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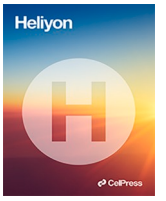

Research article

Effects of oscillatory positive expiratory pressure therapy in patients undergoing thoracic or upper abdominal surgery: A systematic review and meta-analysis

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ABSTRACT

Background: Preventing postoperative complications and accelerating patient recovery are critical issues in clinical treatment and nursing care. This meta-analysis aimed to evaluate the effects of oscillatory positive expiratory pressure therapy (OPEPT) in patients undergoing thoracic or abdominal surgery.

Methods: We searched PubMed, the Cochrane Library, Web of Science, EBSCO, SinoMed, Weipu, WanFang, and China National Knowledge Infrastructure (CNKI) for randomized controlled trials (RCTs) on the role of OPEPT on patients undergoing thoracic and upper abdominal surgeries. Two researchers independently conducted literature screening, quality assessment, and data extraction based on the inclusion and exclusion criteria, and used the RevMan 5.4 software to perform the meta-analysis.

Results: A total of 13 RCTs involving 1166 patients undergoing thoracic or abdominal surgery were included. The meta-analysis results showed that the decreases in FEV_1[MD = 0.30, 95%CI (0.22, 0.38), $P < 0.001$] and FVC levels [MD = 0.38, 95%CI (0.26, 0.49), $P < 0.001$] were statistically less in the OPEPT group than those in the control group. OPEPT could increase the postoperative drainage volume [MD = 91.53, 95%CI (57.55, 125.50), $P < 0.001$] and reduce the length of hospital stay [MD = −1.85, 95%CI (−3.42, −0.28), P = 0.02]. no significant effects on the FEV_1/FVC [MD = 2.60, 95%CI (−0.46, 5.67), P = 0.10] and the indwelling time of drainage tube [MD = −1.39, 95%CI (−3.18, 0.41), P = 0.13] between patients undergoing OPEPT and routine care. No publication bias was detected amongst the synthesized outcomes (all $P > 0.05$).

Conclusion: OPEPT, with its promising therapeutic approach, has shown to positively influence the recovery process for patients undergoing thoracic and upper abdominal surgeries. More high-quality, large-sample studies are needed in the future to explore the efficacy and safety of OPEPT.

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1. Introduction

Patients who have undergone thoracic and upper abdominal surgical procedures are at an increased risk for the development of postoperative pulmonary complications [1]. Such complications significantly impede the recovery process, protract hospital stays, and even contribute to elevated mortality rates [2,3]. Research underscores that these complications are often linked to an increase in airway secretions and a diminished capacity for sputum clearance [4]. The swift and efficient removal of respiratory secretions, when complemented by well-informed respiratory exercises, stands as a potent preventative measure against pulmonary issues post-surgery, thereby accelerating the recovery phase [5]. As such, mitigating the respiratory distress experienced by these patients, fostering the resurgence of their respiratory capabilities, and enhancing their overall quality of life are pivotal in shaping a favorable prognosis [6,7].

Oscillatory positive expiratory pressure therapy (OPEPT) is a therapeutic approach that synergizes positive expiratory pressure with the power of high-frequency oscillations [8].

OPEPT is a respiratory treatment method that includes several key steps to assist in the clearance of lung secretions. Patients use a specialized device with an oscillator to create positive pressure and vibrations. Under the guidance of a healthcare professional, they are instructed to take deep breaths during the therapy, which helps in opening the airways and allowing air to reach deeper lung areas. The oscillatory effect of the device serves to dislodge and mobilize secretions within the airways. With the synergistic action of positive pressure and vibration, the expulsion of sputum and other secretions is made easier through coughing, enhancing respiratory function and overall patient well-being [9–11]. It provides a two-fold advantage by facilitating pressurized breathing and vibration, which work in tandem to clear mucus through airway vibrations during respiration [10,12]. This process enhances postoperative lung function and mitigates the risk of developing postoperative pulmonary complications [11,13]. Over recent years, OPEP-based devices, exemplified by the Acapella, have shown promise in facilitating mucus clearance in conditions such as chronic obstructive pulmonary disease (COPD) and bronchiectasis [14,15]. Despite these advancements, there remains a significant void in robust evidence that substantiates

