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Combined Effect of Incentive Spirometry and Diaphragmatic Exercise on Respiratory Outcomes Post Upper Abdominal Surgery: A Literature Review

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Abstract

Upper abdominal operations mainly cause respiratory complications because the incision across the abdominal region reflects decreased diaphragmatic movement , e.g., atelectasis and pneumonia. Incentive spirometry (IS) and diaphragmatic breathing exercises (DBE) are the most employed interventions to enhance lung function and minimize these complications. Although each of these has been demonstrated with positive results individually, their interactive effects on respiratory recovery after surgery are not fully understood. The present literature review investigates the synergy between IS and DBE in respiratory outcomes after upper abdominal surgery, particularly concerning lung volumes, oxygenation, and minimizing postoperative pulmonary complications. This review aims to evaluate the combined effect of incentive spirometry and diaphragmatic exercise on improving respiratory outcomes in individuals recovering from upper abdominal surgery. A web-based literature search was conducted using PubMed to identify studies on the combined effects of incentive spirometry and Diaphragmatic exercises. The search focused on their impact on peak expiratory flow rate, breathing patterns, and chest expansion in post-operative upper abdominal surgery patients. Titles and abstracts were screened, and relevant articles were included. Additionally, secondary searching was performed by reviewing reference lists for relevant citations. The review suggests that incentive spirometry and diaphragmatic exercises impact Respiratory outcomes i.e. PEAK EXPIRATORY FLOW RATE, breathing patterns, and chest expansion. However, the combined approach appears more effective, as mean differences indicate. This highlights the potential benefits of integrating incentive spirometry and diaphragmatic exercises in postoperative care. The review indicates that incentive spirometry and diaphragmatic exercises enhance respiratory outcomes in individuals recovering from upper abdominal surgery.

Keywords

Incentive Spirometry, Abdominal Surgery, Postoperative Pulmonary Complications

Introduction

Abdominal surgery is a specialized procedure performed to address a variety of conditions affecting the organs within the abdominal cavity. It plays a crucial role in treating digestive disorders, removing tumors, and improving patients' overall health and quality of life. Common abdominal surgeries include appendectomy, cholecystectomy, hernia repair, and

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gallbladder removal. These procedures can be performed using four main surgical approaches: open surgery, laparoscopic surgery, robotic-assisted surgery, and endoscopic surgery (Cliftonsmith, & Rowley, 2011).

In the past few decades, the number of abdominal surgical procedures has significantly increased. Recent estimates suggest that millions of major abdominal surgeries are performed worldwide each year. Postoperatively, many patients report symptoms resembling breathing pattern disorders. (Christie, & Armstrong, 2017). To minimize pain and protect surgical incisions, patients often restrict abdominal expansion, an essential component of normal breathing cycles. Prolonged reliance on chest breathing and excessive use of accessory muscles may contribute to postoperative pulmonary complications, such as secretion retention and increased risk of respiratory issues (Kelkar, 2015).

Incentive spirometry (IS), also referred to as sustained maximal inspiration, is a widely used respiratory intervention aimed at improving lung expansion and preventing pulmonary complications. It provides real-time feedback by enabling patients to achieve a predetermined inspiratory volume or flow rate and sustain lung inflation for several seconds. The patient is instructed to hold the spirometer upright, usually exhale, and then inhale slowly through the mouthpiece to raise the device's marker (ball or piston). At peak inhalation, the mouthpiece is removed, followed by a breath-hold and a controlled exhalation (Qaseem et al., 2011).

