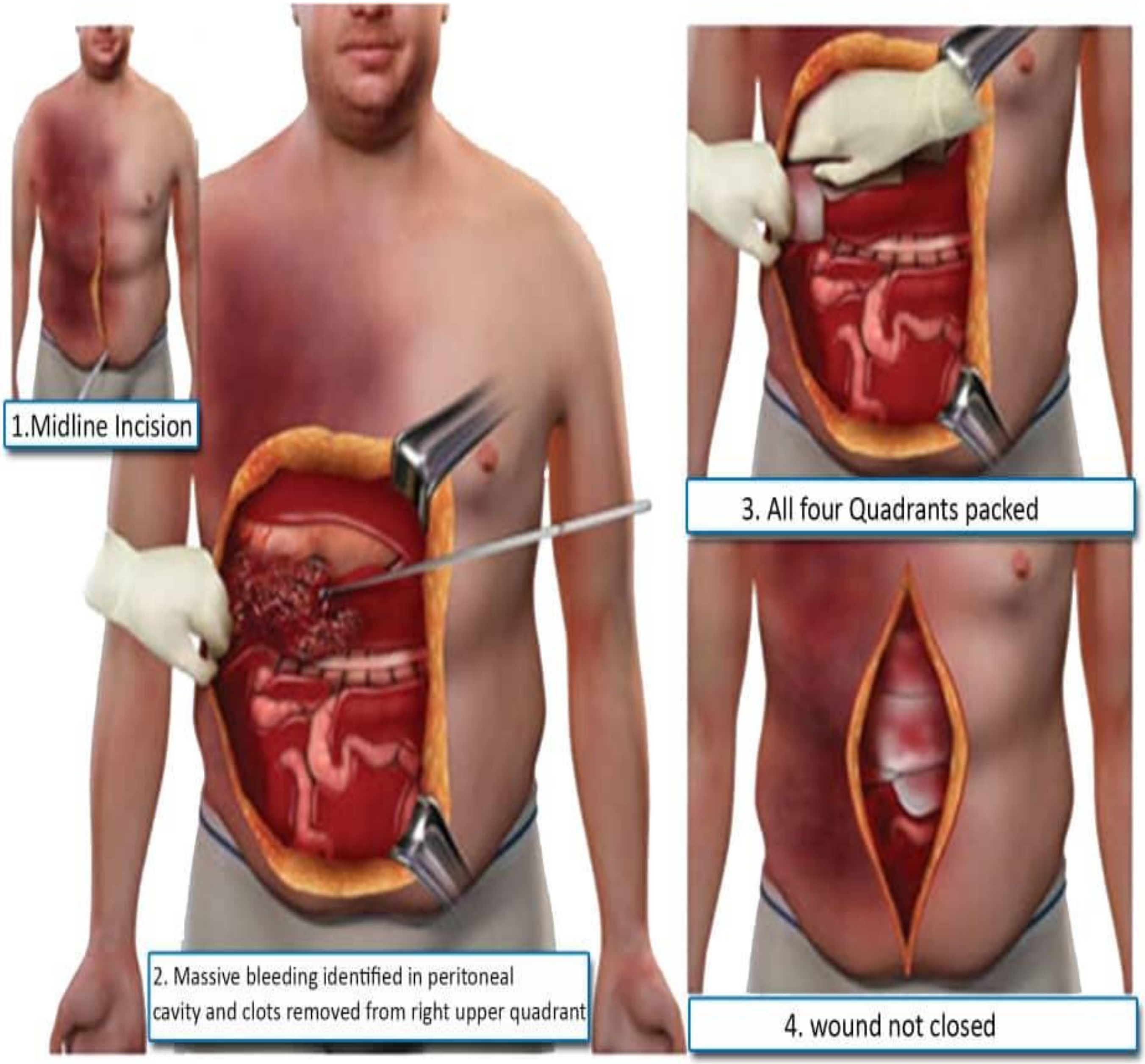


Figure 1: Surgical Exposure of the Abdomen in Exploratory Laparotomy

2.2.2 Indications for Laparotomy

The range of indications for laparotomy is extensive, reflecting the wide variety of abdominal conditions that necessitate direct operative management. This surgical approach is utilized in both urgent and planned contexts. In urgent scenarios, it is frequently undertaken for conditions such as perforated peptic ulcers, bowel obstructions, abdominal trauma, ruptured ectopic pregnancies, perforated appendicitis, and peritonitis (Scott et al., 2023). These pathologies commonly manifest as acute abdominal crises, hemodynamic compromise, or widespread peritoneal inflammation, requiring prompt surgical exploration to avert sepsis, shock, or failure of multiple organs (Patel et al., 2022). Exploratory laparotomy retains its critical role in these instances because it facilitates direct evaluation and management of hemorrhage, perforations, and nonviable tissue, particularly in settings with limited resources where sophisticated imaging or laparoscopic equipment is not accessible (Abiodun et al., 2023).

In the elective context, laparotomy is selected for operations that demand extensive exposure and exacting tissue handling, including oncological resections, major gastrointestinal reconstructions, abdominal hysterectomies, excision of endometriosis, and organ transplantation (Mitra et al., 2022). It is also employed when minimally invasive techniques prove unsuccessful or are unsuitable due to factors such as dense adhesions, substantial tumor dimensions, or concurrent patient health issues (Okafor et al., 2021). The necessity for a laparotomy can also emerge during a laparoscopic procedure if visualization becomes inadequate or complications develop, a situation described as conversion to open surgery (Ball et al., 2023). Such conversions occur frequently in complex colorectal, hepatobiliary, and gynecological operations where tactile feedback is essential for ensuring safety and accuracy.

In trauma cases and obstetric emergencies, laparotomy frequently serves a life-saving function. In the context of trauma, it is warranted for penetrating abdominal injuries, blunt abdominal trauma accompanied by internal hemorrhage, or perforated internal organs (Saunders et al., 2021). For obstetric emergencies, it may be necessary for uterine rupture, uncontrolled postpartum bleeding, or torsion of the adnexa (Okafor et al., 2021). In nations with limited resources, such as Nigeria, where access to imaging and laparoscopic surgery may be constrained, laparotomy remains the standard approach for both diagnosing and managing acute intra-abdominal conditions (Abiodun et al., 2023). Therefore, it continues to hold a vital position in surgical practice, especially within tertiary institutions that manage a large volume of emergency cases.

2.2.3 Surgical Procedures and Techniques in Laparotomy

The technical execution of a laparotomy follows a sequence of methodically organized phases, starting with preoperative preparation, followed by incision, exploration, the principal procedure, and concluding with closure (Scott et al., 2023). Preoperative preparation encompasses fluid resuscitation, the administration of prophylactic antibiotics, and the delivery of anesthesia, all adapted to the patient's physiological state. The midline incision, which may be upper, lower, or extend the full length, is the most frequently employed due to its provision of rapid access, minimal blood loss, and wide exposure to all abdominal quadrants (Patel et al., 2022). Alternative incision types, such as paramedian or transverse, are selected according to the site of the pathology or the aim of reducing postoperative discomfort (Mitra et al., 2022). Following entry into the peritoneum, a thorough exploration is conducted from the diaphragm to the pelvic cavity to locate the pathology before the therapeutic phase begins.

During the operative phase, surgeons apply precise techniques to manage bleeding, minimize contamination, and protect essential anatomical structures. In instances of trauma or sepsis, damage control laparotomy is frequently used to swiftly arrest hemorrhage and contain contamination, followed by temporary closure with sterile dressings or negative pressure wound therapy systems (Ball et al., 2023). In elective operations, emphasis is placed on meticulous dissection, gentle handling of tissues, and strict hemostasis to lower the likelihood of postoperative complications. The selection of surgical instruments and retractors is made carefully to optimize visualization while preserving tissue integrity. Technological advancements, including electrosurgical devices, ultrasonic scalpels, and hemostatic agents, have contributed to greater intraoperative efficiency and shorter operative durations (Saunders et al., 2021).

Wound closure constitutes the final and crucial stage. The fascial layer is generally closed with a continuous absorbable suture, whereas the skin may be closed using interrupted sutures, staples, or adhesive strips (Patel et al., 2022). To reduce the risk of postoperative wound disruption, contemporary guidelines advocate for mass closure techniques employing a suture length to wound length ratio of no less than 4:1 (Scott et al., 2023). For patients at elevated risk, such as those with obesity or malnutrition, the use of mesh reinforcement may be considered to prevent incisional hernia formation (Abiodun et al., 2023). Additionally, the adoption of enhanced recovery after surgery (ERAS) protocols, which prioritize early mobilization, effective pain management, and the early resumption of oral intake, has led to a marked decrease in postoperative complications and a faster return to functional recovery (Mitra et al., 2022).

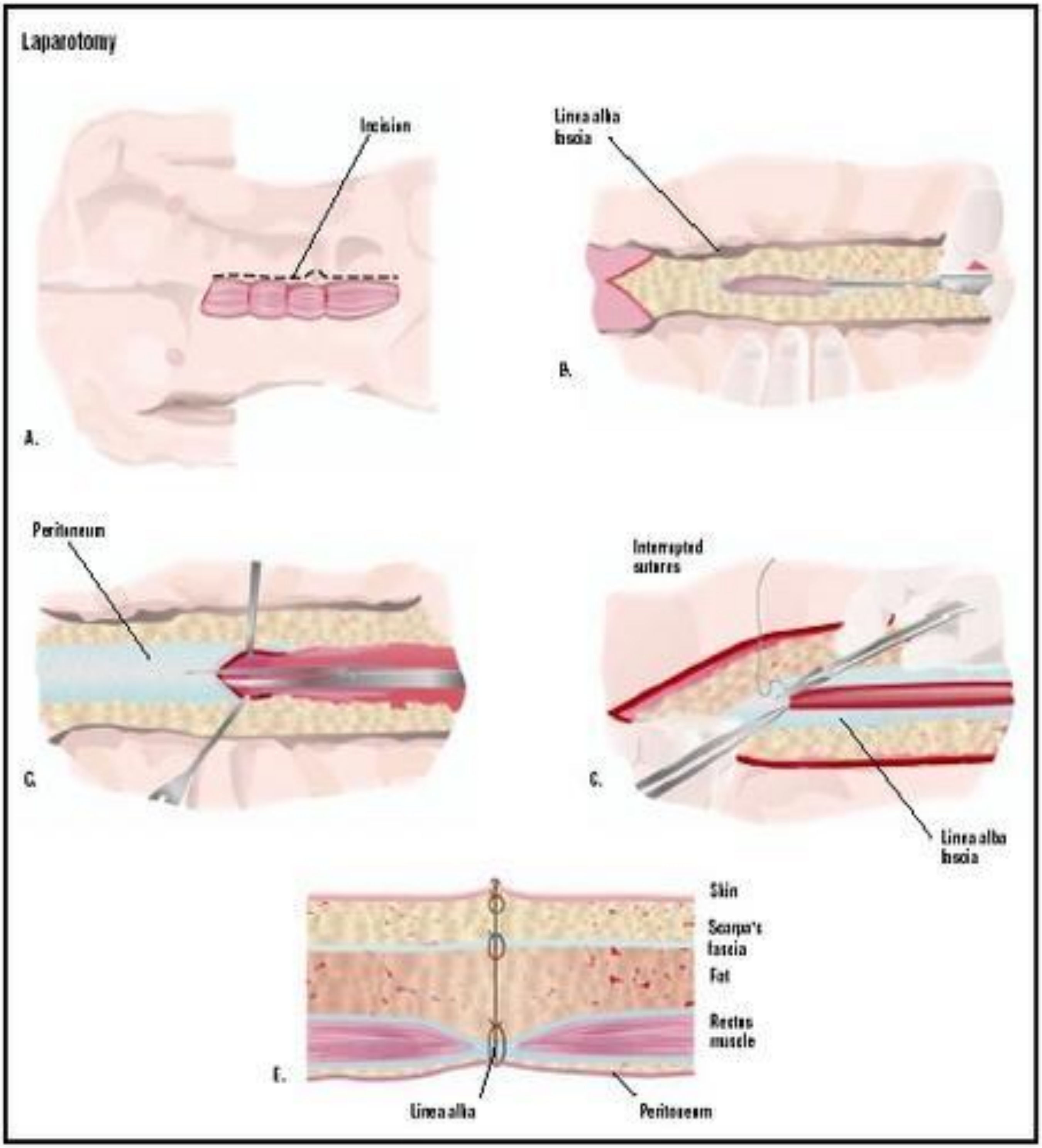


Figure 2: Surgical Incisions in Exploratory Laparotomy

2.2.4 Physiological and Cardiovascular Effects of Laparotomy

The performance of a laparotomy induces complex physiological and cardiovascular changes resulting from surgical injury, the effects of anesthetic agents, and the activation of systemic inflammatory pathways. The surgical incision together with manipulation of the viscera provokes activity within the hypothalamic pituitary adrenal axis, which in turn raises levels of catecholamines, cortisol, and proinflammatory cytokines (Patel et al., 2022). This neuroendocrine activation leads to elevations in heart rate, arterial blood pressure, and the oxygen demand of the myocardium, which can exacerbate existing cardiac conditions. Additionally, the surgical stress response promotes insulin resistance, elevated blood glucose, and alterations in immune function, all of which may delay wound repair and increase susceptibility to infection (Mitra et al., 2022). In older patients or those who are critically unwell, such responses can precipitate postoperative myocardial ischemia or cardiac arrhythmias, underscoring the need for vigilant cardiovascular monitoring (Scott et al., 2023).

During the intraoperative period, hemodynamic instability may arise from blood loss, the administration of anesthesia, and fluctuations in intrathoracic or intraabdominal pressure (Ball et al., 2023). Reduced circulating volume and venous pooling can diminish cardiac output, whereas excessive fluid administration may result in pulmonary edema or place strain on the right ventricle (Saunders et al., 2021). Moreover, exposure of the abdominal viscera prompts the release of vasoactive mediators, including nitric oxide, which contributes to vasodilation and low blood pressure (Abiodun et al., 2023). For these reasons, anesthesiologists and surgical teams must utilize goal directed fluid therapy alongside continuous hemodynamic monitoring to preserve adequate tissue perfusion without imposing excessive demands on the cardiovascular system.

In the postoperative phase, patients frequently exhibit diminished pulmonary compliance and restricted diaphragmatic motion, leading to atelectasis, low blood oxygen levels, and a reduction in functional residual capacity (Okafor et al., 2021). Pain and limited mobility further compromise respiratory mechanics, resulting in decreased oxygen saturation and an elevated risk of pneumonia. From a cardiovascular perspective, venous stasis related to immobility increases the likelihood of deep vein thrombosis and pulmonary embolism. Consequently, physiotherapy strategies implemented after surgery, including early mobilization, deep breathing exercises, incentive spirometry, and activities that promote circulation, are essential for restoring cardiorespiratory function and averting secondary complications (Mitra et al., 2022).

2.2.5 Post-Laparotomy Complications Affecting Rehabilitation

Complications arising after laparotomy exert a substantial influence on a patient's capacity for rehabilitation and the overall course of recovery. Frequently encountered complications include infection at the surgical site, wound dehiscence, intraabdominal abscess, ileus, and the development of incisional hernia (Patel et al., 2022). Surgical site infections are among the most common and typically result from intraoperative contamination, inadequate aseptic practices, or systemic factors such as poorly controlled diabetes and poor nutritional status (Scott et al., 2023). Such infections impede wound healing, extend the duration of hospitalization, and restrict mobility because of associated pain and wound drainage (Ball et al., 2023). In addition, wound dehiscence, characterized by partial or complete separation of the abdominal closure, can severely undermine recovery and may necessitate repeat surgery.

Respiratory and gastrointestinal complications are equally detrimental to the rehabilitation process. Pain induced shallow breathing together with prolonged immobility increases vulnerability to atelectasis, pneumonia, and pulmonary embolism, particularly among elderly individuals and those with obesity (Saunders et al., 2021). Paralytic ileus, a consequence of intestinal manipulation and the effects of anesthesia, delays the reintroduction of oral nutrition, thereby compromising the energy reserves required for effective rehabilitation (Mitra et al., 2022). Venous thromboembolism, often associated with extended periods of bed rest, represents a significant threat to both survival and functional recovery.

Late complications, including incisional hernia, intraabdominal adhesions, and persistent pain, may emerge months after surgery and have lasting effects on functional outcomes (Abiodun et al., 2023). These sequelae compromise core stability, affect postural control, and limit participation in physiotherapy activities. Therefore, rehabilitation protocols following laparotomy must be comprehensive, with emphasis on early mobilization, progressive strength training, respiratory exercises, and effective pain management to optimize function and mitigate complications (Okafor et al., 2021). The physiotherapist thus plays an essential role in restoring independence, reducing disability, and securing optimal outcomes after this surgical procedure.

2.2.6 Physiotherapy Management Following Laparotomy

Physiotherapy is integral to improving postoperative recovery, preventing complications, and restoring functional autonomy after laparotomy. Management is multidisciplinary in nature and commences as early as the immediate postoperative period. Initial efforts concentrate on averting respiratory complications through the use of deep breathing exercises, incentive spirometry, and effective cough techniques (Mitra et al., 2022). Pain control achieved via appropriate positioning, splinting, and gentle movements facilitates lung expansion and the clearance of secretions (Scott et al., 2023). Early mobilization, typically initiated within the first 24 to 48 hours, promotes venous return, reduces the risk of deep vein thrombosis, and encourages gastrointestinal motility (Patel et al., 2022).

During the intermediate phase, physiotherapy interventions shift toward progressive ambulation, postural correction, and core strengthening (Abiodun et al., 2023). Techniques such as lower limb range of motion exercises, trunk stabilization training, and gradual gait retraining help to build endurance and improve balance. The use of an abdominal binder may be recommended to alleviate pain and provide support during movement, particularly for individuals with large incisions or weakened abdominal muscles (Ball et al., 2023). Patients also receive instruction on safe movement strategies, such as the log roll technique for turning in bed, to minimize stress on the healing incision.