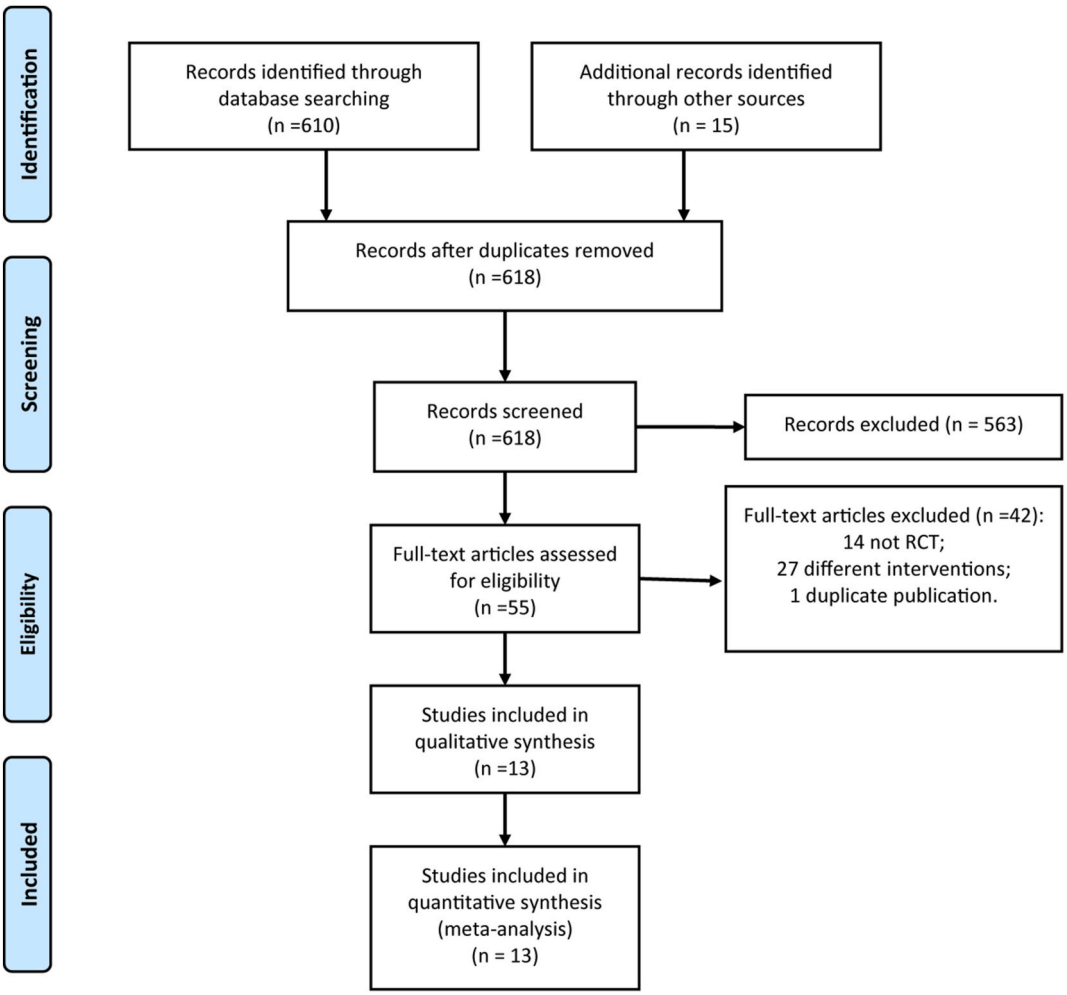

Fig. 1. The flow diagram of study selection.

Table 1
The characteristics of included studies.

RCT	Sample size		Study population	Intervention		Duration of intervention	Outcomes
	OPEPT group	Control group		OPEPT group	Control group		
Alam 2020	135	135	Patients undergoing coronary artery bypass grafting	Acapella vibratory positive pressure expiratory training combined with standard physiotherapy	Incentive vital capacity measurement combined with standard physiotherapy	Postoperative 3 days	(7)
Allam 2015	30	30	Patients undergoing upper abdominal surgery	Acapella vibratory positive pressure expiratory training combined with traditional chest physiotherapy	Traditional chest physiotherapy	4 weeks after operation	(1)(2)
Allam 2016	15	15	Patients undergoing upper abdominal surgery	Acapella vibratory positive pressure expiratory training combined with traditional chest physiotherapy	Traditional chest physiotherapy	4 weeks after operation	(3)
Cho 2014	39	39	Patients with lung cancer treated by selective thoracoscopic pneumonectomy	Acapella vibratory positive pressure expiratory training	Routine care	From preoperative to postoperative 3 days	(5)(6)
Jiang 2019	35	35	Patients undergoing lobectomy	Acapella vibratory positive pressure expiratory training	Routine care	3 days before operation to 7 days after operation	(1)(2)(3) (7)
Joh 2013	25	24	Selective lobectomy in the treatment of lung cancer	Acapella vibratory positive pressure expiratory training combined with inspiratory vital capacity measurement	Routine care	Postoperative 3 days	(4)(5)
Li 2018	35	34	Patients with primary non-small cell carcinoma undergoing thoracoscopic lobectomy	Acapella vibratory positive pressure expiratory training	Routine care	Perioperative period	(1) (4)(6) (7)
Lu 2021	30	30	Lung cancer patients undergoing thoracoscopic lobectomy	Acapella vibratory positive pressure expiratory training combined with postoperative routine lung rehabilitation exercise	Routine lung rehabilitation exercise	From 1 day before operation to discharge	(1)(2)(4)
Naswa 2017	15	15	Patients undergoing cardiac valve replacement	Acapella vibratory positive pressure expiratory training	Standardized active inspiratory circulation technology intervention	5 days after operation	(4)
Qiang 2020	30	30	Patients with lung cancer treated by thoracoscopic surgery	Acapella vibratory positive pressure expiratory training	Routine care	From postoperative to discharge	(1)(2)(4) (5)(6)
Zhang 2015	44	43	Patients undergoing radical resection of lung cancer under thoracoscope	Positive pressure expiratory training	Routine care	5 days after operation	(10)(11)
Zhang 2021	99	104	Adult patients undergoing chest and upper abdominal surgery	Using a modified vibratory positive pressure ventilation device for positive pressure expiratory training	Routine care	5 days after operation	(4)(8)(9)
Zhou 2019	50	50	Patients with lung cancer treated by thoracoscopic surgery	Acapella vibratory positive pressure expiratory training combined with routine lung rehabilitation exercise before and after operation	Routine lung rehabilitation exercise	From 2 weeks before operation to the first day after operation	(6)(8)

Note:(1)FEV_1; (2)FVC; (3)FEV_1/FVC; (4) Length of hospital stay; (5) The postoperative drainage volume; (6) Indwelling time of drainage tube; (7) Partial pressure of arterial oxygen; (8)White blood cell count; (9)The duration of antibiotic treatment; (10)Quality of life score; (11) weakness score.

the utility of such devices in hastening recovery following thoracic and upper abdominal surgeries. In an effort to bridge this knowledge gap, this study aims to conduct a meta-analysis of randomized controlled trials (RCTs) to systematically evaluate the effectiveness of OPEPT in patients undergoing thoracic or abdominal surgery, to provide clinical evidence for the rational formulation of early respiratory intervention strategies.

