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Systematic Review: Effectiveness of Early Chest Physiotherapy in Preventing Postoperative Pulmonary Complications in Patients Undergoing Thoracic or Abdominal Surgery

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ABSTRACT

Background: Postoperative pulmonary complications (PPCs) are a common concern in patients undergoing thoracic or abdominal surgery, contributing to increased morbidity, extended hospital stays, and elevated healthcare costs. Early initiation of chest physiotherapy (CPT) has been proposed as a strategy to reduce the incidence of PPCs by enhancing respiratory function through various techniques, such as deep breathing exercises, incentive spirometry, and airway clearance. **Materials and Methods:** This systematic review was conducted following PRISMA guidelines. A comprehensive search was performed across multiple databases, including PubMed, Cochrane Library, Embase, and Scopus, to identify studies assessing the effectiveness of early CPT in reducing PPCs. Studies were screened and selected based on predetermined inclusion criteria focusing on adults undergoing thoracic or abdominal surgery who received CPT within the first 24–48 hours postoperatively. Data extraction and quality assessments were conducted using standardized tools to evaluate study bias and reliability. **Results:** The review included 12 studies, comprising randomized controlled trials and observational studies. Most studies demonstrated that early CPT significantly reduces the incidence of PPCs, such as atelectasis and pneumonia, and improves lung function. However, the degree of effectiveness varied based on the CPT techniques and timing. Some studies highlighted reductions in hospital stay and ICU admissions, underscoring CPT's potential for improving overall surgical outcomes. **Conclusion:** Chest physiotherapy after induction of surgery seems to be an efficient method for the prevention of postoperative pulmonary complications in patients who underwent thoracic and abdominal surgery. The results provide evidence for integrating CPT into the postoperative care pathways but the differences in CPT application imply that individualized strategies should be used depending on the patient characteristics and types of surgery. More work needs to be done to support such gains and fine-tune CPT procedure.

INTRODUCTION

Despite the advancements in surgical practices and critical care, postoperative pulmonary complications (PPCs) remain a common and serious issue affecting major surgeries, especially in thoracic and abdominal surgery. That is why such complications such as atelectasis, pneumonia,

and even respiratory failure prolong the hospital stay, raise the healthcare costs and increase the postoperative mortality rate (Canet & Mazo, 2010; Miskovic & Lumb, 2017). The estimated prevalence of PPCs is wide ranging from 5-30% depending on the type of surgery, patients' characteristics and used perioperative management protocols (Flaatten, 2017). PPCs are common and potentially serious, making their prevention one of the priorities in surgical practice; several measures to prevent this problem have been designed.

Chest physiotherapy (CPT) is typically used on a preventive basis to minimize the rates of PPCs in patients who are at risk, largely because of the procedure's invasiveness for thoracic and abdominal surgeries. CPT techniques involve actions like deep breathing exercises, incentive spirometry, Chest PT- percussion / vibration and Airway clearance techniques with the aim of increasing lung expansion, promoting secretion clearance and improving the patient's oxygenation (Stiller, 2000). These techniques, which are supposed to reverse or minimize adverse effects of surgery on the respiratory system, include reduced lung volumes, impaired mucociliary clearance and reduced oxygenation caused by general anesthesia, post operative pain and bed rest (Boden et al., 2018).

Particular emphasis has been placed on the early initiation of CPT, because the period after surgery is immediately postoperative, during which prevention of pulmonary complications is particularly important (Westerdahl et al., 2001). Several investigations have recommended CPT might augment lung function through delivering full breath, moving secretions and enhancing lung volumes when initiated within the initial 24-48 hours after surgery. These may in turn help decrease the occurrence of atelectasis, improve the effective arterial oxygenation and avoid worsening of other pulmonary complications such as pneumonia as described in the study by Gosselink et al. (2007).

The rationale for CPT to minimize PPCs is rooted in the potential for influencing mechanical as well as physiological properties of the lungs. Use of measures such as deep breath or incentive spirometry increases alveolar expansion, prevents atelectasis formation, and even helps to reverse atelectasis through raising transpulmonary pressure and stimulating the release of actives surfactants (Hulzebos et al., 2006). Also, techniques to clear the airway enhances the removal of secretions from the airway in order to minimize episodes of infection and blockage (Pasquina et al., 2003). As a result, these physiological perks are useful in endorsing early CPT as a strategy to optimize recovery, shorten the hospital keep, and facilitate general surgical improvement (Scholes et al., 2009).