To effectively manage atelectasis, residual secretions must be cleared, and lung tissue should be re-expanded to facilitate optimal parenchymal function. Described an ideal deep breathing strategy for re-expanding collapsed alveoli, Colucci et al. (2015) highlighting the importance of a prolonged, slow inhalation with an inspiratory hold of several seconds. Incentive spirometry was designed to provide visual feedback on inspiratory effort, encouraging precise and consistent execution of this technique. (Grott et al., 2024). There are two primary types of IS devices: flow-oriented and volume-oriented. Flow-oriented IS devices consist of three interconnected columns containing lightweight plastic floats that serve as inspiratory effort markers. The patient inhales through a mouthpiece, attempting to elevate the floats to a specified level for a sustained duration. Volume-oriented IS devices, on the other hand, include a visible scale within a chamber, where the patient aims to raise a marker as high as possible. Clinical practice guidelines recommend volume-oriented devices for postoperative use, as they impose a lower work of breathing, minimize pain, and reduce fatigue. (Franklin, & Anjum, 2023)

This literature review highlights the limited number of studies demonstrating the clinical benefits of IS in the general abdominal surgery population. However, emerging evidence suggests that incentive spirometry may provide significant benefits, particularly in high-risk populations such as patients with chronic obstructive pulmonary disease (COPD). Findings indicate that IS may contribute to reducing the incidence of postoperative pulmonary complications in these patients. Further research is warranted to establish its efficacy across broader patient populations undergoing abdominal surgery.

Methodology

Search strategy

Searching is based on the following keywords via database of Pub Med and Cochrane:

: incentive spirometry, improved lung Volume, Thoracic surgery, Pulmonary surgery, Cardiac Surgery, Post OP Pulmonary complications, QoL.

Procedure

A web-based literature search was done, and the database source included Pub Med. The primary search aimed to yield studies on the effectiveness of incentive spirometry in Thoracic surgeries. A search strategy was developed for sourcing information that describes its effects in improving lung volume, Reducing Post OP Pulmonary complications, and improving QoL. The titles and abstracts of the available articles were reviewed, and relevant articles were included. Secondary searching was also conducted, whereby the reference list of the included studies was scanned for relevant citations.

Inclusion criteria:

i. Articles Published in English
ii. Timeline 2014 to 2024
iii. Type of Study: Randomized Control Trial, Quasi-experimental studies

Exclusion criteria:

i. Articles not accessible online
ii. Duplication articles
iii. Articles that are of poor quality

Review of literature

The review of the literature is given in Table 1.

Table 1. Review of Literature

Study	Objective	Methods	Discussion	Critical Review
1. Huang et al. (2022)	Impact of fully engaged Inspiratory Muscle Training (IMT) on respiratory muscle strength and postoperative pulmonary complications (PPCs)	Randomized Controlled Trial (RCT), 3-week preoperative IMT.	Significant improvement in maximal inspiratory pressure (MIP) and fewer PPCs. Pleural effusion rates were lower in the IMT group.	The small sample size and lack of long-term follow-up limit generalizability. No significant differences in lung capacity (FEV1, FVC) suggest that IMT primarily benefits inspiratory muscle strength rather than overall lung function.
2. Walaa et al. (2019	Effects of Incentive Spirometry (IS) on postoperative breathing patterns in	Pre- and postoperative evaluation of	IS significantly improved breathing patterns and vital	The study supports IS use for improving pulmonary

	abdominal surgery patients	breathing patterns and vital signs	signs on the first two postoperative days	function and reducing PPCs, although it lacks long-term follow-up data to assess sustained benefits.
3. Ahmed et al. (2018)	Comparison of Flow Incentive Spirometry (FIS) and diaphragmatic breathing exercises on respiratory outcomes.	Trial with FIS and diaphragmatic breathing vs. control.	Combined FIS and diaphragmatic breathing significantly improved respiratory status and reduced hospital stay.	The study highlights the synergistic effect of FIS and diaphragmatic breathing, though it doesn't provide a detailed mechanism of action behind the observed improvements.
4. Boden et al. (2018)	Evaluating preoperative physiotherapy for PPC prevention.	Randomized controlled trial across multiple centers.	Significant relative risk reduction (52%) in PPCs with preoperative physiotherapy.	Results suggest preoperative physiotherapy can prevent PPCs, though the study faced limitations like varied practitioner experience and heterogeneous patient demographics.
5. Alaparthi et al. (2016)	Comparison of diaphragmatic breathing, flow, and volume incentive spirometry on pulmonary function post-laparoscopic surgery.	Randomized controlled trial, four groups.	Diaphragmatic breathing and volume improved lung function and diaphragmatic excursion.	While the study supports both interventions, the lack of a control group that received no intervention weakens the conclusions. Long-term outcomes were not assessed.
6. Elgaphar & Hamdy (2021)	Effect of post-anesthetic chest physiotherapy on ventilatory function and hospital stay post-abdominal surgery.	Evaluation of early post-anesthetic chest physiotherapy (breathing exercises).	Chest physiotherapy improved FEV1 and FVC, reduced PPCs, and shortened hospital stay.	The study supports the use of early post-anesthetic chest physiotherapy but does not explore the optimal timing and technique for these interventions.