2. Methods

This meta-analysis is conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) [16] statement. The requirement for written and informed consent is waived for our research, as it is a meta-analysis.

2.1. Literature search

We performed a comprehensive search for RCTs that have examined the impact of OPEPT on patients who have undergone thoracic and upper abdominal surgeries, from the establishment of the database to May 10, 2024. Our search encompassed several databases, including PubMed, Embase, the Cochrane Library, Web of Science, EBSCO, SinoMed, Weipu, WanFang, and China National Knowledge Infrastructure (CNKI). Employing a strategy that combined both indexed terms and free-text searches, we conducted a thorough manual search. The literature search strategies were as following: ("oscillatory positive expiratory pressure therapy" OR "OPEPT") AND ("thoracic" OR "abdominal" OR "surgery" OR "operation"). We engaged in a meticulous process of pre-screening, followed by a full reading of titles, abstracts, and complete texts. After excluding those that did not meet our criteria, we incorporated the pertinent original literature. Additionally, we screened the references of the included studies when necessary to ensure a complete review.

2.2. Inclusion and exclusion criteria

The inclusion criteria for this meta-analysis were as follows: (1) The study population was patient who had undergone thoracic or upper abdominal surgery. (2) The experimental group received OPEPT intervention, while the control group followed standard postoperative recovery measures. (3) The study design was an RCT; (4) The literature reported relevant outcome indicators, such as forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC), FEV_1/FVC, postoperative drainage volume, indwelling time of drainage tube, and length of hospital stay. We excluded non-English and non-Chinese literature, as well as studies with incomplete data or those that, despite attempts to contact the authors, could not provide additional information to complete the data set.

2.3. Literature selection and data extraction

Two researchers independently screened the literature according to the pre-established inclusion and exclusion criteria, excluding non-randomized controlled trials and review articles. For any literature that was uncertain, the full text was retrieved for further evaluation. Disagreements were resolved through discussion, and if needed, a third researcher was consulted to help resolve the dispute. In instances where the literature provided incomplete information or raised questions or disagreements, contact was made with the original authors to obtain relevant details before making a decision on inclusion or exclusion. Two researchers extracted the data using a pre-designed data extraction form and then jointly verified it, resolving any discrepancies through discussion or by consulting a third party. The data extracted included the first author's name, publication year, country, sample size, the nursing interventions applied in the control and experimental groups, outcome measures, and measurement tools.

2.4. Literature quality assessment

Two researchers independently conducted the quality assessment of the literature based on the Cochrane Handbook's RCT evaluation form, covering seven aspects: sequence generation of randomization; allocation concealment; performance bias; detection bias; completeness of outcome data; selective reporting; and other biases. The evaluators made judgments on each of the above items as "low bias," "high bias," or "unclear." In cases of disagreement, a third party was consulted to reach a decision.

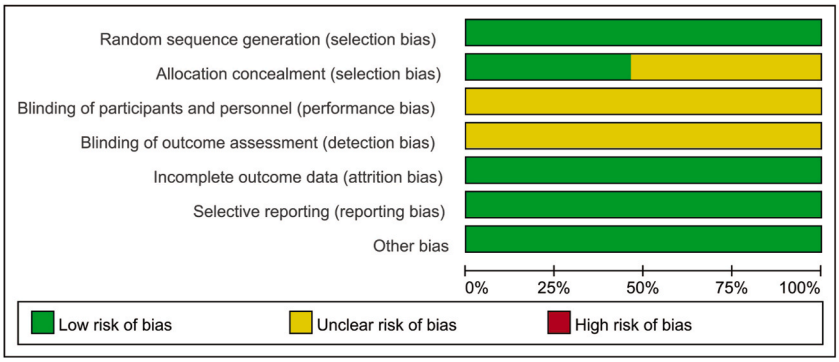

Fig. 2. Risk of bias graph.