Long term physiotherapy goals focus on restoring functional independence, preventing chronic pain, and promoting overall physical fitness (Saunders et al., 2021). Emphasis is placed on strengthening the respiratory and core musculature, improving flexibility, and facilitating a gradual return to normal daily activities. Physiotherapists also attend to psychosocial considerations, supporting patient adherence to exercise regimens and lifestyle modifications that enhance recovery (Okafor et al., 2021). The incorporation of physiotherapy into postoperative care has been demonstrated to reduce morbidity, shorten hospital stays, and improve quality of life, establishing it as an indispensable element of comprehensive rehabilitation following laparotomy (Mitra et al., 2022).

2.3 Overview of Thoracostomy

2.3.1 Definition and Types of Thoracostomy (Open versus Closed)

Thoracostomy is defined as a surgical procedure in which an opening is created in the chest wall to permit insertion of a tube into the pleural cavity for drainage of air, fluid, or blood, thereby restoring negative intrathoracic pressure and enabling lung reexpansion (Martin et al., 2023). This intervention is among the most critical in emergency and critical care medicine for addressing life threatening conditions including pneumothorax, hemothorax, and pleural effusion. According to O'Connor and Adams (2022), the purpose of thoracostomy is to prevent respiratory compromise and mediastinal shift by reestablishing equilibrium between intrapleural and atmospheric pressures. The procedure may be temporary for acute management or maintained for ongoing drainage until the underlying condition resolves.

Two principal forms of thoracostomy exist: open (surgical) and closed (tube) thoracostomy. Open thoracostomy involves making a direct incision through the chest wall, typically between the ribs, and manually placing a large bore chest tube into the pleural cavity under direct visualization (Brown et al., 2023). This approach is often selected in cases of massive hemothorax, empyema, or when large volumes of viscous fluid require evacuation. By contrast, closed thoracostomy, also referred to as tube thoracostomy, is a less invasive technique that employs a trocar or guidewire to insert the chest tube through a small incision with minimal tissue disruption (Johnson et al., 2022). This method is generally used for non traumatic pneumothorax and small effusions where only limited drainage is needed.

The decision between open and closed thoracostomy is influenced by clinical indications, the severity of the condition, and available resources. Recent literature indicates a growing preference for image guided percutaneous (closed) thoracostomy owing to its lower complication rates and improved patient comfort, although open thoracostomy remains indispensable in trauma settings and surgical emergencies (Sharma et al., 2021). Furthermore, the use of ultrasound guidance during tube placement has been shown to decrease the risk of organ injury and malpositioning (Abubakar et al., 2022).

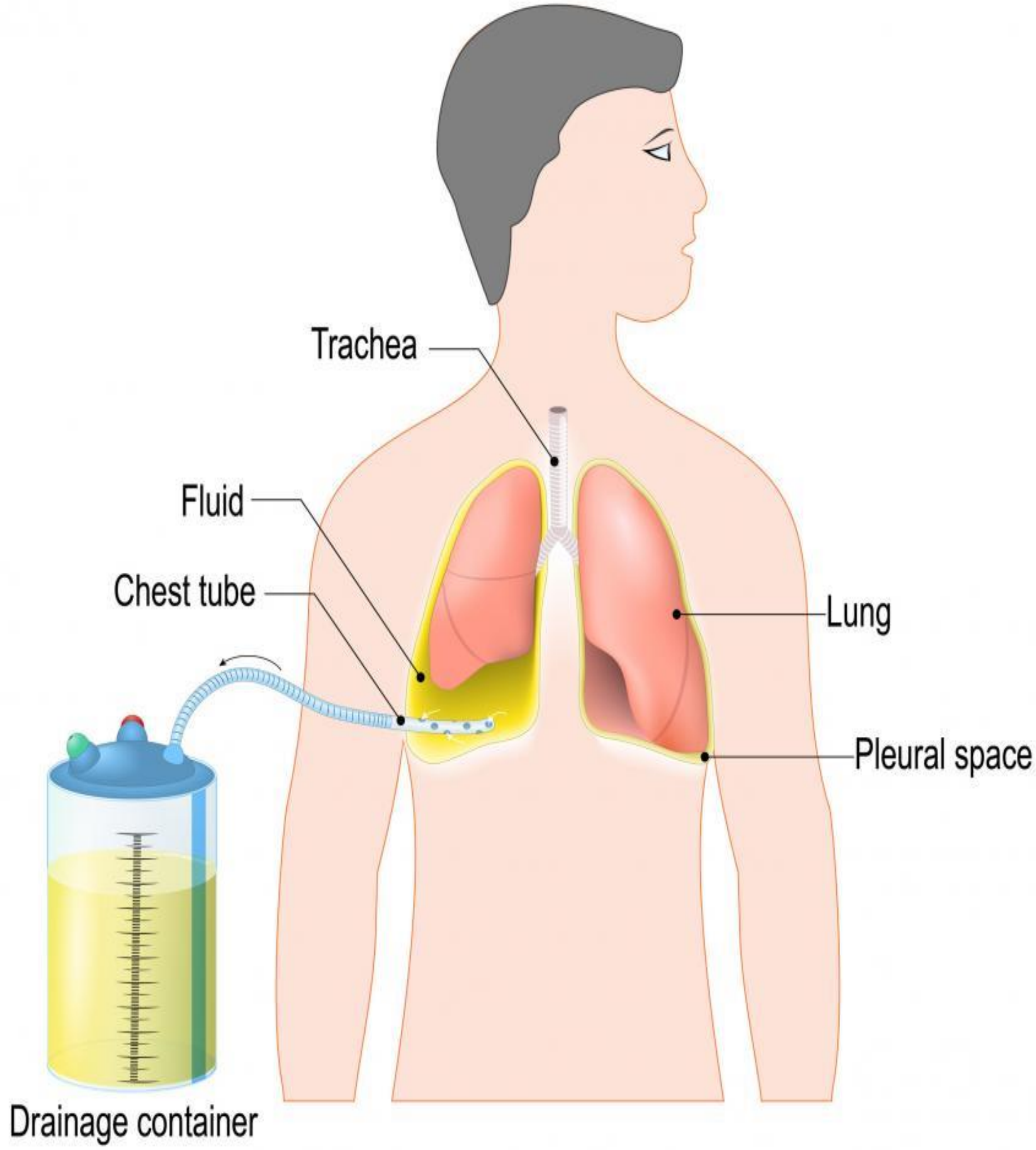


Figure 3: Basic view of Thoracostomy process in Chest Tube Drainage

2.3.2 Indications and Surgical Techniques

Thoracostomy is warranted for various pleural and pulmonary conditions where air or fluid accumulates abnormally within the pleural cavity. Common indications encompass pneumothorax arising from spontaneous or traumatic causes, hemothorax, pleural effusion, empyema, and chylothorax (Hassan et al., 2023). In the context of trauma, this constitutes an urgent intervention aimed at decompressing the chest to avert cardiopulmonary failure, particularly in cases of tension pneumothorax or massive hemothorax. Beyond trauma, indications include malignant effusions and persistent air leaks subsequent to thoracic operations (Oluwole et al., 2022). The choice of chest tube caliber and the anatomical site for insertion are determined by the nature and volume of the pleural collection, the patient's anatomical considerations, and the desired function of drainage.

The procedural execution of thoracostomy requires rigorous sterile precautions, the administration of local anesthetic, and the precise positioning of the chest drain to facilitate effective drainage while limiting damage to surrounding tissues. According to Lee et al. (2021), the optimal location for evacuating air is the fifth intercostal space along the mid axillary line, whereas fluid collections are typically addressed via the sixth or seventh intercostal spaces. In an open thoracostomy approach, blunt dissection is performed through the subcutaneous layers and intercostal musculature to prevent injury to nerves and blood vessels. Subsequently, the tube is introduced into the pleural cavity and attached to an underwater seal system to prevent the reflux of air (Green et al., 2023).

Conversely, closed thoracostomy is frequently executed using the Seldinger method, a process involving aspiration with a needle, the introduction of a guidewire, sequential dilation of the tract, and final insertion of the tube (Ahmad et al., 2022). This minimally invasive strategy has been associated with reduced rates of infection and less procedural discomfort relative to open techniques. Nevertheless, in situations involving clotted hemothorax, localized empyema, or complex thoracic trauma, the open thoracostomy approach is frequently preferred because it provides superior drainage capacity and facilitates easier manual exploration (Ibrahim et al., 2023). The selection of a drainage system, whether involving suction assistance, a water seal mechanism, or a Heimlich valve, is guided by clinical requirements and the patient's ability to mobilize (Wilson et al., 2021).

2.3.3 Cardiopulmonary and Musculoskeletal Implications of Thoracostomy

Thoracostomy carries significant implications for cardiopulmonary function, with the primary goal being the restoration of normal lung expansion and the enhancement of gaseous exchange. By eliminating the air or fluid compressing the lung, this procedure improves alveolar ventilation, oxygenation, and the return of venous blood to the heart (Bamidele et al., 2023). However, incorrect tube positioning or extended drainage can lead to complications, including re expansion pulmonary edema, hypoxemia, or a shift in mediastinal structures (Kumar et al., 2021). The procedure may temporarily influence cardiac output due to fluctuations in intrathoracic pressure, a concern particularly relevant for individuals with preexisting cardiac or pulmonary conditions. Consequently, continuous surveillance of oxygen saturation, respiratory rate, and hemodynamic status is imperative following chest tube insertion.

Musculoskeletal structures, including the intercostal muscles, ribs, and adjacent soft tissues, are also impacted during thoracostomy. The intervention frequently leads to localized discomfort, muscle spasms, and postural imbalances, all of which can compromise the mechanics of the chest wall and the efficiency of breathing (Okafor et al., 2023). Involuntary muscle guarding and diminished shoulder mobility on the treated side are common, especially following open thoracostomy where tissue dissection is more extensive. Such musculoskeletal disturbances can persist after the procedure, thereby affecting the outcomes of pulmonary rehabilitation and impeding functional recovery. Extended periods of immobility or insufficient pain management following thoracostomy may give rise to secondary issues such as atelectasis, rigidity of the chest wall, and a decline in overall functional capacity (Nguyen et al., 2022). Therefore, effective pain control, early patient mobilization, and respiratory physiotherapy are essential for restoring normal cardiopulmonary and musculoskeletal function. The adoption of multimodal analgesic strategies alongside organized physiotherapy programs substantially improves recovery, lessens the likelihood of pulmonary complications, and leads to better long term outcomes (Obi et al., 2023).

2.4.1 Anatomical and Physiological Differences in Surgical Impact

A major laparotomy, or open abdominal surgery, primarily affects the structural integrity and function of the abdominal wall, the peritoneum, and the mechanics of the diaphragm. This results in diminished diaphragmatic movement, reduced tidal volumes, and a predisposition to atelectasis and postoperative pulmonary issues. The mechanical effects arise from incisional pain, reflexive impairment of the diaphragm, and, in some instances, the presence of pneumoperitoneum or elevated intra abdominal pressure, especially with laparoscopic approaches. Collectively, these factors compromise ventilation, venous return, and gastrointestinal motility (Boden et al., 2024; Nozaki et al., 2017). Clinically, these pathophysiological changes manifest as shallow respiration, an ineffective cough reflex, and early hypoventilation, which become central targets for postoperative care following abdominal procedures (Boden et al., 2024).

In contrast, thoracostomy, involving chest tube placement, directly engages the pleural space and the chest wall, producing an immediate mechanical influence on lung re expansion and pleural dynamics. The presence of a chest tube alters intrapleural pressure dynamics, may provoke irritation of the intercostal nerves and musculature of the chest wall, and can induce localized pleural inflammation. These factors collectively reduce chest wall compliance and modify regional ventilation patterns (Merkle et al., 2023; Kwiatt et al., 2014). Since the tube resides within the thoracic cavity, its anatomical consequences are more focused on ipsilateral lung expansion, chest wall motion, and shoulder girdle function, in contrast to the more widespread diaphragmatic dysfunction typically seen after laparotomy (Merkle et al., 2023). From a systemic perspective, these two surgical categories elicit differing inflammatory and neuroendocrine responses based on the tissues involved and the magnitude of the surgery. Abdominal interventions frequently initiate inflammatory cascades within the peritoneum that influence gut motility and systemic cytokine levels. Meanwhile, thoracic procedures exert a more direct effect on pulmonary endothelial surfaces and the structures responsible for gas exchange, potentially resulting in more pronounced hypoxemia or mismatches in ventilation and perfusion. These distinct forms of tissue injury lead to differing priorities for patient monitoring: following abdominal surgery, clinicians must remain vigilant for ileus and pulmonary complications stemming from diaphragmatic impairment, whereas after thoracic procedures, attention is directed toward pleural drainage, ensuring lung re expansion, and managing pain localized to the ipsilateral chest wall (Nozaki et al., 2017; Merkle et al., 2023).

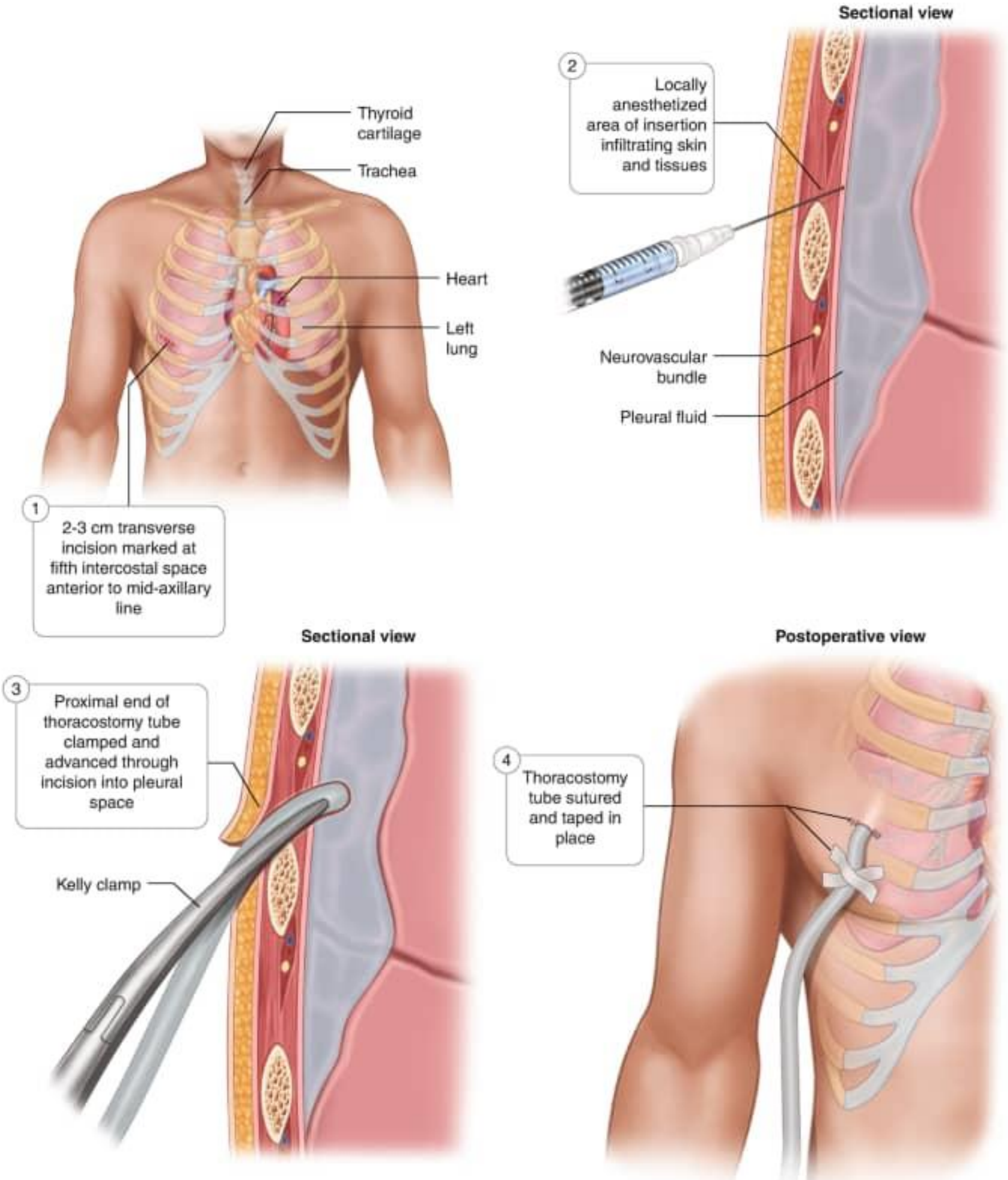


Figure 4: Surgical steps in CTTD procedure.

2.4.2 Pain Response and Functional Limitation in Both Procedures

Following a laparotomy, pain arises from two primary sources: somatic pain originating from the surgical incision and visceral pain resulting from the handling of internal organs. This combination commonly restricts coughing, deep breathing, and movement of the trunk, leading to systemic effects on respiratory function and delays in early ambulation. The presence of incisional and visceral pain diminishes the capacity to produce sufficient expiratory force, which in turn elevates the risk of postoperative pulmonary complications (PPCs) and extends functional limitations. These limitations often affect basic activities of daily living, such as sitting, standing, and walking, during the immediate recovery phase (Boden et al., 2024). Consequently, the integration of multimodal analgesia with early mobilization is essential for restoring trunk control and preventing the progression from pain to pulmonary compromise (Boden et al., 2024).

In contrast, thoracostomy and other thoracic interventions typically generate more intense and localized chest pain, frequently incorporating a neuropathic element due to irritation or damage to the intercostal nerves. This pain commonly restricts chest wall expansion, shoulder movement, and upper limb function. In the acute phase following surgery, post-thoracostomy pain manifests as severe nociception; without adequate management, it carries a recognized risk of evolving into chronic post-thoracotomy pain syndromes (Bayman et al., 2017; Jiwnani et al., 2019). Functionally, patients experience diminished shoulder range of motion, adopt guarded breathing patterns, and face challenges performing bed mobility tasks. These issues heighten the risk of atelectasis and impede rehabilitation progress unless targeted physiotherapy interventions are implemented promptly (Jonsson et al., 2024).