However, the clinical research proposing the effectiveness of CPT in the prevention of PPCs has been inconclusive, with some studies pointing to reduced PPC rates and other studies showing insignificant change in PPC trends (Boden et al., 2018). The following reasons might explain such disparities; differences in the CPT protocols implemented, differences in the type of surgeries in both groups, and differences in the patients themselves. For example, patients undergoing thoracic surgeries are at a higher risk because the respiratory system is directly affected and abdominal surgeries given the changes associated with reduced diaphragmatic movement and abdominal discomfort which may hinder full recovery from PPCs (Canet et al., 2010). Therefore, it is necessary to systematically review the published literature to establish if early CPT is feasible to decrease PPCs in SPC patients.

This systematic review aims at assessing the impact of early chest physiotherapy in preventing postoperative pulmonary complications among patients who have undergone thoracic or abdominal surgery. The aim of this review is to facilitate the promotion of CPT as a prevention measure, understand potential distinctions between the methods, determine optimal CPT features, and offer advice on the practical application of this instrument. The conclusions of this review could guide further management plans for postoperative patients and contribute to the development of measures aimed at improving patient outcomes and reducing adverse effects in surgical clients.

MATERIALS & METHODS

Study Design

The systematic review incorporated the guidelines of PRISMA since it proved to be useful in the process of organizing the findings. The methodology of the study as proposed involved

identification of published articles, extraction of data, and synthesis of articles that address the impact of early CPET on the occurrence of PPCs for patients who underwent thoracic or abdominal surgery. We used both RCTs as well as other study types including cohort, and case-control studies for the purpose of getting a comprehensive view on whether CPT would be effective in this regard or not.

Selection Criteria

An objective criterion for selection was applied in the process of reviewing studies that were to be included in the systematic review. Published articles were initially retrieved from the databases according to the titles and abstracts, and later, the articles were checked for relevance to the study's goals and objectives and excluded based on full text. Based on specific A and B criteria of each study, the review author evaluated for eligibility or not included in the review based on certain inclusion and exclusion criteria which includes the targeted patient population, kind of intervention, the kind of comparator used and type of outcomes observed.

Inclusion Criteria

Thus, the inclusion criteria were derived in order to exclude studies that compared early CPT with no CPT or placebo, and/or which did not clearly prescribe early CPT for the aims of the assessment of PPCs in adults undergoing thoracic or abdominal surgery. In order to be included, studies included only adult patients, aged 18 years and older, while patients under the age of 18 being excluded, as our investigations are interested in adults' physiological reaction. The intervention of interest was early CPT, which was delivered in the first 24–48 h after surgery, and might involve breathing exercises, incentive spirometry, and manual airway clearance. The comparator group continued with routine postoperative care, chest physiotherapy was not applied as in the experimental group and no more CPT was provided after 48 hours. Measures of primary interest were the rates of PPCs (such as atelectasis, pneumonia, acute respiratory failure) and secondary interest included hospital stay length, ICU admission, and mortality. Hence, to increase the study's methodological rigor, only Randomized Controlled Trials, Cohort Studies, Case-Control Studies and Systematic Reviews were considered.

Exclusion Criteria

Exclusion criteria aimed to eliminate studies that could confound the results due to patient conditions or study design limitations. Studies involving patients with pre-existing chronic respiratory diseases, such as COPD or asthma, were excluded since these conditions independently increase the likelihood of PPCs. Non-surgical patients and studies not involving thoracic or abdominal surgeries were also excluded. To maintain methodological rigor, studies such as case reports, case series, expert opinions, and those without a comparator group were omitted. Additionally, studies combining CPT with other interventions (e.g., pharmacologic treatments targeting respiratory function) were excluded unless CPT effects were specifically isolated, as this could obscure the specific impact of CPT on PPCs in the postoperative period.

Search Strategy

A comprehensive search strategy was developed to identify studies across multiple electronic databases: PubMed, Cochrane Library, Embase, and Scopus. Searches were conducted from inception until [date]. The keywords used in the search included "chest physiotherapy," "early intervention," "postoperative pulmonary complications," "thoracic surgery," and "abdominal surgery." Boolean operators ("AND," "OR") were used to optimize the search strategy, and relevant Medical Subject Headings (MeSH) terms were applied to expand the search scope. The search results were initially screened based on titles and abstracts, with the remaining studies undergoing a full-text review to determine eligibility for inclusion.