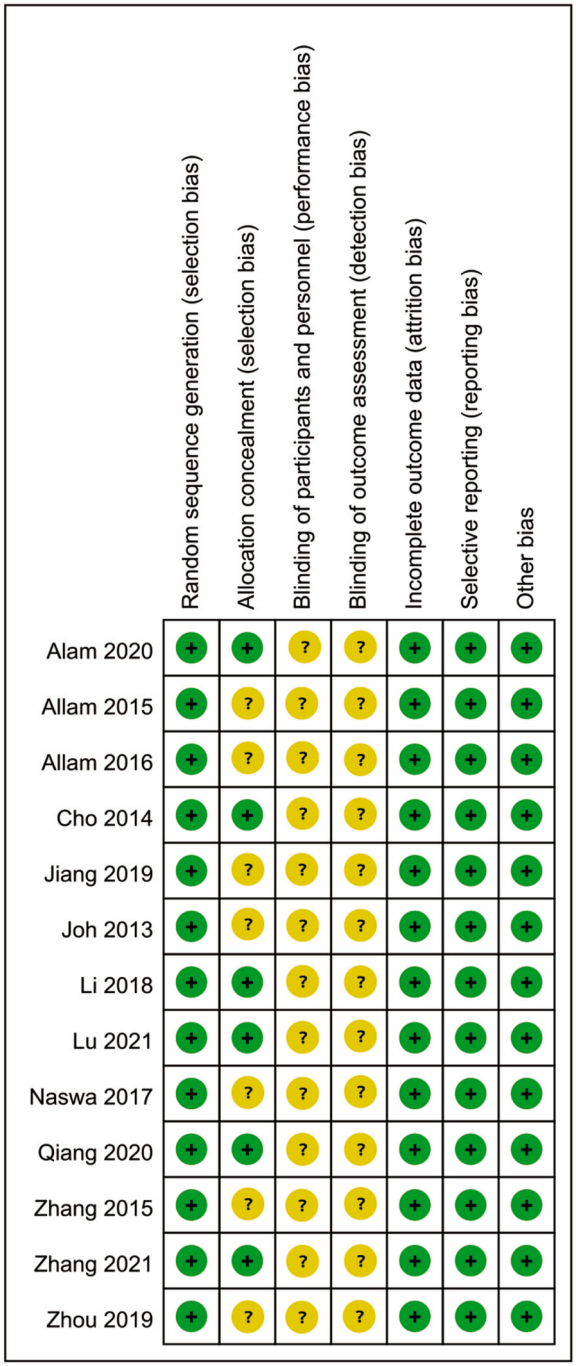

Fig. 3. Risk of bias summary.

2.5. Statistical analysis

For this research, we utilized the RevMan 5.4 software package to perform a meta-analysis on the selected literature. A chi-square test was employed to determine the presence of heterogeneity, with a significant level set at $\alpha = 0.1$. Homogeneity among studies was assumed when $P > 0.1$ and I^2 was less than or equal to 50 %, leading to the selection of a fixed-effects model. Conversely, when $P < 0.1$ and I^2 exceeded 50 %, indicating considerable heterogeneity among the results, we analyzed the causes of heterogeneity and chose a random-effects model. The findings of this study were deemed to have statistically significant differences at a P-value less than 0.05.

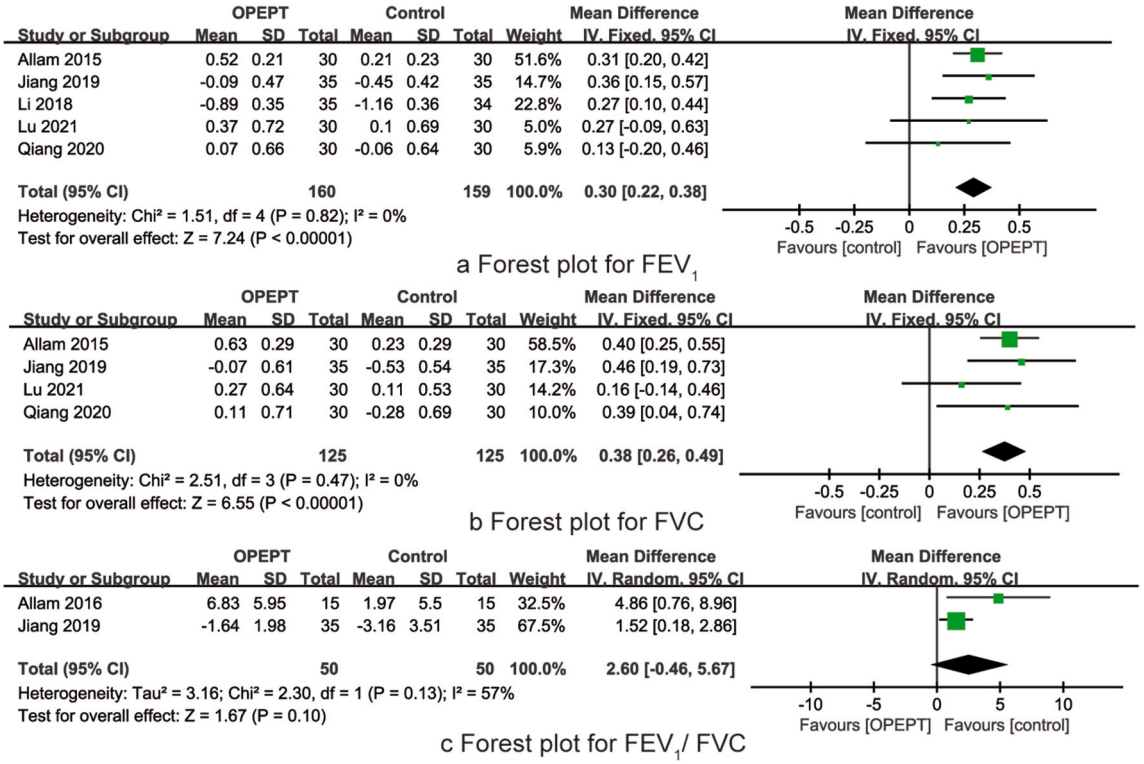

Fig. 4. Forest plots for the forced expiratory volume in 1 s (FEV_1), forced vital capacity (FVC) and FEV_1/FVC.