When comparing the two procedures, both result in functional limitations, yet the nature of these limitations differs. Laparotomy primarily impairs axial and trunk control, as well as ventilation, largely through the inhibition of diaphragmatic function. Thoracostomy, however, more directly restricts unilateral chest wall and upper limb mechanics, with a greater likelihood of shoulder girdle dysfunction. These distinct limitations necessitate procedure-specific functional assessments. For laparotomy, this involves evaluating the abdominal wound and core stability, whereas for thoracostomy, it requires assessment of shoulder range of motion, scapular control, and chest wall expansion as part of early rehabilitation planning (Jonsson et al., 2024; Merkle et al., 2023).

2.4.3 Cardiovascular and Pulmonary Responses to Surgery

Both laparotomy and thoracic interventions provoke systemic sympathetic activation and an inflammatory response, affecting heart rate, blood pressure, and myocardial oxygen demand. However, the patterns of these responses and the associated acute risks differ according to the procedure. Abdominal surgeries can elevate intra-abdominal pressure, particularly when pneumoperitoneum is used in laparoscopic approaches. This increase can raise systemic vascular resistance, diminish venous return, and compromise cardiac preload, with measurable consequences for cardiac output and oxygen delivery in vulnerable patients (Nozaki et al., 2017; research on pneumoperitoneum physiology). These cardiovascular changes are significant for perioperative hemodynamic management and influence the appropriate timing and intensity of rehabilitation activities.

Thoracic surgery and chest tube placement have a more direct impact on pulmonary mechanics, frequently resulting in ventilation-perfusion mismatch, hypoxemia, and increased pulmonary vascular resistance in the immediate postoperative period. Any reduction in oxygenation or lung volumes elevates the workload on the cardiopulmonary system and may exacerbate right ventricular afterload in susceptible individuals. This necessitates careful monitoring of both oxygenation and hemodynamic status during physiotherapy and mobilization (Merkle et al., 2023; Kourek et al., 2024). Furthermore, the combination of thoracic pain and shallow breathing can increase heart rate and sympathetic tone, underscoring the importance of effective analgesic strategies and graded mobilization to minimize undue cardiovascular stress.

Evidence also suggests that perioperative respiratory dysfunction, common after both abdominal and thoracic procedures, can indirectly increase myocardial oxygen demand by contributing to tachycardia and blood pressure variability. This creates a clinically significant interplay between pulmonary impairment and cardiac stress. Literature on cardiac rehabilitation emphasizes the need to reintroduce physical activity in gradual, graded steps following major thoracic or abdominal surgery to avoid excessive increases in myocardial workload, particularly for patients with pre-existing cardiac conditions (Kourek et al., 2024; Liu et al., 2025).

2.4.4 Comparative Effects on Rate Pressure Product (RPP)

The Rate Pressure Product (RPP), calculated as heart rate multiplied by systolic blood pressure, serves as a practical surrogate for myocardial oxygen consumption and is therefore a valuable metric for assessing cardiac stress during postoperative rehabilitation. Factors such as surgical stress, inadequate analgesia, and hypoxia—all more common in cases of thoracic compromise—can elevate both heart rate and systolic pressure, thereby increasing RPP. Consequently, thoracic procedures that induce greater hypoxemia and sympathetic activation may have a more pronounced short-term impact on RPP compared to uncomplicated abdominal surgery (Tydén et al., 2000;

Kourek et al., 2024). Several perioperative studies utilize RPP to monitor myocardial demand during mobilization and to inform the safe progression of exercise following surgery.

Direct comparative studies quantifying RPP differences specifically between laparotomy and thoracostomy remain sparse in the existing literature. Most available perioperative RPP research has been conducted within cardiac or major thoracic surgery cohorts, rather than in populations undergoing general abdominal surgery. Small observational studies and case series have documented perioperative variability in RPP related to factors such as the type of analgesia, oxygenation status, and the timing of mobilization—factors that tend to be more problematic after thoracic procedures, where pain and lung collapse more acutely elevate heart rate and blood pressure (Tydén et al., 2000; research on perioperative RPP measurements). Therefore, while a plausible physiological argument supports the likelihood of higher transient RPP increases following thoracic interventions, robust, head-to-head trials comparing RPP in routine laparotomy and thoracostomy are lacking. Given this gap in direct comparative evidence, clinicians are advised to employ individualized RPP monitoring—or continuous heart rate and blood pressure observation—when initiating mobilization in patients after either operation, especially those with cardiac comorbidities. Prioritizing the optimization of analgesia and oxygenation is also crucial to minimizing surges in myocardial demand (Kourek et al., 2024; cardiac perioperative reviews). This pragmatic approach acknowledges the evidence gap while applying established cardiac physiology principles to reduce perioperative cardiac risk.

2.4.5 Recovery Duration and Rehabilitation Needs

The recovery time following a laparotomy varies depending on the extent of the procedure, the occurrence of wound complications, and the patient's baseline physical fitness. Nevertheless, many patients regain basic mobility within a few days with appropriate analgesia and physiotherapy, although a full return to preoperative functional levels may take weeks to months. Enhanced Recovery After Surgery (ERAS) protocols for abdominal surgery have consistently demonstrated reductions in hospital stays and accelerated recovery of bowel function and ambulation by prioritizing multimodal analgesia, early feeding, and physiotherapy-led mobilization (Boden et al., 2024; Rajabaleyan et al., 2025). Thus, structured early rehabilitation focusing on core muscle activation, supported coughing, and progressive walking can significantly decrease the length of hospital stay and reduce postoperative morbidity.

Thoracostomy and thoracic surgery often require a more extended and specialized course of respiratory rehabilitation due to the higher incidence of chest pain, reduced lung volume on the ipsilateral side, and the risk of pulmonary complications. Even minimally invasive thoracic procedures, such as video-assisted thoracoscopic surgery (VATS), may necessitate targeted chest physiotherapy and shoulder rehabilitation. Historically, patients undergoing thoracotomy have experienced more prolonged pain and functional impairment than those receiving VATS. Although VATS reduces recovery time compared to open thoracotomy, chest tube management and respiratory training remain central to the recovery process (Nozaki et al., 2017; Yang et al., 2024). Consequently, patients following thoracic surgery frequently require more intensive early breathing exercises, airway clearance techniques, and upper limb mobility programs. Some may also need extended outpatient pulmonary rehabilitation to restore their exercise tolerance.

Comparing the two, recovery from laparotomy is often dominated by abdominal wound healing and the return of gastrointestinal function, whereas recovery from thoracostomy centers on lung re-expansion, pleural healing, and shoulder girdle function. This distinction shapes the duration and focus of rehabilitation pathways. While both patient groups benefit from early mobilization and optimized analgesia, those who have undergone thoracic procedures generally require longer periods of supervised respiratory physiotherapy and a greater frequency of targeted interventions to restore chest wall mechanics and prevent chronic shoulder dysfunction (Jonsson et al., 2024; Yang et al., 2024).

2.4.6 Implications for Post-Surgical Physiotherapy Intervention

Following a laparotomy, physiotherapy should be directed toward the restoration of diaphragmatic function, the prevention of postoperative pulmonary complications, and the reestablishment of trunk stability. This is best achieved through a phased program that incorporates breathing retraining, supported coughing techniques, early mobilization into an upright position, and a graduated approach to abdominal strengthening. Current evidence and clinical guidelines for postoperative abdominal care support the use of incentive spirometry, deep breathing exercises, early ambulation, and patient education regarding safe coughing and bracing methods to facilitate secretion clearance without placing excessive strain on the surgical wound (Boden et al., 2024; Medscape tube thoracostomy care guidance). When these interventions are integrated with multimodal analgesia and elements of Enhanced Recovery After Surgery protocols, pulmonary complications are reduced and recovery times are shortened.

For patients undergoing thoracostomy, physiotherapy is more specifically directed toward improving chest expansion on the ipsilateral side, ensuring airway clearance, addressing shoulder mobility limitations caused by pain, and facilitating a gradual return to aerobic conditioning. Commonly used and effective treatment modalities include targeted deep breathing exercises, the use of positive expiratory pressure devices, early ambulation, progressive range of motion exercises for the shoulder, and techniques aimed at minimizing pleural adhesions while preserving scapulothoracic mechanics (Jonsson et al., 2024; Merkle et al., 2023). Given that discomfort from the chest tube may limit patient engagement, close collaboration with analgesic strategies, such as regional blocks, along with the prescription of graded activity, is essential to ensure safe rehabilitation without inducing hypoxemia or excessive cardiac strain.

For both patient groups, particularly older individuals or those with preexisting cardiac conditions, an individualized physiotherapy plan that accounts for the specific surgical procedure and considers both the Rate Pressure Product and cardiopulmonary reserve is critical. Clinicians should conduct baseline cardiovascular screening, monitor heart rate and blood pressure during the initial stages of mobilization, and adjust the intensity of activity based on oxygenation levels, pain control, and trends in the Rate Pressure Product. Exercise intensity can be progressed gradually as pain management and lung mechanics improve (Kourek et al., 2024; Liu et al., 2025). Incorporating such measures into standard ERAS or thoracic ERAS pathways contributes to better functional outcomes and a lower incidence of complications for both laparotomy and thoracostomy populations.

2.5 Rate Pressure Product (RPP) and Its Clinical Importance

2.5.1 Definition and Physiological Basis of RPP

The Rate Pressure Product, also referred to as the double product, is derived by multiplying heart rate, measured in beats per minute, by systolic blood pressure, measured in millimeters of mercury. This calculation, expressed as HR × SBP, is widely employed as a noninvasive indicator of myocardial oxygen consumption. The physiological foundation for this index originated from experimental and clinical research that demonstrated a strong linear relationship between myocardial oxygen uptake and the work performed by the heart, as represented by its rate and systolic pressure. Consequently, RPP serves as a practical surrogate for cardiac metabolic demand in awake and exercising individuals (Wilkinson, 1979; Pinkstaff et al., 2010). Contemporary reviews and clinical literature continue to regard RPP as a useful bedside estimate of left ventricular workload, as it incorporates two principal determinants of myocardial energy expenditure: the frequency of contraction and the pressure against which the ventricle must eject (Wilkinson, 1979; Pinkstaff et al., 2010; Nakata, 2024).

From a physiological perspective, an elevation in heart rate shortens the duration of diastole and increases myocardial oxygen consumption per minute, whereas an increase in systolic pressure raises ventricular wall stress during ejection, thereby augmenting oxygen demand. Multiplying these two variables produces a value that correlates with directly measured myocardial oxygen consumption across a range of conditions. It is important to note, however, that RPP reflects global myocardial demand rather than localized ischemia or coronary blood flow. Its interpretation must also take into account factors such as contractility, preload, and afterload, which can alter the relationship between RPP and actual oxygen consumption in certain clinical scenarios (Nakata, 2024; Carter et al., 2016). Therefore, RPP is best understood as a practical clinical index with recognized physiological constraints, rather than a flawless measure of myocardial oxygen consumption.

Given its dimensional simplicity and ease of calculation using standard monitoring equipment, such as electrocardiogram for heart rate and noninvasive cuff measurements for systolic blood pressure, RPP has become a common metric in exercise testing, perioperative monitoring, and cardiac rehabilitation. It is frequently used as a rapid assessment of myocardial workload and stress. Many exercise studies report peak RPP as an indicator of the maximal cardiac stress achieved during testing, and the rate at which RPP recovers following exertion carries prognostic significance for cardiac outcomes. Current literature in cardiology and rehabilitation suggests that RPP should be used alongside other clinical markers rather than as a standalone measure (Pinkstaff et al., 2010; Kiviniemi et al., 2019; Jiang et al., 2023).

2.5.2 Factors Influencing RPP in Surgical Patients

In the surgical population, preexisting comorbidities significantly influence perioperative RPP. Conditions such as hypertension and uncontrolled tachyarrhythmias can elevate resting or perioperative RPP, thereby increasing myocardial oxygen demand and the associated cardiac risk during the perioperative period. Multiple observational studies have indicated that patients with hypertension or coronary artery disease often present with elevated preoperative and intraoperative RPP values, and these elevations are linked to a higher incidence of perioperative ischemic events unless managed with appropriate medical or anesthetic interventions (Aseni et al., 2019; Sujatha & Niveditha, 2023). Accordingly, optimizing blood pressure and heart rate control before surgery, using beta blockers or calcium channel blockers when appropriate, is a fundamental strategy to lower RPP and reduce cardiac stress during the procedure.

Acute modulators of perioperative RPP include anesthetic technique, analgesia, surgical stress, and fluid shifts. Noxious stimuli such as intubation and incision, along with sympathetic nervous system activation, can increase both heart rate and systolic blood pressure, resulting in transient spikes in RPP that may provoke ischemia in susceptible patients. Conversely, maintaining adequate anesthetic depth, administering opioid analgesia, and ensuring smooth extubation can help suppress sympathetic surges and thereby moderate peaks in RPP (Aseni et al., 2019). Additionally, vasoactive medications administered during surgery, including vasopressors and inotropes, directly alter systolic blood pressure and heart rate, leading to rapid changes in RPP. Clinicians must therefore interpret RPP within its clinical context, recognizing that drug induced increases in systolic blood pressure, while necessary to maintain perfusion, may concurrently raise RPP.

In the postoperative period, factors such as pain, hypoxemia, anemia, and fever can also elevate RPP by increasing sympathetic tone and cardiac workload. Untreated pain or inadequate oxygenation in the immediate recovery phase frequently results in elevated heart rate and systolic blood pressure, producing correspondingly high RPP values. Monitoring RPP during early recovery can therefore assist in identifying patients who may require interventions such as analgesia, supplemental oxygen, or beta blockers to reduce myocardial oxygen consumption and prevent ischemic complications (Cheng et al., 2025; Nakata, 2024). In summary, perioperative RPP and the associated cardiac risk are shaped by a combination of patient comorbidities, anesthetic and surgical factors, the use of vasoactive medications, and various postoperative physiological stressors.

2.5.3 The Interplay between RPP, Myocardial Oxygen Demand, and Exercise Capacity

An elevated rate pressure product during submaximal exertion signifies that the myocardium requires substantial oxygen to perform a given amount of external work. This suggests that exercise limitation may stem from cardiac factors rather than peripheral mechanisms. Research in exercise physiology indicates that individuals engaging in identical external workloads can exhibit considerably divergent RPP values due to variations in heart rate and blood pressure responses. Those presenting with higher RPP levels during submaximal activity frequently terminate exercise prematurely or experience angina, as the demand for myocardial oxygen surpasses its supply (Pinkstaff et al., 2010; Carter et al., 2016). Consequently, RPP offers clinicians a means to correlate subjective exertion or treadmill stage with probable myocardial stress, thereby identifying patients who may require further cardiac assessment.

The peak RPP attained during standardized exercise testing is commonly employed as an indicator of maximal cardiac performance. A subdued peak RPP may point to chronotropic incompetence, the effects of beta-blockade, or diminished cardiovascular reserve. Conversely, an excessively elevated submaximal RPP may signal exaggerated blood pressure or heart rate responses that curtail exercise capacity (ClinicalView, 2024; Nakata, 2024). The pattern of RPP recovery following exercise also holds diagnostic value; a delayed decline in RPP is associated with autonomic dysfunction and a less favorable prognosis. Several cohort studies have confirmed that sluggish RPP recovery independently predicts subsequent cardiac events and mortality among patients with coronary artery disease or diabetes (Kiviniemi et al., 2019; Jiang et al., 2023). Given that myocardial oxygen demand must be balanced by coronary blood flow, a high RPP in the presence of obstructive coronary disease frequently results in exercise-induced ischemia or angina, thus impairing exercise tolerance. For this reason, both exercise prescription and diagnostic stress testing incorporate RPP thresholds to mitigate the risk of provoking ischemia while still achieving therapeutic benefits. Utilizing RPP in conjunction with electrocardiographic changes, symptoms, and perceived exertion establishes a safer framework for prescribing graded activity in cardiac patients (Pinkstaff et al., 2010; Zhou et al., 2024).

2.5.4 The Role of RPP in Physiotherapy and Exercise Prescription

Within physiotherapy and cardiac rehabilitation, the rate pressure product serves as a pragmatic instrument for customizing and regulating exercise intensity in patients with known or suspected cardiac disease. It achieves this by linking external workload to myocardial oxygen demand more directly than heart rate considered in isolation. Numerous rehabilitation guidelines and clinical reviews advocate for the monitoring of heart rate and systolic blood pressure, along with the calculation of RPP, during graded exercise sessions. This practice ensures patients remain below individualized ischemic thresholds, particularly during the early stages of cardiac rehabilitation or in the period following recent surgery (Physio-Pedia; Pinkstaff et al., 2010). As such, RPP can assist in establishing safe submaximal targets—for instance, maintaining RPP below a predetermined percentage of the peak value achieved during formal testing—thereby balancing the benefits of conditioning against potential cardiac risks.

Practical applications within physiotherapy include employing RPP to direct warm-up progression, determine interval durations, adjust aerobic training intensities, and select safe endpoints for sessions when continuous electrocardiographic monitoring is unavailable. For patients taking rate-limiting medications such as beta-blockers, relying solely on heart rate may underestimate myocardial stress. In these cases, RPP offers a more accurate estimate of cardiac workload by incorporating systolic blood pressure, particularly during submaximal activities typical of physiotherapy sessions (ResearchOpenWorld; ClinicalView, 2024). Consequently, for musculoskeletal or post-surgical patients with concurrent cardiovascular conditions, physiotherapists can apply RPP thresholds to safely advance goals related to ambulation and stair climbing while minimizing cardiac risk.

Furthermore, RPP proves valuable for educating patients in self-monitoring. Individuals can be instructed to measure their pulse and, where feasible, spot blood pressure readings—or utilize wearable devices capable of monitoring these parameters—to calculate their RPP at home and adjust their activity levels accordingly. This practice supports safer engagement in home exercise programs and a gradual return to function after surgery. Nevertheless, clinicians must provide thorough training to patients on interpreting RPP in the context of accompanying symptoms such as chest pain, unusual breathlessness, or dizziness, and must ensure the reliability of blood pressure measurement techniques. When uncertainty persists, supervised testing or referral for formal exercise testing remains advisable (Pinkstaff et al., 2010; Physio-Pedia).

