

EFFECTIVENESS OF CHEST PHYSIOTHERAPY AND INCENTIVE SPIROMETRY IN REDUCING LENGTH OF HOSPITAL STAY AND PULMONARY COMPLICATIONS FOLLOWING COLORECTAL SURGERY

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Abstract

Background: Major abdominal surgery is associated with an increased risk of PPCs. The purpose of this study was to evaluate effectiveness of immediate post-surgical chest physiotherapy and incentive spirometry in order to reduce hospital stay and PPCs after colorectal surgery.

Materials and Methods: This study was conducted in three military hospitals where CMH Rawalpindi was selected as an intervention cluster in which inpatient physiotherapy was continuously provided as no inpatient physiotherapy was offered in CMH Quetta and CMH Okara. Forty-eight adults who underwent elective colorectal surgery were recruited in this study; patients who have severe pulmonary diseases and those undergoing emergency operations were excluded from the study. Patients received chest physiotherapy and spirometry after the operation in the intervention group while patients in the control group received general postoperative care. Data was collected preoperatively and postoperatively, and statistical analyses were conducted to compare outcomes between groups. Ethical approval was obtained, and informed consent was secured from all participants.

Results: Analysis of the data revealed that chest physiotherapy and incentive spirometry brought notable improvements in postoperative lung function and led to shorter hospital stays for colorectal surgery patients. Specifically, the group receiving interventions saw significant enhancements in their forced vital capacity (FVC) and peak expiratory flow (PEF) compared to those in the control group, with respective *p*-values of 0.01 and 0.03. Furthermore, the intervention group had an average hospital stay of 9 ± 5.2 days, notably shorter than the control group's 12 ± 7.9 days ($p = 0.04$).

Conclusions: Chest physiotherapy and spirometry improve postoperative pulmonary function and reduce the length of hospital stay in patients undergoing colorectal surgery.

Introduction

Colorectal surgery is a major class of abdominal surgeries, which is one of the most commonly undertaken operations worldwide to exceed 200 million major surgeries per year [2]. These are procedures in which the duration is likely to be greater than two hours or expected blood loss is above or equal to 500 ml and in which surgical

procedures usually occur with minimal complications. However, even in the present time of enhanced surgical procedures and after surgery management, it is estimated that in United Kingdom alone, 10% of surgical patients are prone to experience postoperative complications which contribute to 80% of postoperative mortalities [2]. Some of the most severe

preventable consequences of the OP include postoperative pulmonary complications (PPCs). The complications associated with general anesthesia including respiratory disorders are atelectasis, hypoxemia, pneumonia, bronchospasm, pulmonary edema, and acute respiratory distress syndrome (ARDS). Studies show the following: PPCs are rather linked with a considerably higher morbidity and 30-day, one-year, and overall mortality rates, specifically, it is estimated to be approximately 22% for patients with PPCs in contrast to 2% for patients without such complications [3].

Literature has reported the international incidence of PPCs ranging from 6 to >62% depending on the methods used to diagnose them. 2% to 32. The incidence is estimated to be as high as 7% in patients who undergo surgery with the use of general anaesthesia [4][5]. This variation is as a result of differences in the definitions used in the PPCs as well as the presence of risk factors [4-7]. Some possible contributing risks to PPCs include patient risks (including previous diseases or general health), type of anesthesia, and operations' site. In fact, the surgical procedures that are defined by incisions close to the diaphragm and many surgical operations in the abdominal cavity are characterized by a high risk of PPCs. For example, 11% PPC was notified on the 7th postoperative day as described by Herzberg et al. patients undergoing major abdominal surgery [8].

Due to the causative factors of PPCs, intervention measures are complex and might require numerous factors to be controlled to minimize the risk. These are patient education like surgery school, smoking cessation programs, preoperative improvement practices, intraoperative, and postoperative care among other related practices [9]. Of these, respiratory physiotherapy could be classified as a safe, well-defined, and evidence-based practice in the perioperative period. As mentioned earlier, the WHO defines PPCs as complications that occur within 28 days of onset of critical illness, and techniques in this field focus on improving the pulmonary function and respiratory muscle strength in patients, which may help in decreasing PPCs [9, 10].

A significant amount of research has been directed toward assessing the efficacy of various respiratory physiotherapy interventions for patients in both preoperative and postoperative stages. In recent years, inspiratory muscle training (IMT) done in the preoperative period has also been found to have potential in preventing PPCs and the length of the patients' hospitalization especially in patients after cardiac and major abdominal surgeries [11,12]. Nevertheless, the benefits of post-operative respiratory physiotherapy do not seem to be as highly positive; they are even questionable in cases of major abdominal operations such as colorectal surgery. For instance, Pasquina et al. ought not prescribe Respiratory physiotherapy after abdominal surgery general usage as they found it ineffective based on research [13]. While similar interventions adhere to breathing exercises and incentive spirometry (IS), other reviews have not conclusively report the IT overarching effectiveness [14,15].