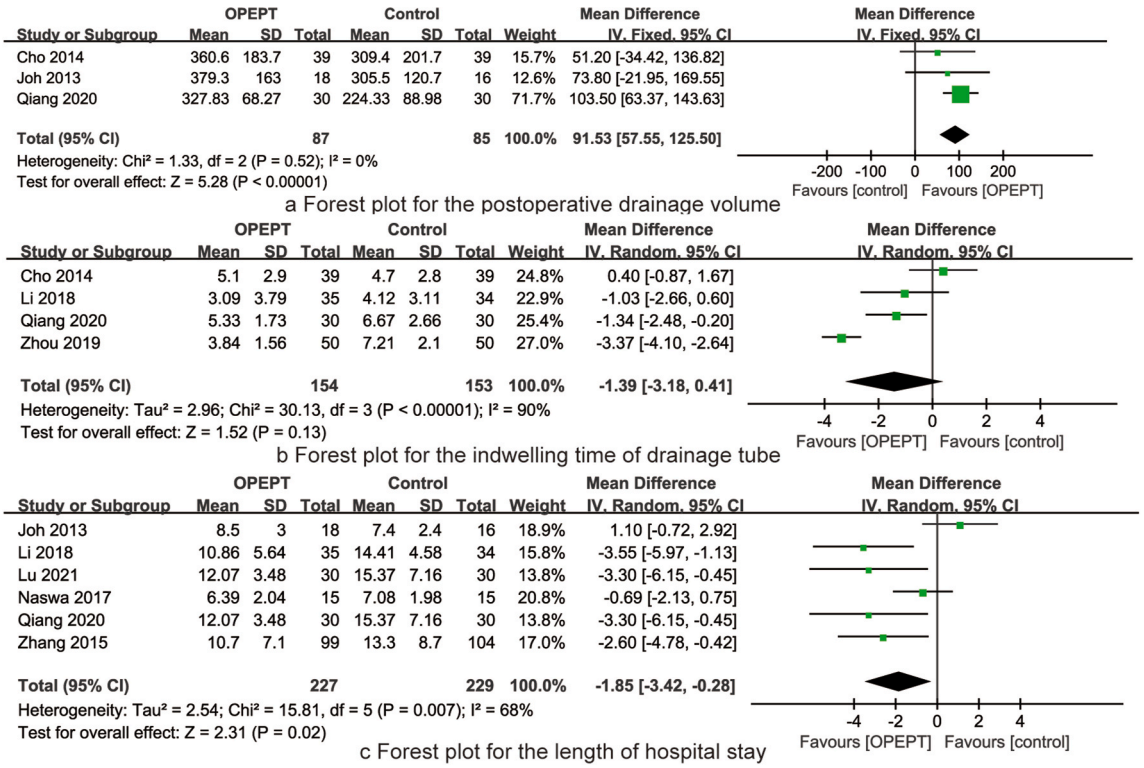

Fig. 5. Forest plots for the postoperative drainage volume, indwelling time of drainage tube and length of hospital stay.