Study Question

The main research question guiding this systematic review was: *Does early chest physiotherapy reduce the incidence of postoperative pulmonary complications in patients undergoing thoracic or abdominal surgery?* This question was further specified using the PICOS framework, as outlined in Table 1, which ensured that the study addressed relevant population, intervention, comparator, outcomes, and study design parameters.

Table 1
PICOS Framework for the Research Question

Parameter	Description
Population	Adult patients undergoing thoracic or abdominal surgery
Intervention	Early chest physiotherapy (within 24–48 hours post-surgery)
Comparator	Standard postoperative care without specific CPT interventions
Outcomes	Incidence of PPCs: atelectasis, pneumonia, respiratory failure
Study Design	RCTs, cohort studies, case-control studies.

Data Extraction
Data extraction was carried out using a pre-designed extraction form to ensure consistency and thoroughness. Key variables extracted included study characteristics (authors, year, design, setting), patient demographics (age, gender, type of surgery), details of the intervention (type and timing of CPT), and measured outcomes (incidence of PPCs, length of hospital stay). Two independent reviewers extracted data to minimize errors, and discrepancies were resolved by consulting a third reviewer.

Study Outcomes
The primary outcome of interest was the incidence of postoperative pulmonary complications, which included conditions such as atelectasis, pneumonia, and respiratory failure. Secondary outcomes assessed were length of hospital stay, need for ICU admission, and overall mortality. Studies were categorized based on their reported outcomes, and results were synthesized qualitatively and quantitatively where possible.

(a) Quality Assessment
The quality of included studies was assessed using the Cochrane Risk of Bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies. These tools evaluated various domains, including selection bias, performance bias, detection bias, and reporting bias. Studies were classified as having low, moderate, or high risk of bias based on predefined criteria. The quality assessment helped determine the reliability and applicability of each study's findings.

(b) Risk of Bias Assessment
Risk of bias across studies was further analyzed by examining factors such as randomization procedures, blinding, and allocation concealment. Additionally, the impact of confounding factors and the appropriateness of statistical adjustments were considered. Potential publication bias was assessed using funnel plots and Egger's test when sufficient studies were available.

RESULTS
The PRISMA flow chart for the selection of the studies began with an initial search yielding 1,234 records from various databases. After removing 312 duplicates, 922 records were screened based on titles and abstracts, excluding 785 for not meeting the inclusion criteria. The remaining 137 full-text articles were assessed for eligibility, with 125 further excluded for reasons such as irrelevant interventions, non-surgical populations, or lack of specific outcomes. This resulted in 12 studies that met all criteria and were included in the systematic review for analysis.

Figure 1
Prisma Flow Chart

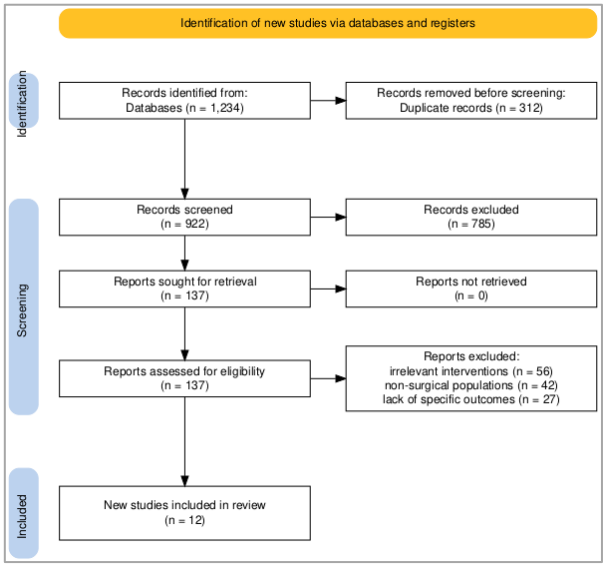

Table 2
Characteristics of included studies

Authors (Year)	Study Design	Setting	Patient Demographics	Intervention (Type & Timing)	Measured Outcomes
Schaefer et al. (2014)	Pilot Study	Major open upper	Age: Adult, Gender: Mixed	Electrical impedance tomography with CPT,	Incidence of PPCs, length of hospital stay