2.5.5 RPP as a Marker of Cardiac Stress and Recovery Following Surgery

Postoperative trends in the rate pressure product can serve as indicators of ongoing cardiac stress or inadequate recovery. A sustained elevation or delayed normalization of RPP after surgery may reflect issues such as pain, anemia, hypoxia, fluid imbalances, silent ischemia, or autonomic dysfunction, all of which warrant prompt clinical evaluation. Observational studies in perioperative care have highlighted that surges in heart rate and systolic blood pressure during extubation and early mobilization commonly increase RPP and may precipitate ischemic events in vulnerable patients. Therefore, monitoring these parameters and implementing early interventions—such as appropriate analgesia, oxygen supplementation, or beta-blockade—can help mitigate such risks (Aseni et al., 2019; Cheng et al., 2025). Tracking RPP during the immediate postoperative period thus provides an accessible metric to assist in triaging patients who may require more intensive monitoring.

Beyond the acute phase, research indicates that the dynamics of RPP during physical tests or mobilization carry prognostic significance. A delayed recovery of RPP following exertional activities correlates with adverse cardiac outcomes and mortality in cardiac populations, and may similarly reflect impaired cardiovascular reserve in postoperative patients. Cohort studies within cardiac cohorts have demonstrated that RPP recovery offers prognostic value that extends beyond peak RPP and conventional risk markers, underscoring its utility as a monitoring endpoint for the restoration of autonomic and cardiovascular function after major interventions (Kiviniemi et al., 2019; Jiang et al., 2023). By extension, for non-cardiac surgical patients with underlying cardiovascular comorbidities, persistently abnormal RPP responses during postoperative physiotherapy should prompt cardiology consultation and the implementation of a tailored rehabilitation plan.

Utilizing RPP to guide the gradual escalation of postoperative activity—for example, by establishing RPP limits during early ambulation and stair-climbing practice—enables safer rehabilitation while concurrently tracking the recovery of cardiovascular efficiency. A reduction in RPP at a consistent workload over days or weeks suggests improvements in myocardial efficiency and autonomic balance. Conversely, an increasing RPP at the same workload may indicate deconditioning or persistent physiological stress, necessitating a reassessment of pain management, oxygenation status, hemoglobin levels, and medication regimens (Pinkstaff et al., 2010; Zhou et al., 2024). In summary, RPP constitutes a low-cost and readily available index that effectively complements clinical evaluation in monitoring cardiac stress and tracking recovery after surgical procedures.

2.6 Post-Surgical Physiotherapy Prescription and Practice

2.6.1 Principles of Post-Surgical Rehabilitation

The foundation of post surgical rehabilitation rests on a staged, goal oriented recovery model that aligns the biology of tissue healing with the progressive application of functional load. In the initial stages, the focus is on safeguarding the surgical site, managing inflammation and discomfort, and sustaining joint mobility through gentle, supervised passive and active assisted movements. Subsequent phases involve a gradual increase in mechanical load, neuromuscular retraining, and activities tailored to specific functional tasks to rebuild strength and capability (Tao et al., 2023; Plater et al., 2024). Evidence consolidated within Enhanced Recovery After Surgery (ERAS) frameworks highlights the value of individualized rehabilitation plans that function within multidisciplinary care pathways. When physiotherapy is synchronized with pain management, nutritional support, and surgical care planning, this cohesive approach has been shown to expedite functional recovery, reduce hospital stays, and lower the incidence of complications (Tao et al., 2023; Burgess et al., 2025). In clinical practice, a principles based approach to prescription relies on objective indicators such as pain scores, thresholds for range of motion, gait assessments, and validated functional outcome measures to guide patient progression. These benchmarks serve to standardize care while enabling a safe increase in activity levels when markers of healing and the patient's clinical response permit (Plater et al., 2024; Balance Rehab, 2024).

Fundamental principles of early rehabilitation also incorporate risk stratification and the concept of a dose response relationship. Individuals with pre existing conditions such as cardiopulmonary disease, diabetes, or frailty often require a more gradual progression, more frequent monitoring, and specific cardiopulmonary conditioning. Conversely, patients classified as low risk may tolerate earlier engagement in intensive, function focused training (Tao et al., 2023; McIlroy et al., 2025). The dual rationale for this approach is to prevent re injury or compromise of the surgical wound by adhering to tissue healing timelines, while simultaneously mitigating the risks of deconditioning and thromboembolic events through appropriate early movement and circulatory stimulation (Plater et al., 2024; NYSSPT, 2025). Furthermore, sound practice involves patient education, collaborative decision making, and clearly defined discharge criteria, such as the ability to perform self care and mobilize safely. These elements collectively foster adherence and contribute to favorable long term surgical outcomes (NYSSPT, 2025; Access Sports Med, 2025).

A further core principle involves the use of evidence informed multimodal therapy. This strategy combines therapeutic exercise, manual techniques, breathing retraining, and targeted modalities such as transcutaneous electrical nerve stimulation and cryotherapy to comprehensively address pain, edema, and functional impairment, rather than relying on a single intervention (Niyonkuru et al., 2024; Tao et al., 2023). When incorporated into ERAS protocols or standardized inpatient pathways, such integrated care bundles consistently yield improvements in early functional recovery and result in fewer pulmonary and thrombotic complications compared to nonstandardized care (Tao et al., 2023; Burgess et al., 2025). Importantly, the literature advocates for meticulous documentation of dosage, intensity, and progression within physiotherapy prescriptions. Such detailed records are essential for enabling replication of interventions and ensuring that progression remains within safe parameters, particularly concerning rate pressure product and cardiovascular limits for patients with heightened vulnerability (Plater et al., 2024; Lässing, 2025).

2.6.2 Early Mobilization and Breathing Exercises

The implementation of early mobilization following surgery, encompassing sitting, standing, and progressive walking initiated within hours to the first postoperative day, has been associated with reduced postoperative pulmonary complications, shorter durations of hospitalization, and a lower incidence of venous thromboembolism across various surgical populations when supported by appropriate analgesia and nursing care (Tao et al., 2023; McIlroy et al., 2025). Systematic reviews conducted within ERAS contexts suggest that mobilization yields optimal results when delivered through a structured protocol that establishes clear objectives for time spent out of bed and walking distance, and is supported by multimodal analgesia to counteract orthostatic intolerance and pain induced limitations (Tao et al., 2023; Access Sports Med, 2025). Beyond these systemic benefits, the early application of load to the limbs and trunk serves to avert joint stiffness, muscle wasting, and functional decline, outcomes that correlate strongly with improved patient reported functional scores in the short term (Tao et al., 2023; Balance Rehab, 2024).

Respiratory techniques, including deep breathing exercises, incentive spirometry, diaphragmatic training, and inspiratory muscle training, remain essential for the prevention of atelectasis and postoperative pneumonia, particularly following upper abdominal and thoracic procedures. Recent randomized trials and systematic reviews indicate that preoperative inspiratory muscle training, along with the postoperative use of incentive spirometry or structured deep breathing exercises, can diminish pulmonary complications and shorten hospital stays, especially when these techniques are delivered as part of a comprehensive pulmonary care bundle rather than as a standalone measure (Sweity et al., 2021; Franklin, 2023; Ababneh, 2025). Nevertheless, variability across studies has led many researchers to recommend that breathing exercises be delivered in a standardized manner, with specified volumes and frequencies and under supervised conditions, and combined with early mobilization and cough or airway clearance strategies to achieve maximal benefit (Dhillon et al., 2023; Ababneh, 2025).

In practical application, a tailored approach is necessary. Individuals with diminished baseline respiratory capacity or chronic obstructive pulmonary disease derive significant benefit from prehabilitation involving inspiratory muscle training and education, along with a lowered threshold for initiating postoperative respiratory therapy. For those at lower risk, comparable pulmonary outcomes can often be attained with simple deep breathing exercises paired with early ambulation (Franklin, 2023; Dhillon et al., 2023). Additionally, supervision by a therapist and objective monitoring using measures such as spirometer volumes, oxygen saturation, and respiratory rate serve to enhance adherence and facilitate timely escalation of care, including the use of bronchial hygiene devices, supplemental oxygen, or referral, should exercise tolerance or oxygenation decline (Franklin, 2023; Ababneh, 2025).

2.6.3 Supervised Exercise Sessions

The presence of physiotherapist supervision during exercise sessions ensures both adherence and safety, yielding superior outcomes relative to unsupervised programs (Paul et al., 2023). During these sessions, therapists are able to monitor vital signs, ensure correct technique to avert injury, and deliver motivational support, which collectively bolsters patient confidence and commitment (Federico et al., 2017). Evidence demonstrates that supervised interventions contribute to greater functional improvements, a lower rate of complications, and shorter recovery periods, particularly in postoperative groups where pain or fatigue may compromise self directed management (Pablo et al., 2023). For example, structured supervision has been shown to enhance cardiorespiratory fitness and quality of life, establishing it as a cornerstone of rehabilitation protocols grounded in evidence (Barakat et al., 2016).

2.6.3.1 High-Intensity Interval Training

High-Intensity Interval Training, characterized by short bursts of intense effort interspersed with periods of rest, enhances cardiovascular fitness but must be carefully adapted to individual patient capacity. This training modality is particularly suitable for patients recovering from thoracostomy, who often experience a faster recovery trajectory. It improves aerobic capacity and metabolic efficiency through alternating efforts performed at 80 to 95 percent of peak heart rate with recovery periods, promoting greater improvements in maximal oxygen consumption than steady state training (Marc et al., 2017). However, this approach is less appropriate for the early phase of laparotomy recovery due to the associated elevation in rate pressure product, as the abdominal nature of the procedure can exacerbate cardiovascular strain and impede tissue healing (Anna et al., 2022). When implemented postoperatively, High-Intensity Interval Training should commence only after medical clearance, with sessions limited to 20 to 30 minutes to mitigate risks such as hypotension or arrhythmias in susceptible individuals (Diana et al., 2025).

2.6.3.2 Moderate-Intensity Continuous Training

Moderate-Intensity Continuous Training involves sustained exercise at a moderate level and is well suited for laparotomy patients who may not tolerate high intensity protocols. This method safely improves maximal oxygen consumption (Franssen, 2022). It also supports gradual cardiovascular adaptation, enhances endothelial function, and reduces inflammation without placing excessive demands on the recovering system (Javier et al., 2023). In the context of post laparotomy care, this form of training facilitates better pain management and adherence, as it avoids the peaks in rate pressure product associated with more intense regimens. Consequently, it represents a preferred option for patients with coexisting conditions such as hypertension or diabetes.

2.6.3.3 Progressive Resistance Training

Progressive Resistance Training serves to strengthen musculature, thereby counteracting the loss of muscle mass that frequently follows surgical intervention, and offers benefits for both patient groups (Minnella et al., 2020). Typically involving two to three sets of eight to twelve repetitions performed at 60 to 80 percent of one repetition maximum, this approach addresses sarcopenia induced by immobility and surgical stress, while simultaneously enhancing joint stability and metabolic health (Pablo et al., 2025). In postoperative settings, it has been shown to accelerate the recovery of strength and reduce disability, with adaptations for thoracostomy focusing on the upper body and for laparotomy emphasizing core stability to avoid placing strain on surgical incisions (Stian et al., 2022).

2.6.4 Psychological Support and Motivation

Patient motivation can be strengthened through psychological support, which in turn promotes adherence to rehabilitation protocols and facilitates effective goal setting. When physiotherapy sessions incorporate techniques such as cognitive behavioral strategies, mindfulness practices, and motivational interviewing, patients often develop greater resilience and more constructive coping mechanisms. The provision of psychological support is essential for sustaining patient engagement in rehabilitation, as evidence indicates a strong association with improved functional outcomes and lower rates of attrition from treatment programs (Derwin et al., 2009).

2.6.5 Physiotherapy Techniques for Pain and Functional Restoration

Managing pain represents a central objective in restoring function. Physiotherapy utilizes an active, multimodal strategy that works alongside pharmacological pain relief to enable patients to engage meaningfully in their rehabilitation. A combination of graded exercise therapy, which includes progressive range of motion activities, strengthening exercises, and functional task training, alongside manual techniques such as soft tissue and joint mobilization, is supported by evidence for reducing pain intensity and enhancing function following a range of orthopedic and soft tissue surgeries (Hayden et al., 2021; Tao et al., 2023). Concurrently, physical agents like transcutaneous electrical nerve stimulation (TENS), cryotherapy, and graded scar mobilization are frequently employed to diminish nociceptive input, decrease swelling, and facilitate earlier improvements in range of motion. Recent reviews indicate beneficial effects on pain and short term function, though the magnitude of these effects varies according to the type of surgery and the methodological quality of the studies (Niyonkuru et al., 2024; Patel, 2025).

A clinical emphasis on neuromuscular reeducation and functional retraining serves to expedite the return to daily activities and reduce the likelihood of developing compensatory movement patterns that may lead to chronic pain. Common strategies involve motor control exercises, eccentric and concentric strengthening progressed according to pain monitoring protocols, proprioceptive and balance training, and task specific practice for gait and transfers. Each of these interventions is typically guided by objective measures, such as range of motion, strength, and standardized questionnaires, to appropriately adjust exercise intensity (Tao et al., 2023; Briem et al., 2025). In cases involving persistent or neuropathic pain, supplementary approaches including graded exposure therapy, cognitive functional therapy, and the integration of pain neuroscience education have demonstrated effectiveness in reducing pain related disability and improving adherence to active rehabilitation programs (Yu, 2025; Niyonkuru et al., 2024).

Optimal outcomes are achieved when hands on and device based interventions are combined with a robust exercise focused plan. For instance, utilizing a brief course of TENS or manual therapy to alleviate acute pain, immediately followed by progressive loading and functional retraining, tends to yield more rapid gains compared to relying solely on passive treatments (Niyonkuru et al., 2024; Patel, 2025). Clinicians are advised to document the parameters of the modalities used, such as TENS frequency and intensity, cryotherapy duration, and exercise specifics like sets, repetitions, and intensity, to ensure reproducibility, monitor for adverse events, and support high quality research and academic reporting (Tao et al., 2023; Yu, 2025).

2.6.6 Cardiopulmonary Conditioning and Monitoring RPP During Therapy

For patients with cardiovascular risk factors or those recovering from major surgical procedures, cardiopulmonary conditioning is a vital element of postoperative rehabilitation. Customized aerobic reconditioning, involving activities such as walking, cycle ergometry, and progressive stepping exercises, can improve exercise capacity, mitigate deconditioning, and enhance tolerance for subsequent functional tasks (Maximidou et al., 2025; Tao et al., 2023). Current clinical practice increasingly incorporates wearable monitors and remote telemetry to track heart rate, blood pressure trends, and physical activity levels. This technology enables therapists to prescribe exercise intensity relative to individualized targets, such as a percentage of peak heart rate or power output, and to identify atypical physiological responses at an early stage (Maximidou et al., 2025). Such technologies prove especially valuable for patients recovering from cardiac or major thoracic surgery, where precise workload management supports safe progression and may lower the risk of hospital readmission (Maximidou et al., 2025).

The Rate Pressure Product (RPP), calculated as heart rate multiplied by systolic blood pressure, serves as a practical index of myocardial oxygen demand. It is utilized in clinical exercise testing and rehabilitation settings to evaluate cardiac workload during therapeutic activities. Elevations in RPP beyond thresholds specific to an individual patient may indicate unsafe levels of myocardial demand, prompting a reduction in exercise intensity or a referral for medical review (Lässing, 2025; ClinicalView, 2024). Recent research indicates that RPP reliably increases in response to higher repetitions and greater exercise intensity, and it can help identify disproportionate cardiovascular responses in individuals recovering from illness or surgery (Lässing, 2025). In practice, therapists should establish baseline RPP values for patients, both at rest and during light exertion, set conservative upper limits informed by cardiology consultation, particularly for those with ischemic heart disease, and consistently monitor symptoms, heart rate, and periodic blood pressure measurements during more intensive sessions (ClinicalView, 2024; Lässing, 2025).

Integrating RPP monitoring into rehabilitation prescriptions supports individualized dosing of therapeutic activity and enhances patient safety. For example, progressive interval training protocols that incorporate regular RPP assessments can guide safe increases in workload, while wearable devices and supervised telemetry allow for safe outpatient progression following hospital discharge (Maximidou et al., 2025; Lässing, 2025). Should RPP values approach or surpass predetermined alarm thresholds established by the treating cardiologist, therapists should pause the progression of exercise and coordinate with the medical team for further cardiac evaluation or adjustments to medication or analgesia. Documenting RPP trends also contributes valuable data for research and quality assurance efforts within postoperative cardiac rehabilitation programs (ClinicalView, 2024; Maximidou et al., 2025).

2.6.7 Precautions and Safety Measures During Post-Surgical Rehabilitation

Ensuring safety in postsurgical rehabilitation begins with a comprehensive prerehabilitation assessment and clear communication of surgical precautions, such as weight bearing status, range of motion restrictions, and brace or sling use. These details must be documented and consistently agreed upon by surgical, nursing, and physiotherapy teams to prevent conflicting instructions that could compromise surgical repairs or cause harm (Aligned Orthotherapy, 2022; NYSSPT, 2025). Prior to each session, therapists are required to screen for clinical red flags, including signs of wound infection, hemodynamic instability, new neurological deficits, or uncontrolled pain, and must cease therapy if such signs are present. The use of standardized screening checklists has been linked to earlier complication detection and safer delivery of therapeutic interventions (Plater et al., 2024; Ambassador PT, 2025). For patients considered high risk due to factors such as anticoagulant use, diabetes, or immunosuppression, additional wound monitoring, gradual loading, and close collaboration with medical teams are essential to balance recovery with complication prevention (Plater et al., 2024).