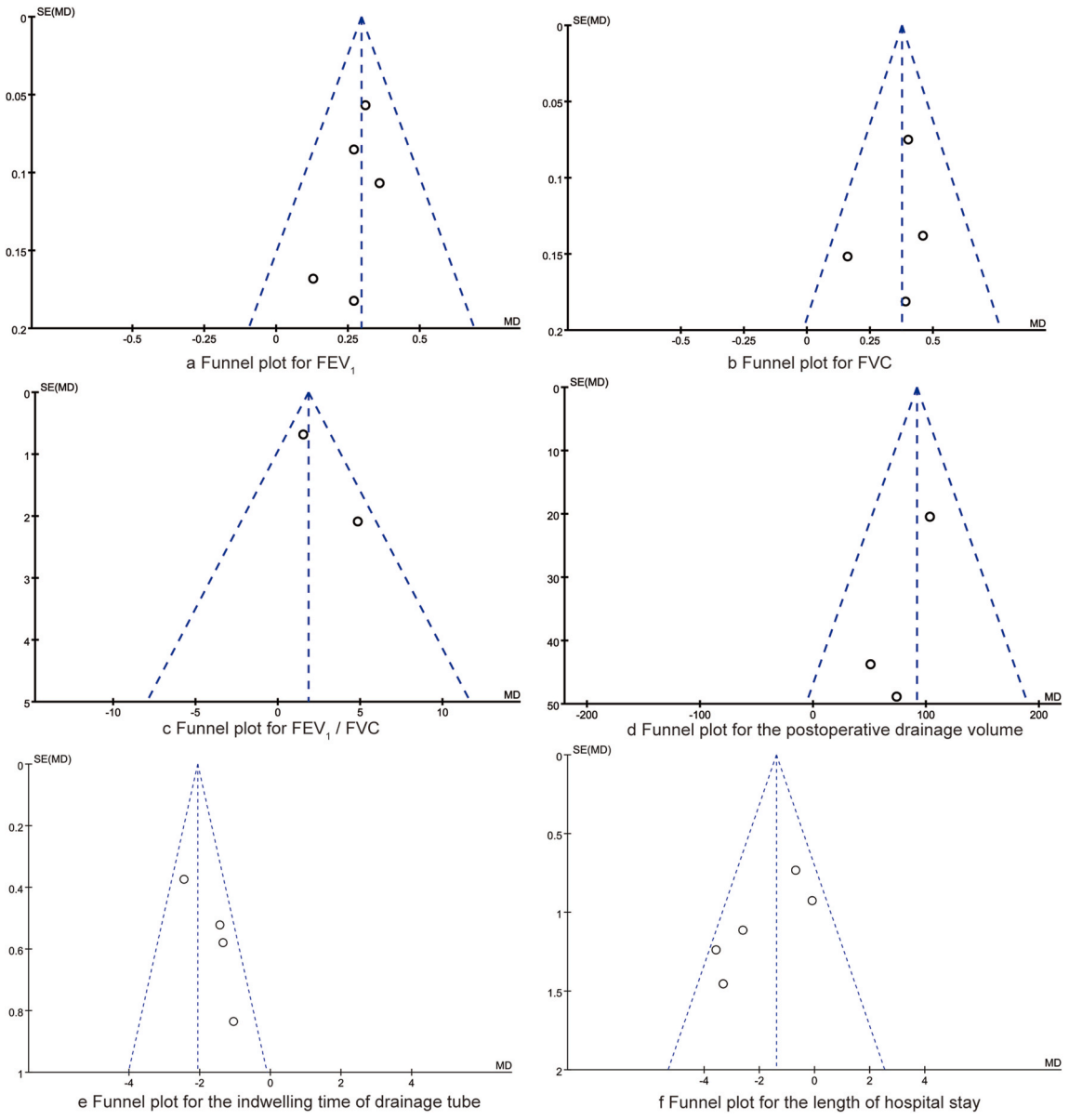

Fig. 6. Funnel plots for synthesized outcomes.

3. Results

3.1. Study selection

As presented in Fig. 1, the initial literature screening identified 625 potentially relevant articles. Upon reviewing the titles and abstracts, we eliminated duplicate studies, review articles, surveys, and other related literature, resulting in 55 articles that were subjected to full-text evaluation. Applying the established inclusion and exclusion criteria, we ultimately included 13 RCTs [17–29] in our analysis.

3.2. Characteristics of included RCTs

As shown in Table 1, of the included 13 RCTs [17–29], 1166 patients undergoing thoracic or abdominal surgery were involved, 582 patients received OPEPT intervention, 584 patients received routine care. The 13 RCTs were sourced from a diverse range of five countries and regions. All of the studies reported that the baseline characteristics of both the intervention and control groups were comparable. Furthermore, each study offered a thorough description of the intervention techniques employed and had well-defined

outcome measures.

3.3. Quality of included RCTs

The methodological quality assessment of the included literature is presented in Figs. 2 and 3. All 13 studies included were RCTs and described their specific randomization methods. Six of the studies reported the use of allocation concealment strategies for participants. Influenced by the inherent nature of the intervention, it was difficult for the included RCTs to apply blinding procedures to the patients or those assessing the outcomes. No other forms of bias were detected.

3.4. Synthesized analysis

A total of 5 RCTs evaluated the impact of OPEPT on the FEV_1 of patients undergoing thoracic and upper abdominal surgery. The results indicated low heterogeneity ($I^2 = 0$ %, $P = 0.82$), and a fixed-effects model was used for the meta-analysis. The meta-analysis results showed that the decreases in FEV_1 were statistically less in the OPEPT group than those in the control group [MD = 0.30, 95%CI (0.22, 0.38), $P < 0.001$, Fig. 4a].

A total of 4 RCTs evaluated the impact of OPEPT on the FVC of patients undergoing thoracic and upper abdominal surgery. The results indicated low heterogeneity ($I^2 = 0$ %, $P = 0.47$), and a fixed-effects model was used for the meta-analysis. The meta-analysis results showed that the decreases in FVC were statistically less in the OPEPT group than those in the control group[MD = 0.38, 95%CI (0.26, 0.49), $P < 0.001$, Fig. 4b].

A total of 2 RCTs evaluated the impact of OPEPT on the FEV_1/FVC of patients undergoing thoracic and upper abdominal surgery. The results indicated high heterogeneity ($I^2 = 57$ %, $P = 0.13$), and a random-effects model was used for the meta-analysis. The meta-analysis results showed that there was no statistical difference in the FEV_1/FVC between patients undergoing OPEPT and routine care [MD = 2.60, 95%CI (−0.46, 5.67), $P = 0.10$, Fig. 4c].

A total of 3 RCTs evaluated the impact of OPEPT on the postoperative drainage volume of patients undergoing thoracic and upper abdominal surgery. The results indicated low heterogeneity ($I^2 = 0$ %, $P = 0.52$), and a fixed-effects model was used for the meta-analysis. The meta-analysis results showed that OPEPT could significantly increase the postoperative drainage volume of patients after thoracic and upper abdominal surgery [MD = 91.53, 95%CI (57.55, 125.50), $P < 0.001$, Fig. 5a].

A total of 4 RCTs evaluated the impact of OPEPT on the indwelling time of drainage tube of patients undergoing thoracic and upper abdominal surgery. The results indicated high heterogeneity ($I^2 = 90$ %, $P < 0.001$), and a random-effects model was used for the meta-analysis. The meta-analysis results showed that there was no statistical difference in the indwelling time of drainage tube between patients undergoing OPEPT and routine care [MD = −1.39, 95%CI (−3.18, 0.41), $P = 0.13$, Fig. 5b].