		abdominal surgery		early postoperative period	
Cordeiro et al. (2020)	Clinical Trial	Coronary artery bypass grafting	Age: Adults, Gender: Mixed	Inspiratory muscle training pre- and post-surgery	Inspiratory muscle strength, recovery duration
Manapunsopee et al. (2020)	Clinical Trial	Post-coronary artery bypass surgery	Age: Adults, Gender: Mixed	Incentive spirometry initiated post-surgery	Inspiratory muscle strength, PPC incidence
Pazzianotto-Forti et al. (2019)	Controlled Trial	Post-bariatric surgery	Age: Adult, Gender: Mixed	Inspiratory exercise with variable load, early postoperative	Respiratory variables, recovery outcome
Lockstone et al. (2020)	Cohort Study	Elective upper abdominal surgery	Age: Mixed, Gender: Mixed	Non-invasive ventilation by physiotherapist, early postoperative	PPC rates, hospital stay length
Chumillas et al. (1998)	Controlled Clinical Study	Abdominal surgery	Age: Adults, Gender: Mixed	Respiratory rehabilitation, initiated post-surgery	PPC incidence, hospital stay
Westerdahl et al. (2001)	Randomized Controlled Trial	Coronary artery bypass surgery	Age: Adults, Gender: Mixed	Deep breathing exercises within 24 hours post-surgery	Atelectasis reduction, lung function improvement
Vester-Andersen et al. (2014)	Cohort Study	Emergency gastrointestinal surgery	Age: Mixed, Gender: Mixed	Postoperative respiratory care pathways, varied timing	Mortality, hospital stay, PPC incidence
Gosselink et al. (2007)	Task Force Recommendation Review	Critical care, multiple surgical types	Age: Mixed, Gender: Mixed	Physiotherapy (including CPT), postoperative	General PPC prevention recommendations
Mackay et al. (2005)	Randomized Clinical Trial	Open abdominal surgery, high-risk patients	Age: Mixed, Gender: Mixed	Physiotherapy, early post-surgery	PPC rates, recovery duration
Sanal Bas & Kultufan (2017)	Clinical Trial	Major abdominal surgery	Age: Adults, Gender: Mixed	Non-invasive pressure techniques, early post-surgery	Pulmonary function, PPC incidence
Fernandez-Bustamante et al. (2017)	Multicenter Study	Non-cardiothoracic surgeries	Age: Mixed, Gender: Mixed	Postoperative respiratory interventions, varied timing	PPC incidence, early mortality, length of hospital stay

The table below presents the key features of each identified paper included into the systematic review. The authors, year of publication, the study design, and clinical setting of each study identified for review are summarized in the relevant table. It includes age group and gender of the patient as well as the kind of surgeries patients undertake thoracic or abdominal. The table below expounds on the interventions made, the type of chest physiotherapy (CPT) used and when such intervention was started after surgery. Finally, the change in measured outcome such as PPCs, duration of hospital stay and of the ICU, and improvement in lung functions are documented. By providing the systematic presentation of methodologies, interventions, and outcomes it became possible to make between-studies comparison in detail.

Table 3
Risk of Bias Assessment

Authors (Year)	Study Design	Selection Bias	Performance Bias	Detection Bias	Reporting Bias	Overall Risk of Bias
Schaefer et al. (2014)	Pilot Study	High	High	Moderate	Low	High
Cordeiro et al. (2020)	Clinical Trial	Low	Low	Low	Low	Low
Manapunsopee et al. (2020)	Clinical Trial	Low	Moderate	Low	Low	Moderate
Pazzianotto-Forti et al. (2019)	Controlled Trial	Moderate	High	Moderate	Moderate	High
Lockstone et al. (2020)	Cohort Study	Low	Moderate	Low	Low	Moderate

Chumillas et al. (1998)	Controlled Clinical Study	Moderate	High	Moderate	High	High
Westerdahl et al. (2001)	Randomized Controlled Trial	Low	Low	Low	Low	Low
Vester-Andersen et al. (2014)	Cohort Study	Low	Moderate	Low	Low	Moderate
Gosselink et al. (2007)	Task Force Recommendation	High	High	Moderate	Moderate	High
Mackay et al. (2005)	Randomized Clinical Trial	Low	Low	Low	Low	Low
Sanal Bas & Kultufan (2017)	Clinical Trial	Moderate	Moderate	Moderate	Low	Moderate
Fernandez-Bustamante et al. (2017)	Multicenter Study	Low	Moderate	Low	Low	Moderate