Practical safety measures encompass gradual progression of activities guided by pain levels and objective criteria, close observation of vital signs including heart rate, blood pressure, and oxygen saturation, fall risk mitigation through assistive device training and supervised transfers, and the provision of clear discharge instructions with red flag warnings for patients and caregivers. Current literature supports the use of pain limited progression rules, such as aiming to keep pain below a score of 3 out of 10 during activity, alongside scheduled analgesic use to allow effective participation in therapeutic exercise while minimizing pain exacerbations (AmbassadorPT, 2025; Access Sports Med, 2025). Additional measures include the application of cryotherapy and elevation to control swelling, proper application and removal of braces, and patient education on safe modifications to household activities, all of which can help reduce readmissions associated with wound complications or falls (Aligned Orthotherapy, 2022; NYSSPT, 2025).

2.7 Empirical Review

Author /Country	Titles	Objectives	Research Design	Sample size	Statistical tool	Findings	Limitations
Agostini et al. (2017)/UK	Risk factors and short-term outcomes of postoperative pulmonary complications after surgery VATS lobectomy	To identify risk factors and outcomes of postoperative pulmonary complications (PPC) after video-assisted thoracoscopic surgery (VATS) lobectomy	Prospective cohort study	82	Logistic regression, Chi-square test	PPC occurred in 14% of patients; risk factors included age, smoking history, and reduced lung function. Early physiotherapy reduced PPC severity.	Small sample size, single-center study, limited generalizability to non-VATS thoracostomy.
Boden et al (2018)/Australia	Preoperative physiotherapy for the prevention of respiratory complicati	To assess if preoperative physiotherapy reduces PPC after	RCT Double binded	76	Intention-to-treat analysis, Fisher's exact test,	Preoperative physiotherapy reduced PPC incidence by 50%	Moderate sample size, limited to elective surgeries, potential

	ons after upper abdominal surgery: Pragmatic, double blinded, multicentre randomised controlled trial	upper abdominal surgery			ANOVA	(p=0.02) and improved respiratory function.	selection bias.
Castelino et al.(2016)/Canada	The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review	To evaluate the impact of early mobilization on postoperative outcomes after abdominal and thoracic surgery	Systematic review	Varied (studies with 20–80 participants included)	Narrative synthesis, meta-analysis (where applicable)	Early mobilization reduced hospital stay and PPC by 1–2 days (p<0.05) in both surgery types	Heterogeneity in study designs, variable physiotherapy protocols, small sample sizes in some included studies.
Gunay et al. (2016)/Turkey	Evaluation of two different respiratory	To compare two respiratory	Randomized controlled trial	60 patients	T-tests, cost-effectiv	Incentive spirometry improved	Single-center study with a small

	physiotherapy methods after thoracoscopy with regard to arterial blood gas, respiratory function test, number of days until discharge, cost analysis, comfort and pain cont	physiotherapy methods post-thoracoscopy for efficacy and cost-effectiveness			eness analysis	oxygenation ($p<0.05$) and reduced hospital stay by 1.2 days. Costs were lower in the spirometry group.	sample. Short-term follow-up limited assessment of long-term benefits.
Lockstone et al. (2020)/Australia	Physiotherapist-administered non-invasive ventilation to reduce postoperative pulmonary complications in high-risk	To investigate the efficacy of physiotherapist-administered non-invasive ventilation (NIV) in reducing postoperat	Randomized controlled trial	80 patients	Chi-square test, p-values	NIV reduced PPC incidence by 40% ($p=0.02$) and shortened ICU stay by 1 day	Limited to high-risk patients, reducing generalizability. Resource-intensive intervention may not be feasible in all settings.

	patients following elective upper abdominal surgery	ive pulmonary complications (PPCs)					
Minnella et al(2020)/Canada	Effect of exercise and nutrition prehabilitation on functional capacity in esophagogastric cancer surgery: A randomized trial		Randomized controlled trial (RCT)	60 patients	Analysis of variance (ANOVA), t-tests	Prehabilitation group improved 6-minute walk distance by 45 meters (p=0.01) and had fewer postoperative complications	Small sample size and single-center design. Adherence to prehabilitation protocol varied.

2.8 Theoretical Framework

The origins of the Surgical Stress Response Theory trace back to 1932, when Sir David Cuthbertson first described the intricate metabolic, endocrine, and inflammatory processes that arise in the body following surgical intervention. Through his observations, Cuthbertson noted that surgery elicits a predictable physiological sequence marked by catabolism, heightened energy demands, hormonal disruption, and altered immune activity (Cuthbertson, 1932). He framed the body's response as a coordinated protective mechanism intended to reestablish homeostasis and facilitate recovery. According to the theory, tissue damage initiates a series of neuroendocrine events involving the hypothalamic pituitary adrenal axis and the sympathetic nervous system, resulting in elevated concentrations of catecholamines, cortisol, and inflammatory cytokines. While this response serves an adaptive purpose when brief, it can become harmful if sustained or excessive, potentially leading to delayed recovery and postoperative complications (Desborough, 2000; Kehlet, 2018).

Within clinical settings, the Surgical Stress Response Theory serves as an essential framework for comprehending how surgical trauma affects various organ systems and shapes the course of postoperative recovery. Its relevance is reflected in contemporary perioperative management approaches, such as Enhanced Recovery After Surgery protocols, which are designed to mitigate the stress response and enhance patient outcomes. Practitioners including physiotherapists, anaesthetists, and surgeons apply the principles of this theory to develop strategies that reduce sympathetic activation and metabolic disturbance (Ljungqvist et al., 2017). For example, interventions such as early ambulation, effective pain management, and nutritional support are employed to limit stress induced catabolism and inflammation. In physiotherapy, insight into the stress response informs the safe implementation of exercises after surgery, monitoring of cardiovascular parameters like the Rate Pressure Product, and scheduling of respiratory treatments to avert complications while preserving the body's adaptive capacity (Fearon et al., 2021).

A key strength of the Surgical Stress Response Theory resides in its broad applicability and physiological robustness. It provides a clear mechanistic account of the systemic changes that commonly follow surgery, including rapid heart rate, elevated blood glucose, loss of muscle mass, and reduced immune function (Kehlet & Wilmore, 2008). This explanatory power has been pivotal in shaping multidisciplinary perioperative strategies aimed at dampening the stress response. Additionally, the theory offers a scientific rationale for both pharmaceutical and non pharmaceutical interventions intended to modulate hormonal and inflammatory pathways, such as the use of beta blockers, regional anaesthesia, and early physiotherapy. Its capacity to forecast outcomes also enables clinicians to anticipate complications in vulnerable groups, including individuals with cardiac or metabolic conditions, and to tailor recovery plans according to individual stress profiles.

Nevertheless, the theory is not without limitations, particularly regarding its incomplete depiction of the full complexity inherent in postoperative physiology. Critics contend that it simplifies the intricate interaction among psychological, immune, and environmental determinants of recovery (Soop et al., 2020). For instance, while the theory emphasizes endocrine and metabolic pathways, it does not sufficiently address individual differences in immune function, persistent inflammation, or the impact of psychosocial stressors. Furthermore, although it effectively accounts for acute physiological events, its explanatory reach is limited when considering prolonged postoperative conditions such as chronic pain or delayed functional recovery. Another shortcoming is that interventions grounded in the theory, such as aggressive stress reduction measures, may occasionally hinder adaptive healing processes if implemented without restraint. Consequently, although the Surgical Stress Response Theory continues to serve as a cornerstone of perioperative care, its contemporary use necessitates integration with biopsychosocial and precision medicine frameworks to achieve a more comprehensive understanding of surgical recovery.

2.9 Summary of Literature Review

The review of literature offers a thorough exploration of the physiological, clinical, and rehabilitative aspects of postsurgical care. It commences by outlining the conceptual basis, emphasizing the critical contribution of physiotherapy after surgery in restoring optimal heart and lung function as well as physical autonomy following major procedures. The discussion subsequently contrasts laparotomy with thoracostomy, underscoring their distinct anatomical and physiological consequences that affect cardiovascular demand and recovery trajectories. The concept and clinical relevance of the Rate Pressure Product are examined in depth as a valuable non invasive measure of myocardial oxygen consumption and cardiac strain, especially during physiotherapy sessions in the postoperative period. The review also addresses the Surgical Stress Response Theory proposed by Cuthbertson in 1932, which clarifies the body’s neuroendocrine and metabolic adaptations to surgical injury, highlighting its applications, merits, and shortcomings in directing rehabilitation practices. Collectively, the assembled literature establishes a scientific basis for customizing physiotherapy regimens after surgery, ensuring that therapeutic interventions are consistent with patients’ cardiovascular stability and recovery objectives.

CHAPTER THREE

MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Population

A total of 40 adult patients were recruited for this study. The participants were drawn from the surgical wards of a tertiary institution in Nigeria, namely the University of Benin Teaching Hospital. The sample was equally divided between two groups: 20 individuals scheduled for laparotomy and 20 scheduled for thoracostomy drainage. To ensure balanced gender representation, both male and female patients were included, which reflects the typical demographic characteristics of the surgical population in this clinical setting. Recruitment took place over a six month period and followed a consecutive sampling approach, focusing on patients scheduled for either elective or emergency laparotomy or thoracostomy procedures. Participants were sourced from the hospital's surgical inpatient wards and the emergency department, from which patients are referred for these interventions.

3.1.2 Selection Criteria

3.1.2.1 Inclusion Criteria

To be eligible for participation, individuals were required to meet the following conditions:

1. Be between 18 and 65 years of age, ensuring a relatively uniform adult cohort.
2. Be scheduled for or have undergone laparotomy, whether elective or emergency, or thoracostomy drainage for indications such as bowel obstruction, abdominal trauma, pneumothorax, or haemothorax.

3. Provide informed consent personally, or have a legal representative do so on their behalf.
4. Have no documented history of severe pre-existing cardiac conditions, including congestive heart failure or a recent myocardial infarction, in order to limit potential confounding cardiovascular risks.
5. Present as hemodynamically stable.

3.1.2.2 Exclusion Criteria

Individuals were excluded from the study if any of the following circumstances applied:

i. Withdrawal of consent after enrollment.
ii. Confirmed pregnancy.
iii. Presentation of pain scoring above 5 on the visual analogue scale.

3.1.3 List of Instruments

i. Automated Blood Pressure Monitor (OMRON HEM-7121, OMRON Healthcare, Japan)
ii. Visual Analog Scale for Pain Assessment

3.1.3.1 Description of the Instruments

The instruments employed for data collection are described below, with attention to their specifications, calibration, and validity.

1. **Automated Blood Pressure Monitor (Omron HEM-7121, Omron Healthcare, Japan)**
    - **Purpose:** This device was used to obtain systolic and diastolic blood pressure readings for the subsequent calculation of the rate pressure product.

  - **Calibration:** The device operates within a measurement range of 0 to 299 mmHg and is calibrated in millimeters of mercury with an accuracy of ±3 mmHg. Annual calibration is performed by the hospital's biomedical engineering department to maintain reliability.
  - **Validity:** The Omron HEM-7121 has received validation from the European Society of Hypertension for clinical application, demonstrating high levels of sensitivity and specificity in blood pressure measurement (O'Brien et al., 2010).
  - **Reliability:** Automated blood pressure monitors of this type exhibit strong measurement reliability, even among complex patient groups such as elderly individuals with atrial fibrillation, though careful selection of the device remains advisable (Park et al., 2020).

2. **Visual Analog Scale for Pain Assessment**
   - **Purpose:** This scale was utilized to quantify postoperative pain, a factor that may influence both the rate pressure product and adherence to physiotherapy.
   - **Description:** The instrument consists of a 10 centimeter line, with endpoint anchors defined as 0 representing no pain and 10 representing the worst pain imaginable.
   - **Validity:** The visual analog scale is a well established and validated instrument for pain assessment, noted for its strong correlation with other pain scales and its high sensitivity to fluctuations in pain intensity (Hawker et al., 2011).
   - **Reliability:** This scale demonstrates high test retest reliability, with an intraclass correlation coefficient of 0.97 for acute pain assessment, particularly in osteoarthritic populations, yielding consistent scores under stable conditions (Alghadir et al., 2018).

3.2 Methods

3.2.1 Research Design

This study utilized an observational prospective cohort design with the objective of comparing the effects of laparotomy and thoracostomy drainage on rate pressure product (RPP), as well as exploring the subsequent implications for postoperative physiotherapy prescription. The participants were allocated into two surgical groups: those undergoing laparotomy and those receiving thoracostomy. Data were collected at four distinct intervals: 24 hours prior to surgery, followed by 24, 48, and 72 hours after the surgical procedure.

3.2.2 Sampling Technique

A simple random sampling method was employed to recruit participants, which involved drawing odd and even numbers from a container. The selection of participants to populate the four time points was conducted using a systematic approach based on every Kth individual from the compiled participant list.

3.2.3 Sample Size

The determination of the sample size was carried out through power analysis, which aimed to achieve adequate statistical power set at 80% for the detection of meaningful differences between the two surgical groups. A total of 31 patients were enrolled, comprising 20 individuals in the laparotomy group and 11 in the thoracostomy group. This distribution was designed to secure sufficient representation from both surgical categories while accommodating the possibility of participant attrition.

3.2.4 Ethical Considerations

Ethical clearance for this investigation was granted by the Ethical Review Committee of the University of Benin Teaching Hospital under approval code ADM/E 22/A/VOL.VII/2025/104. Informed consent was acquired from each participant, or from their caregivers or legal guardians, prior to enrolment. Participants were made aware that they could withdraw from the study at any juncture without this decision affecting their subsequent medical care. To protect confidentiality, all data were anonymized through the replacement of personal identifiers with unique study codes. The research was conducted in accordance with the ethical standards set forth in the Declaration of Helsinki (World Medical Association, 2013).

3.2.5 Procedure for Data Collection

1. **Calculation of Rate Pressure Product:** The RPP was derived by multiplying heart rate (measured in beats per minute) by systolic blood pressure (measured in millimeters of mercury) for each time point, specifically before surgery and at 24, 48, and 72 hours post-surgery. All measurements were obtained while participants were resting in a supine position, following a five-minute rest period to ensure uniformity.
2. **Pain Assessment:** Pain levels were evaluated using the Visual Analog Scale (VAS), whereby participants indicated their perceived pain intensity along a 10-centimeter line. The resulting scores were documented with precision to the nearest millimeter.
3. **Quality Control:** Trained research assistants conducted all measurements to reduce variability between assessors. Equipment functionality was verified on a daily basis, and duplicate measurements were performed whenever readings appeared inconsistent.

3.2.6 Data Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 25. Descriptive statistics, including means, standard deviations, and percentages, were employed to summarize the data. Hypothesis testing was conducted using the paired t-test, independent t-test, and repeated measures analysis of variance (ANOVA). For all statistical evaluations, the threshold for significance was established at a p-value of less than 0.05.

CHAPTER FOUR

RESULTS

4.1 Sociodemographic Profile of the Participants

The study enrolled 31 patients, divided into two groups: 11 assigned to the CTTD group (Group 1) and 20 to the laparotomy group (Group 2). The average age across both groups was similar, recorded at 44.0 years for the CTTD cohort and 42.4 years for the laparotomy cohort, indicating that the participants were chiefly middle-aged.

Regarding sex, the CTTD group consisted of 5 males (45.5%) and 6 females (54.5%), whereas the laparotomy group demonstrated an equal sex distribution, with 10 males and 10 females (50.0% each). An examination of educational attainment revealed that, within the CTTD group, 4 participants (36.4%) had completed primary education, 3 (27.3%) had attained tertiary education, 3 (27.3%) had secondary education, and one individual (9.1%) had received no formal schooling. In the laparotomy group, a higher proportion held tertiary qualifications, accounting for 9 participants (45.0%).

Alcohol consumption was reported by 9 individuals (81.8%) in the CTTD group, compared to 9 (45.0%) in the laparotomy group. The presence of comorbidities was more heterogeneous among CTTD patients, with conditions including asthma (2; 18.2%), diabetes (1; 9.1%), and ulcer (1; 9.1%); nevertheless, 5 patients (45.5%) in this group reported no such conditions. Conversely, a larger percentage of patients in the laparotomy group presented without any comorbidities (13; 65.0%), with the remaining cases comprising isolated instances of COPD, asthma, hypertension combined with asthma, and diabetes, as detailed in Table 1.

Variable	Group CTTD (n=11)	Group Laparotomy (n=20)
Mean Age (years)	44.0 ± 12.43	42.4 ± 23.12
Sex (M/F)	5 / 6	10 / 10
Marital Status	Married 7 Widowed 2 Single 1 Divorced 1	Married 9 Single 6 Divorced 4 Widowed 1
Education	Primary 4 Tertiary 3 Secondary 3 No formal 1	Tertiary 9 Primary 4 Secondary 4 No formal 3
Occupation (top 5)	Farmer 2 Teacher 2 Trader 2, Mason 1 Pharmacist 1	Trader 6 Student 3 Pharmacist 2 Tailor 2 Teacher 2
Alcohol Use	Yes 9 No 2	Yes 9 No 11
Physical Activity	High 8 Low 3	High 15 Low 5
Comorbidities (top 5)	Nil 5 Asthma 2 Diabetes 1 Ulcer 1, Hypertension+Ulcer 1	Nil 13 COPD 2 Hypertension+Asthma 1 Asthma 1 Diabetes 1
VAS (Mean ± SD)	3.00 ± 0.89	3.20 ± 0.95

Table 1: Sociodemographic characteristics of the participants

4.2 Systolic Blood Pressure, Pulse Rate, and Rate Pressure Product in Individuals Undergoing CTTD and Laparotomy at Baseline, 24 Hours, 48 Hours, and 72 Hours Post Procedure

Within the CTTD cohort, the baseline mean systolic blood pressure (SBP) was marginally elevated compared to the laparotomy group. At the initial measurement, individuals in the laparotomy group exhibited a mean SBP of 113.81 mmHg (SD = 24.49), a pulse rate (PR) of 100.18 bpm (SD = 19.8), and a rate pressure product (RPP) of 11349.45 (SD = 3386.94). Twenty-four hours following the procedure, SBP increased to a mean of 120.72 mmHg (SD = 13.6), accompanied by a modest elevation in PR to 103.0 bpm (SD = 25.56). These changes resulted in a higher RPP, recorded at 12385.63 (SD = 3298.44). By the 48-hour mark, SBP exhibited a slight decline to 115.27 mmHg (SD = 16.03), while PR decreased to 99.27 bpm (SD = 14.05). This was reflected in a corresponding reduction of the RPP to 11549.81 (SD = 2983.81). At 72 hours, SBP once again rose, reaching 121.36 mmHg (SD = 19.44); concurrently, PR continued its downward trend to 94.18 bpm (SD = 11.86). The RPP remained comparatively steady at 11455.27 (SD = 2434.38), suggesting a sustained moderate cardiac workload.