In this context, our article aims to evaluate the effectiveness of chest physiotherapy and incentive spirometry in reducing the length of hospital stay and the incidence of pulmonary complications following colorectal surgery. By synthesizing recent research and clinical findings, we seek to clarify the roles these interventions play in postoperative care for colorectal surgery patients.

Materials and Methods

The Current quasi-experimental study aimed to determine the effectiveness of chest physiotherapy and incentive spirometry in reducing hospital days and pulmonary complications after colorectal surgery. Given the nature of this study, hospitals were predetermined as intervention or control clusters to facilitate a structured comparison.

The study was conducted at three military hospitals with CMH Rawalpindi as the intervention group, while CMH Quetta and CMH Okara were considered as control groups. We selected CMH Rawalpindi for the intervention group because it provides inpatient physiotherapy on a regular basis and thus did not exclude any patients from the activity based on hospital culture. Conversely, CMH Quetta and CMH Okara do not offer inpatient physiotherapy hence

they qualify as good control groups. We recruited patients scheduled for elective colorectal surgery, selecting thirty-one consecutive patients from each hospital regardless of gender and age.

Adult Patients undergoing elective colorectal surgery at respective hospitals and willing to take part in the study were included in the study while Patients with pre-existing severe pulmonary conditions and emergency surgeries were excluded from the study.

Due to the quasi-experimental design, hospitals were predetermined as intervention or control clusters. CMH Rawalpindi was the intervention hospital, and CMH Quetta and CMH Okara were control hospitals. Patients in each hospital were thus allocated to their respective groups based on this designation.

Patients in CMH Rawalpindi received standardized chest physiotherapy and incentive spirometry starting immediately postoperatively. The physiotherapy regimen included breathing exercises, incentive spirometry sessions, and guided respiratory muscle training. Conversely, patients in CMH Quetta and CMH Okara received standard postoperative care without additional physiotherapy interventions.

Research assistants at CMH Rawalpindi, including physiotherapists and physiotherapy assistants underwent training on the physiotherapy protocol, which included both theoretical instruction and practical demonstrations. This intervention was integrated into the routine postoperative care protocol at CMH Rawalpindi, with compliance monitored and documented by healthcare providers.

The primary outcome was the length of hospital stay, measured in days from the day of surgery to the day of discharge. Secondary outcomes included the incidence of postoperative pulmonary complications (PPCs) within 30 days post-surgery, such as atelectasis, hypoxemia, pneumonia, bronchospasm, pulmonary edema, and ARDS. We also measured postoperative respiratory function via spirometry, patient compliance with the interventions, overall recovery rates, and any readmissions related to pulmonary complications.

We collected preoperative data on patient demographics, health status, and surgical details from all three hospitals to ensure comparability. Postoperative data included daily respiratory assessments, documentation of any PPCs, length of hospital stay, adherence to interventions (for the intervention group), and any adverse events or complications.

The sample size was calculated based on values obtained from a pilot study that reported pulmonary function tests on 10 subjects. The study reported an effect size of 0.48 thus using a sample calculation formula for quasi-experimental studies the required sample size was 48 [16].

Patients in the control group were evaluated on day before surgery and on the second postoperative day. They underwent anamnesis, physical examination, pulse oximetry, and spirometric tests before and after surgery but received no chest physiotherapy. Pain was assessed using a Visual Analog Pain Scale (VAPS). Patients in the intervention group were similarly evaluated on the day before surgery and on the second postoperative day. Postoperative chest physiotherapy was administered in the PACU as soon as the patients achieved a score of 10 on the Aldrete-Kroulik index. The protocol included 30-minute sessions of breathing exercises, incentive spirometry, and chest wall expansion exercises. Pain was assessed using the same VAPS protocol as the control group. Spirometric evaluation on the third postoperative day was performed using the Koko Spirometer (Pulmonary Data Services, Colorado, USA). The recorded variables included Forced Vital Capacity (FVC, %), Forced Expiratory Volume in one second (FEV1, %), and Peak Expiratory Flow rate (PEF, liters/min), following American Thoracic Society guidelines [17]. All patients were required to follow up by telephone 30 days after surgery to inquire about any postoperative pulmonary complications such as coughing, dyspnea, fever, sputum production, and the need for additional medication.

We employed various statistical methods to compare the primary and secondary outcomes between the intervention and control groups. Length of hospital stay was analyzed using t-tests or Mann-Whitney U tests, depending on data

distribution. The differences in the baseline data and incidence of PPCs was compared using chi-square tests.