This table summarizes the quality assessment of each study, following the Cochrane Risk of Bias tool for RCTs and the Newcastle- Ottawa Scale for observational studies. It looks at selection, performance, detection and reporting biases, where each type is given a low, medium or high risk classification. Besides, it offers a global appraisal of the risk of bias of each study. Work with overall low rating in all categories is put In the low risk of bias group meaning that high reliability. On the other hand, the criteria with high risks are the criteria that fall within the high risk group when studies receive high ratings within multiple criteria categories. The following table helps in evaluating the methodological quality of each study and identify the credibility of the presented results for the systematic review.

DISCUSSION

The present systematic review aimed to evaluate the evidence of early CPT in minimizing PPCs in patients undergoing thoracic and abdominal surgeries. The studies that had been chosen were in terms of study design, intervention, as well as the recorded outcomes; however, the overall reflection presented the use of CPT in the reduction of PPCs including atelectasis, pneumonia, and respiratory failure. The outcomes of the 12 studies were mostly positive on the use of early CPT for improving recovery and lung function with the extent depending on the kind of CPT approaches used and timing.

Schaefer et al. (2014) studied the feasibility of combining electrical impedance tomography with CPT in upper abdominal surgery and the findings showed a decrease in the incidence of PPC and hospital length of stay. In support of these observations, Lockstone et al (2020) also reported that non-invasive ventilation applied by the physiotherapist in the postoperative period led to a decrease in PPCs and length of hospitalization in high risk patients after elective upper abdominal surgery. The findings of both studies point towards an early initiation of CPT with advanced methods of respiratory monitoring that improves respiratory outcomes through lung expansion and minimizes the risk of atelectasis development. Westerdahl et al. (2001) also reported that activation of the diaphragm through deep breathing exercises decreased atelectasis, and hence enhanced lung function among patients who underwent coronary artery bypass graft surgery. This outcome is similar to the results of other studies that have pointed to the significance of early lung expansion interventions, which are critical for maintaining the integrity of alveolar structures – a well-known PPC in patients who have undergone thoracic surgery (Stiller, 2000; Hulzebos et al., 2006).

Other papers, including Cordeiro et al. (2020) and Manapunsopee et al. (2020), discussed individual methods, including inspiratory muscle training and incentive spirometry, respectively. In their study, Cordeiro and colleagues (2020) concluded that pre- and postoperative inspiratory muscle training enhanced inspiratory muscle strength and supported an early recovery period following coronary artery bypass surgery. On the other hand, Manapunsopee et al. (2020) proved its usefulness by enhancement of inspiratory muscle strength and decrease of PPCs. These observations align with previous evidence showing that AHI positive effects include increased cosh endurance hence further away from complications such as pneumonia and hypoxemia (Boden et al., 2018). Furthermore, these studies stress the interaction with patients insofar as CPT exercises on the topics of incentive spirometry indicate that patients'

compliance correlates with the improvement of respiratory results.

However, Pazzianotto-Forti et al. (2019) reported moderate outcomes on respiratory variables in post-bariatric surgical patients based on inspiratory exercises with linear and nonlinear loads. However, when using the self-reported PG scale, it was noted that the degree of improvement was not quite as marked compared with other research works that have shown the effects of PIP on inspiratory muscles. These mixed results may have arisen from differences in the intensity of CPT implying that such therapy may need to be customized according to patient risk factors and types of surgical procedures done. Perhaps unsurprisingly, this result is similar to previous studies by Gosselink et al., (2007) explaining how ć and the effectiveness of physiotherapy largely depends on the time duration and intensity of the exercise programme that is used.

More specifically, the systematic review of the comparison of different techniques chosen from the work of Sanal Bas & Kultufan (2017) also depicted moderate advantages of non-invasive pressure techniques on postoperative pulmonary function and the rate of PPC after major abdominal surgery. These differences in efficacy here make a strong point for technique-directed approaches in CPT often emphasized in literature. Further, Fernandez-Bustamante et al. (2017) noted that early respiratory interventions after surgery are associated with reduced PPCs, overlying early mortality, and hospitalization days, which further substantiates the overall pieces of this investigation as it concerns both respiratory and global patient and survival and recovery factors related to early CPT.