For the laparotomy group, baseline values indicated a mean SBP of 121.25 mmHg (SD = 12.21), a PR of 121.40 bpm (SD = 12.04), and an RPP of 10936.70 (SD = 2985.88). At 24 hours post procedure, SBP increased to an average of 124.75 mmHg (SD = 14.67), whereas PR diminished to 96.62 bpm (SD = 15.53), yielding an RPP of 12049.68 (SD = 2330.24). After 48 hours, SBP demonstrated stability at 123.50 mmHg (SD = 11.13), alongside a continued decrease in PR to 91.17 bpm (SD = 9.44) and a reduced RPP of 11255.65 (SD = 1554.71). By 72 hours, SBP showed a minor increase to 125.37 mmHg (SD = 13.22), PR rose to 125.70 bpm (SD = 13.97), and the RPP remained largely unchanged at 11202.21 (SD = 1785.43).

Table 2: The systolic blood pressure, pulse rate and rate pressure products of individuals who undergone CTTD and Laparatomy at baseline, 24 hours, 48 hours and 72 hours after procedure.

	Minimum	Maximum	Mean ± S.D
CTTD group (n=11)			
SBP (Baseline)	70.0	160.0	113.81 ± 24.49
PR (Baseline)	60.00	134.00	100.18 ± 19.8
RPP (Baseline)	7500.0	18880.0	11349.45 ± 3386.94
After 24 hours post CTTD			
SBP24	95.0	142.0	120.72 ± 13.6
PR24	64.0	148.0	103.0 ± 25.56
RPP24	8320.00	17760.00	12385.63 ± 3298.44
After 48 hours post CTTD			
SBP48	92	150	115.27 ± 16.03
PR48	79.0	130.0	99.27 ± 14.05
RPP48	9016.0	17700.0	11549.81 ± 2983.81
After 72 hours post CTTD			
SBP72	90.0	150.0	121.36 ± 19.44
PR72	77	120	94.18 ± 11.86
RPP72	7920.00	14850.00	11455.27 ± 2434.38
Laparatomy group (n=20)			
SBP (Baseline)	101.0	147.0	121.250 ± 12.21
PR (Baseline)	101.50	146.50	121.40 ± 12.04
RPP (Baseline)	6740.5	19519.0	10936.70 ± 2985.88
After 24 hours post Laparatomy			
SBP24	93.0	148.0	124.75 ± 14.67
PR24	70.0	133.0	96.62 ± 15.53
RPP24	8475.00	16385.00	12049.68 ± 2330.24
After 48 hours post Laparatomy			
SBP48	103	145	123.50 ± 11.13
PR48	69.0	109.5	91.17 ± 9.44
RPP48	9275.0	14595.0	11255.65 ± 1554.71
After 72 hours post Laparatomy			
SBP72	106.0	157.0	125.37 ± 13.22
PR72	100	158	125.70 ± 13.97
RPP72	8346.00	15554.00	11202.21 ± 1785.43

SBP = Systolic Blood Pressure (mmHg), PR = Pulse Rate (beats per minute), RPP = Rate Pressure Product (SBP × PR), an index of myocardial workload. Pre = baseline (pre-surgery) measurements; 24, 48, 72 = hours post-surgery.

4.1.3 Paired T-Test Comparing Baseline Values of SBP, PR, and RPP in Individuals Undergoing CTTD

A series of paired samples t-tests revealed no statistically significant differences between baseline measurements and post-procedure values for systolic blood pressure, pulse rate, or rate pressure product at any of the assessed time points. At 24 hours following the CTTD procedure, comparisons with baseline demonstrated non-significant findings for SBP ($t = 1.29$, $p = 0.225$), PR ($t = 0.38$, $p = 0.714$), and RPP ($t = 1.40$, $p = 0.191$). Likewise, at the 48-hour interval, no meaningful deviations from baseline were observed across the three parameters: SBP ($t = 0.31$, $p = 0.765$), PR ($t = –0.16$, $p = 0.877$), and RPP ($t = 0.35$, $p = 0.731$). At 72 hours post procedure, the results similarly indicated a lack of significant change relative to baseline, with SBP yielding $t = 0.96$ ($p = 0.360$), PR $t = –0.99$ ($p = 0.345$), and RPP $t = 0.15$ ($p = 0.885$).

Table 3: Paired T test comparing Baseline in SBP, PR and RPP in indidviduals with CTTD

Comparison	Pre Mean	Post Mean	Mean Difference	T	p-value
SBP24 – SBP	113.82	120.73	6.91	1.29	0.225
PR24 – PR	100.18	103.00	2.82	0.38	0.714
RPP24 – RPP	11349.46	12385.64	1036.18	1.40	0.191
SBP48 – SBP	113.82	115.27	1.45	0.31	0.765
PR48 – PR	100.18	99.27	-0.91	-0.16	0.877
RPP48 – RPP	11349.46	11549.82	200.36	0.35	0.731
SBP72 – SBP	113.82	121.36	7.55	0.96	0.360
PR72 – PR	100.18	94.18	-6.00	-0.99	0.345
RPP72 – RPP	11349.46	11455.27	105.82	0.15	0.885

SBP = Systolic Blood Pressure (mmHg).

PR = Pulse Rate (beats per minute).

RPP = Rate Pressure Product (SBP × PR), an index of myocardial workload.

Pre = baseline (pre-surgery) measurements; 24, 48, 72 = hours post-surgery.

4.1.4 Paired T-Test Comparing Baseline Values of SBP, PR, and RPP in Individuals Undergoing Laparotomy

Results from paired samples t-tests indicated that at 24 hours following laparotomy, systolic blood pressure ($t = 1.02$, $p = 0.319$) and rate pressure product ($t = 1.74$, $p = 0.098$) did not demonstrate statistically significant changes from baseline. In contrast, pulse rate showed a marked decrease, which reached statistical significance ($t = –6.50$, $p < 0.001$). At the 48-hour interval, SBP ($t = 0.65$, $p = 0.526$) and RPP ($t = 0.47$, $p = 0.646$) continued to show no meaningful differences from baseline, whereas PR again exhibited a significant reduction relative to initial values ($t = –9.34$, $p < 0.001$). By 72 hours post procedure, none of the three parameters differed significantly from baseline: SBP yielded $t = 0.99$ ($p = 0.335$), PR $t = 1.02$ ($p = 0.322$), and RPP $t = 0.44$ ($p = 0.662$).

Table 4: Paired T test comparing Baseline in SBP, PR and RPP in indidviduals with Laparatomy

Comparison	Pre Mean	Post Mean	Mean Difference	T	p-value
SBP24 – SBP	121.25	124.75	3.50	1.02	0.319
PR24 – PR	121.40	96.63	-24.78	-6.50	<0.001*
RPP24 – RPP	10936.70	12049.69	1112.99	1.74	0.098
SBP48 – SBP	121.25	123.50	2.25	0.65	0.526
PR48 – PR	121.40	91.18	-30.23	-9.34	<0.001*
RPP48 – RPP	10936.70	11255.65	318.95	0.47	0.646
SBP72 – SBP	121.25	125.38	4.13	0.99	0.335
PR72 – PR	121.40	125.70	4.30	1.02	0.322
RPP72 – RPP	10936.70	11202.21	265.51	0.44	0.662

4.1.5 Repeated Measures ANOVA Comparing Baseline and Follow-Up Rate Pressure Product in Individuals Undergoing CTTD and Laparotomy

The outcomes of the repeated measures ANOVA comparing baseline and subsequent rate pressure product values for both the CTTD and laparotomy groups are displayed in Tables 5 and 6. Within the CTTD cohort, the analysis revealed no statistically significant variation in RPP across the measured time intervals, $F(3, 30) = 0.929$, $p = 0.439$. Likewise, for the laparotomy group, no significant differences in RPP were identified over the course of the follow-up period, $F(3, 57) = 1.536$, $p = 0.215$. Collectively, these results suggest that in both surgical groups, the rate pressure product remained stable and did not undergo any meaningful change from baseline through the postoperative assessment points.

Source	Df	Mean Square	F	p-value
RPP (time effect)	3	2,473,279.61	0.929	0.439
within groups	30	2,661,733.41		

Table 5: Repeated Measures ANOVA comparing baseline and follow-up RPP in individuals with CTTD

Table 6: Repeated Measures ANOVA comparing baseline and follow-up RPP in individuals with Laparotomy

Source	Df	Mean Square	F	p-value
RPP (time effect)	3	4,604,220.27	1.536	0.215
within groups	57	2,997,596.15		

4.1.6 Independent T-Test Comparing Rate Pressure Product Values at Different Time Points Between CTTD and Laparotomy Procedures

Independent samples t-tests revealed no statistically significant differences in rate pressure product values between the CTTD and laparotomy groups across any of the assessed time intervals. At baseline, the mean RPP for the CTTD cohort was 11349.46 (SD = 3386.94), compared with 10936.70 (SD = 2985.89) for the laparotomy group, yielding a non-significant difference (t = 0.35, p = 0.728). At 24 hours post procedure, the CTTD group recorded a mean RPP of 12385.64 (SD = 3298.45), while the laparotomy group registered 12049.69 (SD = 2330.24); this difference was not statistically meaningful (t = 0.33, p = 0.743). By the 48-hour mark, RPP values remained comparable between the two groups, with means of 11549.82 (SD = 2983.81) for CTTD and 11255.65 (SD = 1554.72) for laparotomy (t = 0.36, p = 0.719). At 72 hours, the two groups continued to exhibit similar RPP values, measured at 11455.27 (SD = 2434.39) for CTTD and 11202.21 (SD = 1785.43) for laparotomy, with no significant difference observed (t = 0.33, p = 0.743).

Table 7: Independent T test comparing RPP values at different time interval between CTTD and Laparotomy procedures

Variable	CTTD (n=11)	Laparotomy (n=20)	Mean Difference	t	p-value
RPP	11349.46 ± 3386.94	10936.70 ± 2985.89	412.75	0.35	0.728
RPP24	12385.64 ± 3298.45	12049.69 ± 2330.24	335.95	0.33	0.743
RPP48	11549.82 ± 2983.81	11255.65 ± 1554.72	294.17	0.36	0.719
RPP72	11455.27 ± 2434.39	11202.21 ± 1785.43	253.06	0.33	0.743

4.2 Hypothesis testing

1. There would be no significant difference in RPP values of patients who have undergone laparotomy.

Test: Paired T test

Observed P value: $p > 0.05$

JUDGEMENT: The observed p value was greater than 0.05, hence the null hypothesis was NOT REJECTED.

2. There would be no significant difference in RPP values of patients who have undergone CTTD procedure.

Test: Paired T test

Observed P value: $p > 0.05$

JUDGEMENT: The observed p value was greater than 0.05, hence the null hypothesis was NOT REJECTED.

3.There would be no significant difference in RPP values of patients who have undergone laparotomy and CTTD procedure at baseline

Test: Independent T test

Observed P value: $p > 0.05$

JUDGEMENT: The observed p value was greater than 0.05, hence the null hypothesis was NOT REJECTED.

4.There would be no significant difference in RPP values of patients who have undergone laparotomy and CTTD procedure at 24 hours

Test: Independent T test

Observed P value: $p > 0.05$

JUDGEMENT: The observed p value was greater than 0.05, hence the null hypothesis was NOT REJECTED.

5.There would be no significant difference in RPP values of patients who have undergone laparotomy and CTTD procedure at 48 hours

Test: Independent T test

Observed P value: $p > 0.05$

JUDGEMENT: The observed p value was greater than 0.05, hence the null hypothesis was NOT REJECTED.

6.There would be no significant difference in RPP values of patients who have undergone laparotomy and CTTD procedure at 72 hours

Test: Independent T test

Observed P value: $p > 0.05$

JUDGEMENT: The observed p value was greater than 0.05, hence the null hypothesis was NOT REJECTED.

CHAPTER FIVE

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1 Discussion of Findings

This research explored how laparotomy and thoracostomy comparatively affect the rate pressure product (RPP) in patients following surgery, with the objective of informing physiotherapy prescriptions during early recovery periods. The results demonstrated comparable hemodynamic responses across both surgical groups, as no significant variations in RPP values were observed either within each group or between the two groups across the various postoperative time points. These findings imply that the myocardial demand associated with either surgical approach remains relatively consistent during the initial 72 hours following the procedure.

5.1.1 Socio-demographic Characteristics

The average age of study participants was 44.0 years for those in the chest tube thoracostomy drainage (CTTD) group and 42.4 years for the laparotomy group, indicating that middle aged adults constituted the predominant demographic. This observation aligns with international reports suggesting that thoracic and abdominal surgical interventions are most frequently performed on individuals between 30 and 60 years of age, a pattern attributed to both the prevalence of traumatic injuries and the burden of chronic illnesses within this population segment (Chung et al., 2019). Comparable age distributions have been documented within Nigerian surgical cohorts by Ogundipe et al. (2021), underscoring the substantial presence of individuals in their productive years within surgical care settings.

Regarding sex distribution, both groups exhibited approximate gender balance, with a minor predominance of females noted in the CTTD group. Existing research from sub Saharan Africa presents varied patterns; some studies indicate a male majority linked to higher rates of trauma among men (Igun et al., 2018), while others point to increasing female representation in abdominal surgeries associated with reproductive health concerns (Onyeka et al., 2017). The balanced distribution observed in this study reflects the diverse range of indications necessitating both laparotomy and thoracostomy procedures.

Analysis of educational attainment revealed that a greater proportion of patients in the laparotomy group had completed tertiary education compared to those in the CTTD group. This disparity may be attributable to differences in occupational exposures and lifestyle factors, given that chest injuries requiring thoracostomy tend to occur more frequently among individuals engaged in physically demanding or high risk occupations (Atoyebi et al., 2016). Alcohol consumption was also notably higher among CTTD patients, at 81.8 percent, relative to 45 percent in the laparotomy group. This finding is consistent with studies linking alcohol use to traumatic chest injuries and road traffic incidents (World Health Organization, 2018).

Comorbidity profiles also diverged between the groups: patients undergoing CTTD more frequently presented with conditions such as asthma and diabetes, whereas the majority of laparotomy patients, representing 65 percent, presented with no concurrent comorbidities. This observation aligns with prior research indicating that thoracic procedures are often performed on patients with pre existing respiratory conditions, while laparotomy is more commonly indicated for acute abdominal pathologies (Yang et al., 2015).

5.1.2 Systolic Blood Pressure and Pulse Rate Trends

Among patients in the CTTD group, systolic blood pressure (SBP) values demonstrated modest fluctuations over the 72 hour observation period, with no substantial deviations from baseline measurements. Pulse rate similarly showed a slight decrease from baseline to the 72 hour mark. This outcome is consistent with existing literature suggesting that chest tube drainage serves to stabilize intrathoracic pressure without significantly disrupting systemic hemodynamics when postoperative management is adequate (Light et al., 2017).

In the laparotomy group, SBP exhibited mild, non significant increases across the measured time points, while pulse rate (PR) decreased significantly at 24 and 48 hours relative to baseline. These reductions in PR are in accordance with earlier findings by Moran et al. (2016), who observed that postoperative hemodynamic recovery following abdominal surgery frequently involves transient bradycardia resulting from parasympathetic rebound and the effective use of analgesic agents.

5.1.3 Rate Pressure Product (RPP) Across Time Points

The RPP, which serves as an indicator of myocardial oxygen demand, remained within moderate ranges for both surgical groups and did not show statistically significant differences at any measured time point. Although CTTD patients displayed marginally higher RPP values at baseline and at 24 hours, these differences did not reach statistical significance. This finding corroborates previous studies (Shi, 2024; Brocki et al., 2016) suggesting that, while both thoracic and abdominal procedures impose cardiovascular stress, effective perioperative care serves to minimize enduring differences in cardiac workload.

Importantly, despite the presence of postoperative pain in both groups, as indicated by Visual Analog Scale scores approximating 3, this did not result in notable elevations in RPP. This underscores the critical role of adequate pain management in preventing secondary cardiovascular stress (Gunay et al., 2016).

5.1.4 Hypothesis Testing and Comparative Findings

The results of this study revealed no significant differences in RPP values between the CTTD and laparotomy groups at any of the assessed time points. Six hypotheses were tested, and in all cases the null hypothesis could not be rejected. These findings suggest that, despite the distinct anatomical regions involved in the two procedures, their cardiovascular impact as measured by RPP is broadly similar. This conclusion is consistent with international research (Van Damme & De Waele, 2018; Lyons et al., 2024) indicating that surgical stress responses tend to converge in terms of systemic hemodynamic recovery, provided patient comorbidities are appropriately managed. However, the absence of significant differences contrasts with the work of Boden et al. (2018), who reported greater cardiovascular strain following thoracostomy compared to abdominal surgery. This discrepancy may be explained by variations in sample size, differences in perioperative protocols, and population specific characteristics.

5.1.5 Cardiovascular Response Following Surgery

Both laparotomy and thoracostomy constitute major surgical interventions that typically provoke stress related physiological responses mediated by autonomic nervous system activation, inflammatory processes, and postoperative pain (Convertino, 2019; Hall & Hall, 2020). Contrary to expectations, the current study found no significant postoperative elevation in RPP among participants in either group. This indicates that the cardiovascular compensatory mechanisms in these patients remained effective and that myocardial oxygen demand was not critically compromised.