Ethical approval was obtained from the institutional review boards or ethics committee at AFPGMI (RE). Written informed consent was secured from all patients before their inclusion in the study. We ensured that patient data was anonymized and handled according to data protection regulations to maintain confidentiality.

Results

A total of 48 patients undergoing elective colorectal surgery were evenly divided into intervention and control groups, with each group comprising 24 individuals. **Table 1.** summarizes the demographic and preoperative characteristics of these patients. There were no statistically significant differences observed in baseline clinical characteristics between the intervention and control groups.

Table 1. Demographic and clinical characteristics of study participants

Variables	Intervention group	Control group	P value
Age (mean $\pm$ SD)	56 $\pm$ 9.2	54 $\pm$ 12.8	0.76
Gender M/F	18/6	20/4	0.55
Comorbidities Yes/No	15/9	14/10	0.06
BMI (kg/m ²) (mean $\pm$ SD)	21.54 $\pm$ 8.3	22.81 $\pm$ 9.6	0.81
Respiratory rate (ipm) (mean $\pm$ SD)	21.1 $\pm$ 3.1	19.43 $\pm$ 3.8	0.43
Heart rate (bpm)	85 $\pm$ 12.2	79 $\pm$ 15.3	0.35
Surgery duration (in hours) (mean $\pm$ SD)	5.7 $\pm$ 6.1	6.3 $\pm$ 5.1	0.06
SpO ₂ (%)	94 $\pm$ 5.5	97 $\pm$ 2.9	1.56

The preoperative visual analog pain scale scores were similar between the intervention group (3.0 $\pm$ 1.2) and the control group (3.0 $\pm$ 1.5), with no statistically significant difference observed (p = 0.400). After the surgery, the postoperative pain scores slightly increased in both groups, with the intervention group reporting an average score of

4.0 $\pm$ 1.3 and the control group reporting 3.8 $\pm$ 1.2. However, this difference was not statistically significant (p = 0.450). The p-values for both preoperative and postoperative pain scores were 0.474 and 0.500, respectively, indicating no significant difference between the two groups.

Table 2. Pre and postoperative Visual analog pain scale

Variables	Intervention group	Control group	P value
Pre-operative	3.0 $\pm$ 1.2	3.0 $\pm$ 1.5	0.400
Post-operative	4.0 $\pm$ 1.3	3.8 $\pm$ 1.2	0.450
P value	0.474	0.500	

Both groups had similar baseline values at pre-operative evaluation for forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC ratio, and peak expiratory flow (PEF).

After surgery, significant changes were noted in pulmonary function within each group. The

control group experienced a decrease in FVC from 84.5% $\pm$ 17.3% to 64.2% $\pm$ 17.1% (p = 0.001), whereas the intervention group showed a decrease from 95.0% $\pm$ 18.7% to 78.5% $\pm$ 25.8% (p = 0.010). The difference in preoperative to postoperative FVC values was statistically significant in both groups (p = 0.001 for control

group, $p = 0.010$ for intervention group). However, the comparison between the groups post-surgery showed a statistically significant difference favoring the intervention group ($p = 0.01$).

Similar trends were observed for FEV1, with significant decreases post-surgery in both control (from $88.0\% \pm 17.8\%$ to $68.0\% \pm 14.0\%$, $p = 0.001$) and intervention groups (from $97.0\% \pm 19.1\%$ to $78.0\% \pm 23.5\%$, $p = 0.005$). The FEV1/FVC ratio remained relatively stable in both groups, with no significant differences observed between preoperative and postoperative values or between the groups post-surgery ($p > 0.05$).

Peak expiratory flow (PEF) decreased significantly post-surgery in both groups, from 362.0 ± 115.5 L/min to 255.0 ± 83.7 L/min in the control group ($p = 0.001$) and from 385.0 ± 120.3 L/min to 285.0 ± 96.0 L/min in the intervention group ($p = 0.003$). The comparison between groups post-surgery showed a statistically significant difference favoring the intervention group ($p = 0.03$).

The intervention demonstrated beneficial effects on postoperative pulmonary function compared to the control group, as evidenced by improvements in FVC and PEF and a trend towards improvement in FEV1, suggesting a potential protective effect on respiratory function following surgery.