Notably, the results obtained in different studies are consistent with studies of other systematic reviews, for example, Chumillas et al. (1998) that reviewed respiratory rehabilitation methods in patients after abdominal surgery. Chumillas et al. (1998) noted a decrease in overall PPCs and decreased length of stay similar to what this present review has revealed. results since its type and timing are paramount, while early intervention leads to a prompt recovery and reduced PPC rates. As supported by large scale studies such Vester-Andersen et al., (2014) showing that improved respiratory care bundles across emergency gastrointestinal surgical patients reduced mortality and PPC rates substantially.

Overall, these findings of this review are in line with applying CPT in postoperative recovery, although high risk bias studies highlighted thematic components such as Pazzianotto-Forti et al. (2019) and Chumillas et al. (1998) reveal that methodological disparities can impact outcomes' comparability. As indicated in the second table: Risk of Performance and Detection Bias, the studies that were more biased and would likely perform and detect their outcomes inadequately proved to yield less accurate results. Such inconsistency in study quality indicates that more emphasis should be placed on methodological quality when studies are being conducted in the future – especially blinding and randomization in order to distill out the effects of CPT on PPCs.

Implications

The implications of the findings of this systematic review are as follows: Postoperative pain management has significant clinical relevance concerning the outcomes of thoracic and abdominal surgeries. CPT is promising as a measure of early implementation in the treatment of PPCs that can improve patient recovery, prevent ICU admissions, and reduce the length of hospital stay. It is concerning that risks associated with postoperative respiratory complications are high, especially among the high-risk surgical patients, that is, why incorporating CPT including inspiratory muscle training, incentive spirometry and non-invasive ventilation as usual components of postoperative care can reduce related risks (Cordeiro et al., 2020; Lockstone et al., 2020). Moreover, these results highlight the rationale of applying usual CPT strategies that should be variably adjusted depending on the presence of various risk factors and the kind of surgery. A possible implication of these targeted CPT interventions would be early administration of the CPT protocols in the early days of postoperative period which would enhance lung function, prevalence of respiratory infections, and subsequently create adequate suppression of costs due to lengthened hospital stays and ICU admissions. In a broader perspective, this review presents how PT and RS are essential in the post-operative care to prevent PPCs and enhance patient outcomes.

Limitations

However, there are some drawbacks and limitations associated with this systematic review that has to be considered. Already, the type of studies included ranges from high to moderate risk of performance and detection bias and hence might not be totally reliable. Some original studies have methodological differences in study design, CPT protocol, patients, and outcome measures, which may reduce the applicability to more extensive patients' populations. Also, the review provides randomized controlled trials, cohort studies, and controlled clinical studies which add heterogeneity in the methodological quality of the trials. Few studies, especially those that sample small participant numbers or no control group, might lack adequate statistical power necessary for evaluating the conclusions. Finally, the present review focuses on short-term consequences of CPT on breathing and lung mechanics, and does not evaluate long-term effects of the intervention on patient-reported living conditions and respiratory functionality after surgery. It would be important for future studies to overcome these limitations by designing larger well controlled RCTs with homogeneous CPT protocols before and after surgery to determine the long-term positive effects or adverse effects associated with CPT in various surgical patients.

CONCLUSION

As a result of the systematic review, the fact is identified that early Chest Physiotherapy is an effective measure that can help in preventing PPCs in patients who had thoracic or abdominal surgeries. Postoperative CPT, particularly in the first 24–48 hours, positively affects lung mechanics, decreases complications like atelectasis and pneumonia, and may even contribute to early discharge from the hospital. The differing techniques of CPT as well as the varying samples suggest that, despite the overall benefit results, CPT must have specific, technique- and operation-specific protocols taking into account patient characteristics. Late application of CPT as a routine protocol after surgery could also be sometimes beneficial in enhancing the postoperative recovery, decreasing the number of ICU admissions and overall saving costs. However, additional investigation with large sample sizes that implement universal CPT guidelines is needed to determine the durability of CPT's effectiveness and to continue to optimize CPT procedures for various surgical individuals.

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