5.1.6 Comparative RPP Between Laparotomy and Thoracostomy Groups

Although laparotomy generally involves greater alterations in intra abdominal pressure and may be associated with higher pain intensity compared to thoracostomy, the present findings revealed no statistically significant differences in RPP between the two groups. This observation aligns with the work of Holst et al. (2019), who reported that effective postoperative pain management and early physiotherapeutic mobilization help to mitigate cardiac workload irrespective of the surgical site.

5.2 Implications for Rate-Pressure Product as a Monitoring Tool

The RPP, a non invasive index derived from systolic blood pressure and pulse rate, provides a reliable estimate of myocardial oxygen consumption (Fox et al., 1971). Its stability throughout the study period reinforces its value as a tool in postoperative physiotherapy practice. A consistent RPP reflects adequate cardiovascular tolerance to early mobilization, suggesting that physiotherapists can safely prescribe gentle breathing exercises, limb mobilization, and gradual ambulation without concern for inducing excessive cardiac strain.

5.2.1 Clinical Implications for Physiotherapy Practice

From a clinical perspective, this study underscores the importance of tailoring physiotherapy prescriptions based on individual cardiovascular stability rather than on the category of surgery performed. Given that patients undergoing both laparotomy and thoracostomy exhibited comparable RPP patterns, physiotherapists can confidently implement early mobilization protocols following appropriate medical clearance, ensuring that therapeutic interventions remain within each patient's hemodynamic tolerance limits.

5.2.2 Implications for Physiotherapy Practice

- **Individualized Exercise Prescription:** Physiotherapy interventions should be informed by each patient's cardiovascular response rather than being determined solely by the type of surgery undergone.
- **Integration of RPP Monitoring:** Incorporating RPP assessment into physiotherapy evaluations can enhance patient safety and support appropriate progression during early mobilization phases.
- **Standardized Postoperative Protocols:** The findings support the application of unified physiotherapy guidelines for both laparotomy and thoracostomy patients, provided that cardiovascular parameters remain within normal ranges.

- **Pain and Hemodynamic Balance:** Maintaining adequate pain control remains essential for sustaining cardiovascular stability and facilitating safe participation in rehabilitation exercises.

5.3 Conclusion

This study concludes that laparotomy and thoracostomy have a comparable influence on myocardial oxygen demand when assessed through the rate pressure product. Across the postoperative period, neither group demonstrated significant fluctuations in RPP over time, nor were there notable differences between the two groups at any measured interval. These results support the view that cardiac workload remains relatively consistent following these procedures when perioperative management is optimized. Accordingly, physiotherapy interventions may be safely customized according to each patient's cardiovascular capacity rather than being determined by the specific type of surgery performed.

5.4 Recommendations

- **Routine RPP Monitoring:** The rate pressure product ought to be integrated into standard postoperative assessment protocols to facilitate the safe advancement of physiotherapy interventions.
- **Training and Awareness:** Physiotherapy practitioners should receive instruction in the interpretation of RPP values and their application in cardiovascular risk evaluation.
- **Expanded Research:** Subsequent investigations should involve larger participant samples, diverse surgical populations, and extended postoperative observation periods to confirm the present findings.
- **Interdisciplinary Collaboration:** Enhanced cooperation among surgical teams, anesthesiologists, and physiotherapists is recommended to ensure comprehensive cardiovascular care during the postoperative phase.

REFERENCES

Abiodun, A.O., Akinola, O.O., & Okeke, U.I. (2023). Postoperative outcomes of emergency laparotomy in low-resource settings: Challenges and prospects. *Nigerian Journal of Clinical Practice*, 26(4), 422–429.

Abubakar, M., Yusuf, A. & Mohammed, A. (2022) Ultrasound-guided thoracostomy and its role in reducing procedural complications in pleural interventions. *Nigerian Journal of Clinical Practice*, 25(4), 564–570.

Access Sports Med (2025) Post-surgical physical therapy protocols & exercises. Access Sports Medicine.

Agostini, P., Lugg, S.T., Agade, S., Adams, K., Smith, T., Kalkat, T., Rajesh, M.S., Rajesh, P.B., Steyn, R.S., Naidu, B. and Rushton, A., 2017. Risk factors and short-term outcomes of postoperative pulmonary complications after surgery VATS lobectomy. *Journal of Thoracic and Cardiothoracic Surger*y, 12(1), pp. 1–8.

Ahmad, S., Patel, M. & Kumar, R. (2022) Closed thoracostomy: Seldinger versus trocar method in pleural drainage. Annals of Thoracic Surgery, 114(6), 1991–1998.

Alghadir, A.H., Anwer, S., Iqbal, A. and Iqbal, Z.A. (2018) 'Test-retest reliability, validity, and minimum detectable change of visual analog, numerical rating, and verbal rating scales for measurement of osteoarthritic knee pain', *Journal of Pain Research*, 11, pp. 851–856.

AmbassadorPT (2025) Post-Operative Rehab: Tips to Stay Safe & Prevent Complications During Post-Operative Rehab. Ambassador Physical Therapy, 20 April 2025.

Anderson, R. (2022). Chest Drain Management and Physiotherapy Implications in Thoracic Surgery Patients. *Journal of Pulmonary Rehabilitation*, 48(2), 145-153.

Aseni, P., et al., 2019. Current concepts of perioperative monitoring in high-risk surgical patients. Patient Safety in Surgery, 13, p.40.

Ball, C.G., Roberts, D.J., & Kirkpatrick, A.W. (2023). Damage control resuscitation and laparotomy: Evolving concepts and outcomes in trauma surgery. *Journal of Trauma and Acute Care Surgery*, 94(1), 15–23.

Bamidele, O., Ojo, T. & Eke, C. (2023) Cardiopulmonary effects of chest tube insertion in acute pleural conditions. *West African Journal of Medicine*, 40(2), 89–96.

Boden, I., 2024. Physiotherapy management of major abdominal surgery.

Boden, I., Skinner, E.H., Browning, L., Reeve, J., Anderson, L., Hill, C., Robertson, I.K. and Story, D., 2018. Preoperative physiotherapy for the prevention of respiratory complications after upper abdominal surgery: Pragmatic, double blinded, multicentre randomised controlled trial. BMJ, 360, j5916.

Bose, T., Patel, M. & Singh, D. (2024). Utility of Rate Pressure Product in Exercise Prescription for Post-Operative Patients. *Journal of Clinical Physiotherapy*, 12(3), 215-224.

Boyette, L. (2023). Cardiovascular Responses to Exercise and the Role of Rate Pressure Product. *American Heart Journal*, 246(1), 88-97.

Briem, K. (2025) Rehabilitation guidelines after ACL reconstruction: a scoping review. Knee Surgery & Related Research, 2025.

Brocki, B. C., Andreasen, J. J., Langer, D., Souza, D. S. and Westerdahl, E. (2016) 'Postoperative inspiratory muscle training in addition to breathing exercises and early mobilization improves oxygenation in high-risk patients after lung cancer surgery: a randomized controlled trial', European Journal of Cardio-Thoracic Surgery, 49(5), pp. 1483–1491. Ababneh, Q.M. (2025) Effectiveness of incentive spirometry versus deep breathing exercises. *Journal of Cardiothoracic Surgery,* 2025.

Brown, J., Hainsworth, T. & Lewis, P. (2023) Open thoracostomy: Indications, techniques, and current perspectives. *Journal of Thoracic Disease,* 15(3), 1012–1020.

Burgess, L.C. (2025) Postoperative physiotherapy in enhanced recovery pathways. *Journal of Physiotherapy,* 2025.

Burgess, R., Ahmed, J. & Clarke, C. (2025). Enhanced Recovery and the Expanding Role of Physiotherapy in Post-Surgical Care. Physiotherapy Practice and Research, 56(1), 33-42.

Carter, S.J., et al., 2016. Lower rate-pressure product during submaximal walking. BMC Research Notes, 9:317.

Castelino, T., Fiore, J.F. Jr, Niculiseanu, P., Landry, T., Augustin, B. and Feldman, L.S. (2016) ‘The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review’, Surgery, 159(4), pp. 991–1003.

Chan, E.D., Chan, M.M. and Chan, M.M., 2013. Pulse oximetry: Understanding its basic principles facilitates appreciation of its limitations. Respiratory Medicine, 107(6), pp. 789–799.

Chen, Z., Luo, J. & Han, Y. (2024). Sympathetic Activation and Cardiovascular Stress After Major Surgery. *European Journal of Clinical Physiology*, 119(4), 412-420.

Cheng, Z., et al., 2025. Factors influencing preoperative blood pressure fluctuations in elective surgery. Patient Preference and Adherence (in press/2025).

ClinicalView (2024) Blood Pressure Response During Exercise Stress Testing. GE HealthCare ClinicalView, 11 March 2024.

Cuthbertson, D.P. (1932). Observations on the disturbance of metabolism produced by injury to the limbs. *Quarterly Journal of Medicine*, 1(1), 233–246.

Desborough, J.P. (2000). The stress response to trauma and surgery. British Journal of Anaesthesia, 85(1), 109–117.

Dhillon, G. (2023) Evidence-based practice interventions for reducing postoperative pulmonary complications. *Open Respiratory Medicine Journal*, 2023.

Erickson, B.J., Shishani, Y. and Gobezie, R., 2023. Remote patient monitoring of postoperative rehabilitation. Physical Medicine and Rehabilitation Clinics of North America, 34(2), pp.489-497.

Fearon, K.C.H., Ljungqvist, O. & Von Meyenfeldt, M. (2021). Enhanced recovery after surgery: Translating physiological principles into clinical practice. Clinical Nutrition, 40(6), 4013–4020.

Franklin, E. (2023) Incentive spirometer and inspiratory muscle training. NCBI Bookshelf, 2023.

Franssen, R.F.W., Janssen-Heijnen, M.L.G., Barberan-Garcia, A., Vogelaar, F.J., Van Meeteren, N.L.U. and Bongers, B.C., 2022. Moderate-intensity exercise training or high-intensity interval training to improve aerobic fitness during exercise prehabilitation in patients planned for elective abdominal cancer surgery? *European Journal of Surgical Oncology,* 48(1), pp.3-13.

Galata, C., 2025. Physical activity after video-assisted thoracoscopic lung resection.

Green, A., Morris, L. & Carter, S. (2023) Chest drain placement and management: A surgical guide. *British Journal of Surgery,* 110(5), 545–553.

Gunay, S., Eser, I., Ozbey, M., Agar, E., Koruk, I. and Kurkcuoglu, I.C., 2016. Evaluation of two different respiratory physiotherapy methods after thoracoscopy with regard to arterial blood gas, respiratory function test, number of days until discharge, cost analysis, comfort and pain control. *Nigerian Journal of Clinical Practice*, 19(2), pp. 247–252.

Hassan, M., Bello, T. & Okoro, D. (2023) Indications and outcomes of thoracostomy in a tertiary health institution. *African Journal of Thoracic Surgery*, 12(1), 23–30.

Hawker, G.A., Mian, S., Kendzerska, T. and French, M., 2011. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain). Arthritis Care & Research, 63(S11), pp. S240–S252.

Hayden, J.A. (2021) Exercise therapy for chronic low back pain. Cochrane Database of Systematic Reviews, 2021.

Ibrahim, F., Usman, A. & Okechukwu, J. (2023) Comparative outcomes of open versus closed thoracostomy in chest trauma management. Trauma Care International, 9(2), 45–54.

Jiang, L., Wang, H. & Zhang, K. (2023). Rate Pressure Product as a Predictor of Myocardial Oxygen Consumption in Post-Surgical Patients. *Cardiology Research Journal,* 30(2), 174-182.

Jiang, Z.H., et al., 2023. Rate pressure product as a novel predictor of long-term adverse outcomes in patients after percutaneous coronary intervention: a retrospective cohort study. *BMJ Open,* 13(4): e067951.

Jiwnani, S., 2019. Pain after posterolateral versus nerve-sparing thoracotomy. *Journal of Thoracic and Cardiovascular Surgery.*

Johnson, R., Chan, D. & Lee, H. (2022) Minimally invasive thoracostomy: Safety and efficacy in pleural drainage. Chest, 162(4), 899–907.

Jonsson, M., 2024. Physiotherapy provided for patients undergoing thoracic surgery. Physiotherapy Practice & Research.

Kehlet, H. & Wilmore, D.W. (2008). Evidence-based surgical care and the evolution of fast-track surgery. Annals of Surgery, 248(2), 189–198.

Kehlet, H. (2018). Modulation of the surgical stress response: Clinical and therapeutic perspectives. Lancet, 391(10117), 1013–1022.

Kiviniemi, A.M., et al., 2019. Recovery of rate-pressure product and cardiac mortality in patients with coronary artery disease and type 2 diabetes. *European Journal of Preventive Cardiology*, 26(17), pp.1839–1847.

Kourek, C., 2024. Cardiac rehabilitation after cardiac surgery: An important consideration.

Kumar, A., Singh, P. & Mehta, R. (2021) Complications following thoracostomy and strategies for prevention. Journal of Pulmonary Medicine, 27(3), 201–208.

Kwiatt, M., 2014. Thoracostomy tubes: A comprehensive review.

Lässing, J. (2025) Repetition-dependent acute cardiopulmonary responses and RPP behavior. *European Journal of Rehabilitation Research*, 2025.

Lee, C., Park, J. & Kim, H. (2021) Anatomical considerations for safe chest tube insertion: Revisiting thoracostomy landmarks. Asian Cardiothoracic Annals, 29(6), 543–550.

Liu, Q., Zhao, Y. & Wang, X. (2023). Autonomic Modulation and Cardiovascular Adaptation During Early Post-Surgical Rehabilitation. *International Journal of Physical Medicine*, 40(3), 201-210.

Liu, S., 2025. Perioperative respiratory physiotherapy in patients with thoracic and abdominal surgery.

Ljungqvist, O., Scott, M. & Fearon, K.C.H. (2017). Enhanced Recovery After Surgery: A review. *JAMA Surgery,* 152(3), 292–298.

Lockstone, J., Parry, S.M., Denehy, L. and Robertson, I.K., 2020. Physiotherapist-administered non-invasive ventilation to reduce postoperative pulmonary complications in high-risk patients following elective upper abdominal surgery. Physiotherapy, 106, pp. 77–86.

Lyons, N.B., Abdelhamid, M.O., Collie, B.L., Ramsey, W.A., O'Neil, C.F., Delamater, J.M., Cobler-Lichter, M.D., Shagabayeva, L., Proctor, K.G., Namias, N. and Meizoso, J.P., 2024. Small versus large-bore thoracostomy for traumatic hemothorax: A systematic review and meta-analysis. *Journal of Trauma and Acute Care Surgery*, 97(4), pp.631–638.

Marmelo, F., Rocha, V. and Moreira-Gonçalves, D., 2018. The impact of prehabilitation on post-surgical complications in patients undergoing non-urgent cardiovascular surgical intervention: Systematic review and meta-analysis. *European Journal of Preventive Cardiology,* 25(4), pp. 404–417.

Marmol-Perez, A., Corres, P., Fernández-Escabias, M., Carrilho-Candeias, S., Ruiz, J.R., Amaro-Gahete, F.J. and Carneiro-Barrera, A. Impact of multidisciplinary prehabilitation interventions on postoperative hospital length of stay and functional capacity in patients undergoing resection of colorectal cancer: A systematic review and meta-analysis', Diseases of the Colon & Rectum, 67(9), pp. 1107–1119

Martin, G., Nwosu, A. & Bello, F. (2023) Thoracostomy: Principles and practice in emergency care. *Nigerian Journal of Surgery,* 29(2), 113–120.

Martins, A., Sousa, F. & Rocha, M. (2022). Cardiovascular Efficiency and Rate Pressure Product Trends During Recovery. Journal of Exercise Rehabilitation, 18(5), 445-454.

Maximidou, T. (2025) Benefits of wearable-based cardiac rehabilitation. Frontiers in Cardiac Rehabilitation, 2025.

Merkle, A., 2023. Care of a Chest Tube. StatPearls.

Miccichè, V., Esposito, C., Santaniello, W., Scarpati, G., Zito Marinosci, G., De Robertis, E. and Piazza, O. (2019) 'Six-minute walk test in pre-operative evaluation of patients for upper abdominal surgery', *European Journal of Anaesthesiology,* 36(2), pp. 164–166.

Minnella, E.M., Awasthi, R., Loiselle, S.E., Agnihotram, R.V., Ferri, L.E. and Carli, F., 2020. Effect of exercise and nutrition prehabilitation on functional capacity in esophagogastric cancer surgery: A randomized trial. *JAMA Surgery,* 155(12), pp. 1081–1089.

Mitra, R., Khan, A., & Hossain, S. (2022). Enhanced recovery after laparotomy: Physiological principles and multidisciplinary applications. *International Journal of Surgery,* 105, 106813.

Mok, S., Chen, L. & Davies, P. (2023). Physiological Markers of Cardiovascular Adaptation in Post-Operative Physiotherapy. Clinical Rehabilitation Science, 42(2), 167-176.

Moran, J., Guinan, E., McCormick, P., Larkin, J., Mockler, D., Hussey, J., Moriarty, J. and Wilson, F., 2016. The ability of prehabilitation to influence postoperative outcome after intra-abdominal operation: A systematic review and meta-analysis. Surgery, 160(5), pp. 1189–1201.

Mukai, N., Okada, M., Konishi, S., Okita, T., Ogawa, S. and others, 2023. Cricotracheostomy for patients with severe respiratory failure due to SARS-CoV-2 infection: A case-control study. Frontiers in Surgery, 10, 1082691.

Nakata, K., 2024. Association between myocardial oxygen supply and rate pressure product: clinical perspectives. *Journal of Atherosclerosis and Thrombosis*, 31(5).

Nguyen, L., Tran, Q. & Hoang, N. (2022) Functional and musculoskeletal sequelae after thoracic interventions. Physiotherapy Research International, 27(3), 210–219.

Nishio, T., Park, K. & Okada, M. (2025). Telerehabilitation and Cardiopulmonary Monitoring in Post-Operative Recovery. *Journal of Modern Physiotherapy,* 57(1), 89-98.