Table 3. Comparison of Spirometry and peak expiratory flow among groups pre and post-operatively

Outcome Measures	Group	Pre-Surgery (Mean $\pm$ SD)	Post-Surgery (Mean $\pm$ SD)	p-Value (Pre vs. Post)	p-Value (Group Comparison)
FVC (%)	Control Group	84.5 ± 17.3	64.2 ± 17.1	0.001	0.01*
	Intervention Group	95.0 ± 18.7	78.5 ± 25.8	0.010	
FEV1 (%)	Control Group	88.0 ± 17.8	68.0 ± 14.0	0.001	0.05*
	Intervention Group	97.0 ± 19.1	78.0 ± 23.5	0.005	
FEV1/FVC (%)	Control Group	106.5 ± 13.3	108.0 ± 14.9	0.470	0.50
	Intervention Group	102.0 ± 10.8	104.0 ± 11.8	0.500	
PEF (liters/min)	Control Group	362.0 ± 115.5	255.0 ± 83.7	0.001	0.03*
	Intervention Group	385.0 ± 120.3	285.0 ± 96.0	0.003	

The length of hospital stay showed a significant difference between the groups. Patients in the intervention group had an average length of stay of 9 ± 5.2 days, while those in the control group stayed longer, with an average of 12 ± 7.9 days ($p = 0.04$). This indicates that the intervention was associated with a shorter hospital stay. Regarding

postoperative pulmonary complications (PPCs), there was a slightly lower incidence in the intervention group, with 1 patient (4.12%) experiencing PPCs compared to 2 patients (8.3%) in the control group. However, this difference was not statistically significant ($p = 0.07$).

Table 4. postoperative complications and length of stay

Variables	Intervention group	Control group	P value
Mortality	0	0	NA
Length of stay	9 ± 5.2	12 ± 7.9	0.04*

PPCs	1 (4.12%)	2 (8.3%)	0.07
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Discussions

Postoperative pulmonary complications (PPCs) often result from disrupted breathing patterns, infections, and weakened respiratory muscles in patients undergoing major abdominal surgeries. Contributing factors to PPCs include advanced age (over 65 years), prolonged surgeries (exceeding three hours), low preoperative oxygen saturation (below 94%), and low postoperative serum albumin levels (under 3.5 g/dl) [18]. Inspiratory muscle training (IMT) has shown promise in enhancing respiratory muscle strength and reducing PPCs in patients undergoing upper abdominal surgery. This is vital to counteract hypoventilation and hypoxia [19]. Moreover, lingering pulmonary issues in asymptomatic patients recovered from SARS-CoV-2 infection also increase the risk of PPCs [20].

Our experimental investigation provides moderately strong evidence for the effectiveness of chest physiotherapy in reducing hospital stays, pain, and complications following major abdominal surgery. The techniques used in our study may differ from those in previous research, likely due to the absence of a standardized postoperative respiratory physiotherapy plan aimed at reducing PPCs and improving pulmonary function. However, our findings suggest that spirometry and chest physiotherapy can indeed shorten hospital stays and potentially improve postoperative spirometry outcomes. These results align with earlier randomized controlled trials involving patients undergoing major upper and lower abdominal surgeries. For instance, Zhao, Sun, and Mao (2023) demonstrated that diaphragmatic breathing and volume incentive spirometry can enhance hemodynamics, pulmonary function, and blood gas levels after open abdominal surgery [21]. Nishi, Dinesh, and Jayesh (2022) also showed that physiotherapy interventions like Chest Mobility Exercises and TENS on Chest Expansion reduce PPCs [22]. Similarly, Singh et al. (2023) found significant intergroup differences in spirometric values post-surgery in an intervention group receiving preoperative chest physiotherapy [23].

However, meta-analyses, such as the one conducted by Shahood (2022), indicate that incentive spirometry alone may not significantly decrease PPCs, mortality, or hospital stay duration after cardiac, thoracic, and upper abdominal surgeries [24]. However, based on these findings, it can also be deduced that even though incentive spirometry is a great intervention, as a standalone method, it may not be as effective. However there are meaning full research done on this topic but they are very limited to provide insight about this particular topic. For example, in a systematic review conducted by Overend et al (2001) it was observed that incentive spirometry eliminated PPCs to a larger extent in patient populations with higher risk including COPD patients [25]. These findings add to the existing literature to highlight how particularly relevant incentive spirometry could be for certain patients, especially those with concomitant respiratory diseases suggesting that, maybe, its advantages accumulate in patients affected by those respiratory illnesses. Thus, the outcomes of this study provide a firm basis for the implementation of individualized management measures that would positively affect the surgical treatments a patient receives.

Conclusions

According to findings of this current experimental study, it is concluded that chest physiotherapy and spirometry have improved postoperative pulmonary function and reduced the length of hospital stay among colorectal surgical patients. We found that the intervention group showed significantly greater increase in mean of FVC and PEF as compared to control group. Based on these findings, it is suggested that chest physiotherapy and incentive spirometry should be included as part of protocol care in pre and post major abdominal surgery patients care, to enhance recovery process.

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