A total of 6 RCTs evaluated the impact of OPEPT on the length of hospital stay of patients undergoing thoracic and upper abdominal surgery. The results indicated high heterogeneity ($I^2 = 68$ %, $P = 0.007$), and a random-effects model was used for the meta-analysis. The meta-analysis results showed that OPEPT could significantly reduce the length of hospital stay of patients after thoracic and upper abdominal surgery [MD = −1.85, 95%CI (−3.42, −0.28), $P = 0.02$, Fig. 5c].

3.5. Sensitivity analysis

We conducted a sensitivity analysis by sequentially excluding each study from the results one by one. The findings did not change significantly upon the exclusion of any single study, indicating that the meta-analysis results are robust.

3.6. Publication bias

We utilized funnel plots to assess publication bias for each outcome, as shown in Fig. 6. The points in the funnel plot were relatively evenly distributed and symmetrical, all falling within the confines of the funnel. The Egger test results indicated that there was no significant publication bias in the meta-analysis results ($P > 0.05$).

4. Discussion

Prevention and care of postoperative complications are crucial for patient prognosis. Respiratory training devices are predominantly utilized to enhance patients' respiratory functions, preventing and mitigating pulmonary complications after surgery [30]. These devices can maintain the normal respiratory cycle during sleep, alleviate respiratory system abnormalities, and prolong the active survival time for patients [31,32]. The findings of this study suggest that OPEPT is more effective than traditional postoperative rehabilitation in reducing the decrease of postoperative FEV_1 and FVC levels, increasing postoperative chest tube drainage, and shortening hospital stays. However, there is no statistically significant difference in chest tube indwelling time and the FEV_1/FVC ratio between OPEPT and traditional postoperative care. OPEPT holds positive implications for patient recovery post-surgery and may be valuable for clinical application and promotion.

Postoperative complications significantly impact the satisfaction with treatment and rehabilitation care for patients who have undergone surgeries in the thoracic and abdominal regions [33]. Early rehabilitation training post-surgery can facilitate the recovery of lung function and physical performance, as well as decrease the rate of complications [34]. The device utilized in OPEPT features a positive end-expiratory pressure device with a bellows structure. The steel balls within generate vibrations during the breathing

process, producing frequencies between 6 and 20 Hz. These vibrations help to dislodge mucus from the airway walls, and the increased airflow from coughing can expedite the movement of mucus upwards in the airways, with the aim of enhancing lung function and oxygenation capabilities [35,36]. In contrast to conventional vibratory mechanical sputum clearance devices, the internal vibrations produced by OPEPT are more efficiently conveyed to the peripheral bronchi and are less influenced by external factors such as the thickness of skinfolds and vibration frequency [37]. Research [38] indicates that OPEPT can lower airway resistance and alleviate airflow obstruction in patients with chronic pulmonary diseases, whether or not they present with airway secretions, thus enhancing pulmonary ventilation functions. In the context of respiratory therapy, an increase in drainage could signify more effective clearance of secretions, which is a desired outcome. This might be particularly true if the increased drainage leads to improved lung function and reduced complications. We have found that the drainage increases after OPEP therapy while hospital stay decreases in this group. It is possible that while the volume of drainage might have increased, the total duration of drainage required before clearance might have been reduced due to the therapeutic effects of OPEPT. This could result in a net decrease in hospital stay. Further researches are warranted to better understand the relationship between increased drainage, hospital stay, and the effects of OPEPT, a more granular analysis of these outcomes, along with a comprehensive assessment of patient recovery profiles, will be crucial in elucidating the mechanisms behind these findings.

Some studies [39,40] have suggested that OPEPT has a beneficial effect on lung function in patients after surgery for non-small cell lung cancer, aligning with the outcomes of this meta-analysis. Previous studies [41,42] have suggest that both perioperative anesthesia and intraoperative procedures can disrupt respiratory function, leading to a decrease in lung capacity. OPEP is believed to aid in the clearance of airways and improve mucous expulsion or bronchial drainage, thereby reducing the risk of postoperative pulmonary infections and atelectasis in patients who have undergone thoracic and upper abdominal surgeries, which in turn helps to improve indicators related to lung function [43]. However, this meta-analysis did not detect an improvement in the FEV_1/FVC ratio with OPEP, likely due to the scarcity of studies using FEV_1/FVC as an outcome measure, with only two articles included and exhibiting considerable heterogeneity. This limits the significance of the findings and calls for more clinical research in the future to validate the impact of OPEPT on the FEV1/FVC ratio.

Studies [44,45] have suggested that intraoperative anesthesia duration, the overall surgical procedure, and the use of postoperative anticoagulants can all contribute to an increase in pulmonary secretions and augment postoperative drainage. The literature included in this analysis did not specifically address these aspects, and future research should endeavor to account for these factors to more strictly control the quality of the experiments. The current meta-analysis indicates that OPEP does not appear to have an effect on reducing the duration of chest tube drainage for postoperative patients. Among the studies, three reported that OPEP shortened the duration of chest tube drainage, while one study reported the opposite effect. This discrepancy might be related to the majority of lobectomy cases in the OPEP group as mentioned by the authors, where an expanded surgical resection range could impact postoperative drainage volume and consequently the duration of chest tube drainage. Moreover, this meta-analysis has found that OPEPT is helpful to reduce the length of hospital stays for patients. Previous studies [46,47] have found that OPEPT can decrease the retention of sputum, lower the risk of postoperative infections and fever in adults who have undergone thoracic and upper abdominal surgeries, thus promoting early recovery and discharge. Besides, enhanced recovery after surgery (ERAS) protocols are evidence-based, multimodal strategies designed to improve postoperative recovery. These pathways often include preoperative education, optimized anesthesia and analgesia, early mobilization, and nutritional support [48,49]. By integrating OPEPT with ERAS protocols, we may be able to further refine postoperative care, potentially leading to synergistic benefits in respiratory function and overall recovery.