7. Nandi et al. (2015)	Impact of Incentive Spirometry on respiratory muscle function post-abdominal surgery.	Comparison of PEAK EXPIRATORY FLOW RATE (PEFR) values in two groups post-surgery.	IS improved PEFR significantly by Day 5 post-surgery, especially in the experimental group.	The study supports IS use for improving respiratory function post-abdominal surgery. However, a larger sample size would be needed for a more generalizable

Discussion

Upper abdominal surgery is one of the most common major surgical procedures, often performed under general anesthesia. A significant challenge associated with such surgeries is the rapid decline in functional residual capacity (FRC), which can decrease by up to 20%, leading to impaired respiratory muscle activity, particularly in the diaphragm (Narayanan et al., 2015). Such dysregulation will lead to lower lung volumes, tidal volumes, and cough efficacy, thus potentially leading to a higher risk of PPCs. The reduction of FRC also contributes to further compromised mucociliary clearance of post-operative patients.

Inspiratory muscle training can improve the strength of respiratory muscles and diaphragmatic excursion to enhance pulmonary function. Inspiratory muscle training was also reported to reduce the risk of PPCs (Mohamed et al., 2022). There were unique breathing pattern characteristics for patients who were undergoing incentive spirometry in combination with abdominal exercises, suggesting its benefits in respiratory rehabilitation.

The respiratory complications were lower among those who received diaphragmatic breathing exercises, as well as flow-oriented incentive spirometry. Using statistical analysis, the differences in postoperative complications between the intervention arms were significant, thus better validating this multimodal combination. (Ahmed et al., 2018)

The reduction in inspiratory muscle activity, particularly that of the diaphragm, is identified as a key factor contributing to impaired pulmonary function. Their study indicates that volume-oriented incentive spirometry is more "physiological" compared to previous methods, as it promotes consistent training volume until maximum inspiratory capacity is reached. This technique provides low-resistance training, minimizing diaphragm fatigue while enhancing peak expiratory flow rate, which helps in preventing postoperative respiratory complications. (Ford, & Guenter, 1984)

The literature supports that the combination of incentive spirometry and diaphragmatic exercises is an effective strategy for improvement in peak expiratory flow rate, breathing patterns, and chest expansion of patients recovering from upper abdominal surgery.

Conclusion

This review highlights that combining incentive spirometry with diaphragmatic exercises helps improve breathing, lung function, and chest expansion in patients recovering from upper abdominal surgery. Patients can experience better respiratory recovery and a smoother healing process by including these simple yet effective exercises in post-operative care.

Incentive spirometry is an effective technique when combined with diaphragmatic exercises, as the diaphragm is the primary muscle involved in inspiration and plays a key role in respiration. Therefore, incentive spirometry improves lung volume, while diaphragmatic exercises help train the diaphragm for better inspiration. This combination can be beneficial in improving respiratory outcomes after abdominal surgeries.

Further studies with larger, diverse populations and extended follow-up periods should be conducted to better assess the long-term benefits and any potential risks of combining IS with diaphragmatic breathing exercises. Additionally, future research could explore optimal timing, frequency, and technique for these interventions to maximize their effectiveness.

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