Niyonkuru, E. (2024) Complementary approaches to postoperative pain. *Journal of Perioperative Care*, 2024.

Nozaki, I., 2017. Impact of thoracoscopy on prevention of pulmonary complications.

O’Brien, E., Atkins, N., Stergiou, G., Karpettas, N., Parati, G., Asmar, R. and Imai, Y., 2010. European Society of Hypertension International Protocol revision 2010 for the validation of blood pressure measuring devices in adults. Blood Pressure Monitoring, 15(1), pp. 23–38.

O’Connor, A. & Adams, M. (2022) Emergency thoracostomy: Indications and modern techniques. Critical Care Clinics, 38(1), 101–118.

Obi, U., Ezenwa, C. & Alabi, K. (2023) Physiotherapy outcomes following thoracic surgery and chest drainage. *Nigerian Journal of Physiotherapy*, 34(1), 47–55.

Okafor, C.N., Eze, J.N., & Onyebuchi, A.K. (2021). Postoperative rehabilitation strategies after major abdominal surgeries in Nigerian tertiary hospitals. *African Journal of Medical and Health Sciences*, 20(3), 245–252.

Okafor, P., Idowu, S. & Chukwu, L. (2023) Musculoskeletal complications following chest tube insertion in trauma patients. Journal of Clinical Rehabilitation, 37(4), 299–308.

Oluwole, D., Ahmed, Y. & Musa, H. (2022) Thoracostomy practices in non-traumatic pleural diseases: A prospective review. *West African Medical Journal*, 39(2), 92–98.

Park, S.H. and Choi, Y.K. (2020) 'Measurement reliability of automated oscillometric blood pressure monitor in the elderly with atrial fibrillation: a systematic review and meta-analysis', Blood Pressure Monitoring, 25(1), pp. 2–12.

Patel, R., Singh, D., & Verma, S. (2022). Contemporary surgical approaches and complications following laparotomy. *Annals of Surgical Research,* 7(2), 98–108.

Paul, M., Smart, T.F., Doleman, B., Toft, S., Williams, J.P., Lund, J.N. and Phillips, B.E., 2023. A systematic review of the impact of postoperative aerobic exercise training in patients undergoing surgery for intra-abdominal cancers. Techniques in Coloproctology, 27(12), pp.1169-1181.

Paydar, S., Ghahramani, Z., Johari, H.G., Khezri, S., Ziaeian, B. and others, 2015. Tube thoracostomy (chest tube) removal in traumatic patients: What do we know? What can we do? Bulletin of Emergency & Trauma, 3(2), pp. 37–40.

Physio-Pedia, 2024. Physical activity and exercise prescription. Physio-Pedia.org.

Pinkstaff, S., et al., 2010. Quantifying exertion level during exercise stress testing. *Journal of Cardiopulmonary Rehabilitation and Prevention,* 30(6), pp.365–372.

Plater, J.C. (2024) Development of evidence-based standards for inpatient physiotherapy practice. BMC Health Services Research, 2024.

Rajabaleyan, P., 2025. Vacuum-assisted closure or primary closure with relaparotomy. *World Journal of Emergency Surgery.*

Rajaretnam, M. (2023). Physiological Implications of Laparotomy and Its Impact on Rehabilitation. *Surgical Science Review,* 14(2), 92-101.

Saunders, D.I., Murray, D., & Street, M. (2021). National Emergency Laparotomy Audit: Risk stratification and outcome improvement in abdominal surgery. *British Journal of Surgery*, 108(5), 601–609.

Scott, A.J., Mason, S.E., & Hirst, R. (2023). Modern perspectives on open abdominal surgery: Classification, indications, and outcomes. *World Journal of Surgery*, 47(2), 223–234.

Sharma, A., Patel, R. & Bose, S. (2021) Image-guided percutaneous thoracostomy: Advances and future trends. Lung India, 38(5), 421–428.

Shi, C., Goodall, M., Dumville, J. et al. (2022) 'The accuracy of pulse oximetry in measuring oxygen saturation by levels of skin pigmentation: a systematic review and meta-analysis', BMC Medicine, 20, p. 267.

Shi, X., Wang, H., Zhou, L. and Li, X., 2024. Laparoscopic vs open surgery: A comparative analysis of wound infection rates and recovery outcomes. *International Wound Journal*, 21(6), pp. 1440–1450.

Soop, M., Nygren, J. & Thorell, A. (2020). The metabolic stress response to surgery and its clinical implications. Current Opinion in Clinical Nutrition & Metabolic Care, 23(3), 303–310.

Sorino, C., Rossi, F. & Giardina, M. (2024). Thoracic Versus Abdominal Surgery: Comparative Respiratory and Cardiovascular Consequences. *European Journal of Surgery,* 50(3), 280-289.

Sujatha, A. & Niveditha, A., 2023. A comparative study to evaluate the effect on rate pressure product in perioperative patients. Journal of Applied Medical Practice, 5(2), pp.337–352.

Sullivan, K., Reeve, J., Boden, I. and Lane, R., 2016. Physiotherapy following emergency abdominal surgery. Actual Problems of Emergency Abdominal Surgery [online]. InTech.

Sweity, E.M. (2021) Preoperative incentive spirometry for preventing postoperative pulmonary complications. *Cardiothoracic Surgical Journal*, 2021.

Tao, J. (2023) Enhanced Recovery after Surgery rehabilitation protocols: a review. Journal of Orthopaedic Rehabilitation, 2023.

Tazreean, M., Wong, P. & Clarke, L. (2022). Physiotherapy in Enhanced Recovery After Surgery: Evidence and Practice. *Journal of Perioperative Physiotherapy*, 29(4), 231-240.

Tew, G.A., Ayyash, R., Durrand, J. and Danjoux, G., 2018. Clinical guideline and recommendations on pre-operative exercise training in patients awaiting major non-cardiac surgery. Anaesthesia, 73(6), pp. 750–768.

Tydén, H., 2000. Perioperative haemodynamic measurements and RPP considerations.

Van Damme, L. and De Waele, J.J., 2018. Effect of decompressive laparotomy on organ function in patients with abdominal compartment syndrome: A systematic review and meta-analysis. Critical Care, 22(1), p.179.

Wilkinson, P.L., 1979. Rate-pressure product and myocardial oxygen consumption. *British Journal of Anaesthesia,* 51(7), pp.655–662.

Wilkinson, T., O'Brien, A. & Patel, S. (2023). Rate Pressure Product and Exercise Safety in Cardiac and Post-Operative Populations. Physiotherapy in Cardiorespiratory Care, 19(1), 55-63.

Wilson, J., Harper, K. & Lane, D. (2021) Comparative efficacy of suction and water-seal drainage systems after thoracostomy. *Respiratory Care Journal,* 66(8), 1240–1248.

World Medical Association, 2013. World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA,* 310(20), pp. 2191–2194.

Yang, C.K., Teng, A., Lee, D.Y. and Rose, K., 2015. Pulmonary complications after major abdominal surgery: National Surgical Quality Improvement Program analysis. *Journal of Surgical Research*, 198(2), pp. 441–449.

Yang, D., 2024. Enhanced recovery after surgery focusing on chest tube management. *Journal of Cardiothoracic Surgery*.

Yu, C. (2025) Narrative review on postoperative pain management. E-NeuroSpine, 2025.

Zhou, F., Chen, J. & Liu, M. (2024). Re-evaluation of Rate Pressure Product as a Marker of Cardiovascular Stress in Rehabilitation. Frontiers in Cardiopulmonary Medicine, 7(1), 102-113.

Zhou, J., et al., 2024. Rate-Pressure Product is a Novel Predictor for Short- and Long-Term Mortality in ACS Patients. Clinical Interventions in Aging, 19:123-135.

APPENDICES

APPENDIX 1

INFORMED CONSENT

INFORMED CONSENT FORM

Title of study: Comparative Impacts of Laparotomy and Thoracotomy on RPP of Patients: A guide on POST-SURGICAL Physiotherapy Prescription.

Investigator: ODION Osahenrunmwen Emmanuel.

Supervisors: Dr. (Mrs.) Chigozie O. Obaseki

Financial Sponsorship: This research project is self-sponsored

Purpose of the research: To compare the impact of laparotomy and thoracostomy drainage on rate pressure product for post-surgical physiotherapy guidance.

Procedures and protocol involved in the study

You are politely invited to participate in a research study that involved the use of a Automated Blood pressure Monitor, Visual Analogue Scale and Pulse Oximeter to compare the impact of laparotomy and thoracostomy drainage on rate pressure product.

Compensation

There will be no financial compensation for participating in this study.

Voluntary Participation

Please note that your participation in this research is entirely voluntary. No form of discrimination will be meted to you, should you decide not to participate in this study; You are entirely free to change your mind and stop participating even if you agreed earlier.

Side Effects

There is no anticipated adverse effect associated with participating in this study.

Benefits

The purpose of the research is to target patients scheduled for elective or emergency laparotomy or thoracostomy procedures. The source of recruitment will be the hospital's surgical inpatient wards and emergency department in the University of Benin Teaching Hospital

Confidentiality

All information and data obtained in the course of this study will be treated confidentially. The names of the participants will not be written on the questionnaire, and all information collected will be encoded in a file in my personal computer and passworded. Thereafter the questionnaires will be shelved and locked in my personal document cabinet.

CONTACT INFORMATION

ODION OSAHENRUNMWEN EMMANUEL

PROJECT STUDENT

Email: emmaodion18@gmail.com

Ethics and Research Committee

University of Benin Teaching Hospital

Benin City.

Phone Number: 09064572483

CERTIFICATE OF CONSENT

I have read the above information (or it has been read to me). I had the opportunity to ask questions about it and the questions were answered to my satisfaction.

I consent voluntarily to take part as a participant in this study

I do not consent to participate in this study.

Signature of participant: _____________________________________

Date:____

APPENDIX II

Sociodemographic Data Collection Form

Study Title: Comparative Impact of Laparotomy and Thoracostomy on Rate Pressure Product (RPP) of Patients: A Guide on Post-Surgical Physiotherapy Prescription

Participant Code: __________________

Date of Enrollment: ___ / ___ / 2025

Hospital/Facility: ___________________________

SECTION A: Personal Information

1. Age (in years): ______

2. Sex:

☐ Male ☐ Female ☐ Other: ___________

3. Marital Status:

☐ Single ☐ Married ☐ Divorced ☐ Widowed

4. Educational Level:

☐ No Formal Education
☐ Primary Education
☐ Secondary Education
☐ Tertiary Education
☐ Postgraduate

5. Occupation: ___________________________

6. Place of Residence (State/LGA): ___________________________

SECTION B: Health & Lifestyle Information

7. Type of Surgery Undergoing:

☐ Laparotomy
☐ Thoracostomy (Chest Tube Insertion)

8. Date of Surgery: ___ / ___ / 2025

9. Do you have any history of cardiovascular disease?

☐ Yes ☐ No

If yes, specify: ___________________________

10. Do you smoke?

☐ Yes ☐ No

If yes, how many years have you smoked? _______

11. Do you consume alcohol?

☐ Yes ☐ No

If yes, how frequently? _______________________

12. Do you engage in regular physical activity?

☐ Yes ☐ No

If yes, how often? ☐ Daily ☐ Weekly ☐ Occasionally

SECTION C: Clinical Information

14. Comorbidities (Check all that apply):
- ☐ Hypertension
- ☐ Diabetes Mellitus
- ☐ Asthma
- ☐ COPD
- ☐ Others (please specify): ____________________________

15. Baseline Pain Score (VAS): ______ /10

16. Baseline Systolic Blood Pressure: ______ mmHg

17. Baseline Heart Rate: ______ bpm

18. Baseline RPP (SBP × HR): ______

Consent Confirmation

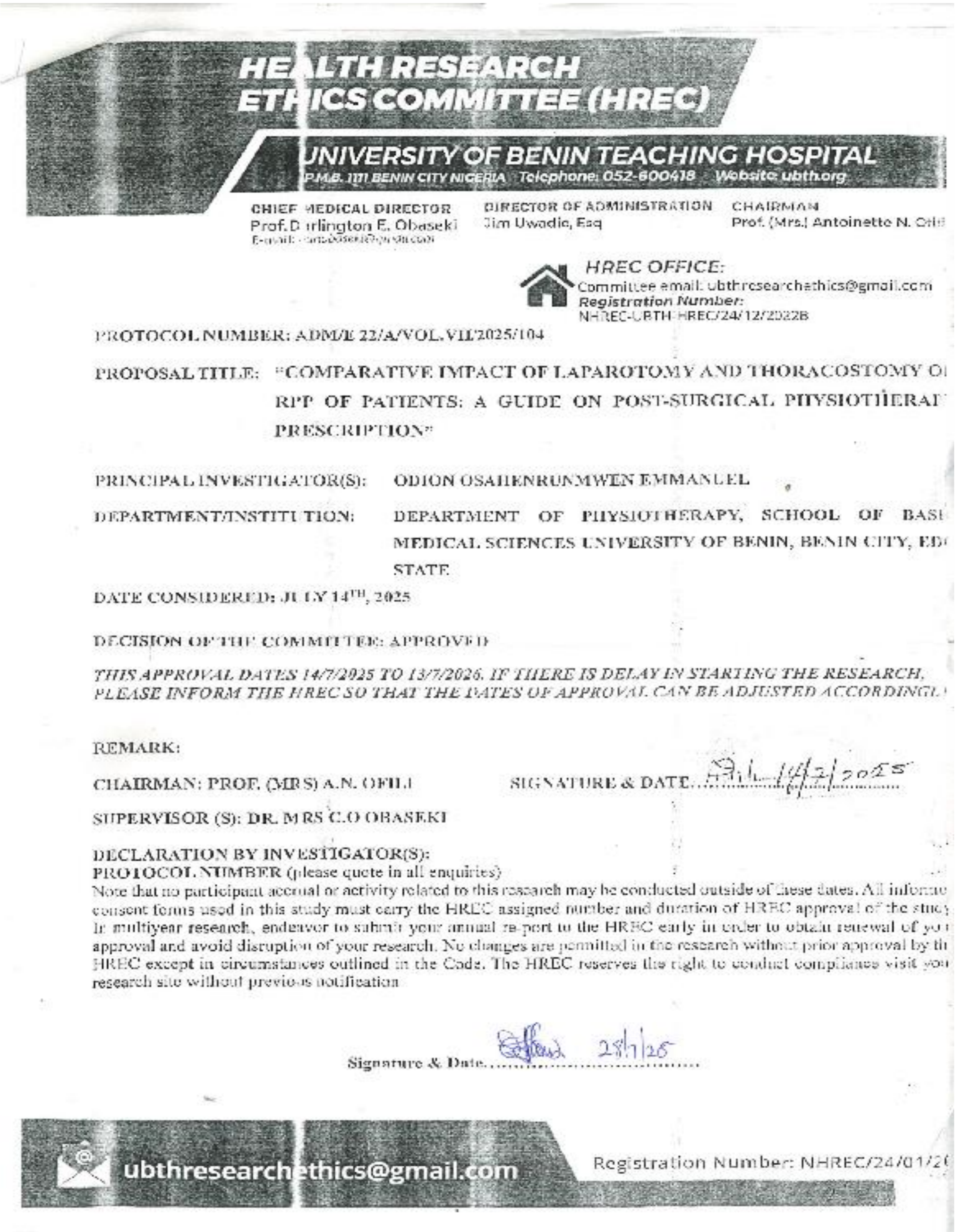
☐ I confirm that informed consent was obtained from this patient.

Signature of Researcher: ______________________

Date: ___ / ___ / 2025

APPENDIX III

ETHICAL APPROVAL



HEALTH RESEARCH ETHICS COMMITTEE (HREC)

UNIVERSITY OF BENIN TEACHING HOSPITAL
P.M.B. 1111 BENIN CITY NIGERIA Telephone: 052-600418 Website: ubth.org

CHIEF MEDICAL DIRECTOR
Prof. Darlington E. Obaseki
E-mail: [illegible]

DIRECTOR OF ADMINISTRATION
Jim Uwadie, Esq

CHAIRMAN
Prof. (Mrs.) Antoinette N. Ofi

HREC OFFICE:
Committee email: ubthresearchethics@gmail.com
Registration Number:
NHREC-UBTH-HREC/24/12/2022B

PROTOCOL NUMBER: ADM/E 22/A/VOL.VII/2025/104

PROPOSAL TITLE: "COMPARATIVE IMPACT OF LAPAROTOMY AND THORACOSTOMY O RPP OF PATIENTS: A GUIDE ON POST-SURGICAL PHYSIOTHERA PRESCRIPTION"

PRINCIPAL INVESTIGATOR(S): ODION OSAHENRUNMWEN EMMANUEL

DEPARTMENT/INSTITUTION: DEPARTMENT OF PHYSIOTHERAPY, SCHOOL OF BAS MEDICAL SCIENCES UNIVERSITY OF BENIN, BENIN CITY, ED STATE

DATE CONSIDERED: JULY 14TH, 2025

DECISION OF THE COMMITTEE: APPROVED

THIS APPROVAL DATES 14/7/2025 TO 13/7/2026. IF THERE IS DELAY IN STARTING THE RESEARCH, PLEASE INFORM THE HREC SO THAT THE DATES OF APPROVAL CAN BE ADJUSTED ACCORDINGL

REMARK:

CHAIRMAN: PROF. (MRS) A.N. OFILI SIGNATURE & DATE 14/7/2025

SUPERVISOR (S): DR. MRS C.O OBASEKI

DECLARATION BY INVESTIGATOR(S):
PROTOCOL NUMBER (please quote in all enquiries)
Note that no participant accrual or activity related to this research may be conducted outside of these dates. All informe consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the stud In multiyear research, endeavor to submit your annual re-port to the HREC early in order to obtain renewal of yo approval and avoid disruption of your research. No changes are permitted in the research without prior approval by th HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit yo research site without previous notification

Signature & Date 28/7/25

ubthresearchethics@gmail.com Registration Number: NHREC/24/01/2