The cost of OPEPT devices and the resources required for training may pose a barrier, particularly in settings with limited healthcare budgets [50]. In some regions, the availability of OPEPT devices may be limited, hindering widespread implementation. The acquisition cost of OPEPT devices and any associated consumables represent direct costs that must be weighed against the potential benefits. The reduction in the length of hospital stay due to improved respiratory outcomes could lead to significant indirect cost savings [51]. The potential for OPEPT to decrease postoperative respiratory complications, such as atelectasis and pneumonia, could result in substantial cost savings by reducing the need for additional treatments and interventions [52]. However, it is important to note that our review did not specifically focus on the economic data associated with OPEPT. To the best of our knowledge, none of the included studies reported detailed cost data or conducted a formal cost-effectiveness analysis. This is a notable gap in the current literature, as economic evaluations are essential for healthcare decision-makers to assess the value of new interventions. Besides, patient acceptance and adherence to OPEPT could be influenced by factors such as discomfort, inconvenience, or lack of understanding of its benefits [53]. To overcome these barriers, a multifaceted approach is necessary, involving advocacy for increased funding for respiratory care, collaborations with device manufacturers to ensure affordability and accessibility, and ongoing education and research to demonstrate the clinical and economic benefits of OPEPT. Additionally, the development of policies and guidelines that endorse the use of OPEPT in postoperative settings could facilitate its integration into standard care.

This meta-analysis, while offering valuable insights, is constrained by several methodological limitations that warrant careful consideration. Initially, despite the fact that the 13 studies included in this synthesis were designed as RCTs, a significant number of them failed to report on critical methodological aspects such as allocation concealment and blinding techniques. This omission is notable, as it may engender the potential for various forms of bias, including selection bias, performance bias, and detection bias, which can compromise the validity of the findings. Furthermore, the analysis of postoperative respiratory function is inherently complex and influenced by a myriad of factors related to surgical and anesthetic procedures. These factors encompass the type of surgery, the extent and size of the surgical resection, the operational duration, and the specific use and dosage of anesthetic agents, all of which are pivotal in determining the respiratory outcomes post-surgery. The limitations in the granularity of data provided by the included studies have restricted our ability to perform subgroup analyses that would have elucidated the impact of these variables on the efficacy of OPEPT. Given these constraints, the current body of evidence must be interpreted with caution. Thirdly, in the context of

abdominal and thoracic surgery, the methodologies employed are fundamentally distinct, each with its own operational dynamics, clinical and surgical ramifications, and divergent postoperative trajectories. This study is constrained by the scope of the data collected, which precludes the execution of a segmented subgroup analysis that would separately examine the surgical approaches for thoracic and abdominal procedures. It underscores the urgent need for future research that is characterized by larger sample sizes and more stringent methodological rigor. Such studies are essential for providing a robust and comprehensive evidence base that can guide clinical practice regarding the use of OPEPT in patients who have undergone thoracic and upper abdominal surgeries.

5. Conclusion

In summary, OPEPT shows certain efficacy in promoting rapid recovery after thoracic and upper abdominal surgeries. The decreases in FVC and FVC are less in the OPEPT group than those in the control group, and OPEPT may increase postoperative chest tube drainage volume, and reduce the length of hospital stays. The current body of research does not provide a definitive assessment of the influence of OPEPT on FEV1/FVC, a critical measure of lung function that reflects the degree of airflow obstruction. Additionally, the data on chest tube drainage duration, which is an important indicator of postoperative recovery, is not comprehensively reported in the studies reviewed. Despite these gaps, the preliminary findings suggest that OPEPT may have a positive impact on accelerating the recovery of surgical patients. The therapy could potentially enhance lung function and reduce the duration of chest tube drainage, contributing to earlier patient mobilization and discharge. Given the promising implications, there is a clear need for further clinical validation of OPEPT's effectiveness on these specific outcomes. Future studies should aim to collect robust data on FEV1/FVC ratios and chest tube drainage duration, allowing for a more precise evaluation of OPEPT's role in respiratory recovery post-surgery.

Ethics approval and consent to participate

In this study, all methods were performed in accordance with the relevant guidelines and regulations. Ethics approval and consent to participate are not necessary since our study is a meta-analysis and systematic review.

Consent for publication

Not applicable.

Funding

This study did not receive any funding in any form.

Availability of data and materials

The data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Jinzhi You: Investigation. **Bo Jiang:** Investigation. **Ninghuang Dai:** Investigation. **Bo Lu:** Investigation. **Chengguang Zhao:** Investigation. **Zhongfeng Zheng:** Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

None.

List of abbreviations

OPEPT	oscillatory positive expiratory pressure therapy
COPD	chronic obstructive pulmonary disease
RCTs	randomized controlled trials
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
CNKI	China National Knowledge Infrastructure
FEV_1	forced expiratory volume in 1 s

FVC forced vital capacity
ERAS enhanced recovery after surgery

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e37798.

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