Jabr *et. al.,* Babcock Univ. Med. J.2026 9(2):143-153
https://doi.org/10.38029/babcockuniv.med.j..v9i2.1408
eISSN: 2756-4657

RESEARCH ARTICLE OPEN ACCESS

Effect of chest mobilisation and deep breathing exercises versus incentive spirometry on oxygenation and chest expansion in upper abdominal surgery patients: A randomised clinical trial

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Submitted: 20th November 2025
Accepted: 24th February 2026
Published: 30th June 2026
ID: Orcid ID

Abstract
Objective: Limited lung expansion following upper abdominal surgery is a common complication, often accompanied by physical discomfort, pain, and respiratory compromise. This study aimed to compare the effects of chest mobilization exercises versus incentive spirometry on oxygen saturation (SpO_2) and chest expansion in patients undergoing upper abdominal surgery.
Methods: a prospective single-blinded randomized controlled multi-centric design was employed in this study with a sample of 150 patients undergoing upper abdominal surgery at AL- kende government hospital, and Baghdad Teaching Hospital. Patients were randomly assigned to three groups: chest mobilization (n=41), incentive spirometry (n=43), or control (n=45). The outcomes measurements were oxygen saturation and chest circumference.
Results: the results shows that oxygen saturation and chest circumference improved significantly when using incentive spirometry and chest mobilization interventions compared to the control group at (p=0.000).
Conclusion: Incentive Spirometry and chest mobilization were effective non-pharmacological techniques in improving chest expansion and Oxygenation after upper abdominal surgery.

Keywords: Incentive Spirometry, chest mobilization, Upper Abdominal Surgery, Chest Expansion, Oxygenation

Plain English Summary

People who have surgery in the upper part of the abdomen often have difficulty breathing deeply afterwards because of pain, weakness of the diaphragm, and limited chest movement. This can reduce the amount of oxygen in the blood and increase the risk of lung problems such as collapsed lungs or infections. This study tested two simple, non-drug breathing methods to help patients recover their breathing after surgery: [1] using an incentive spirometer (a handheld device that encourages deep breathing) and [2] chest mobilisation exercises (arm and chest movements combined with deep breathing). A total of 129 patients from two hospitals in Baghdad were randomly assigned to one of three groups: incentive spirometry, chest mobilisation exercises, or usual hospital care.
The researchers measured how well the patients could expand their chest and how much oxygen was in their blood before and after the interventions. They found that both incentive spirometry and chest mobilisation exercises significantly improved chest expansion and oxygen levels compared to standard care alone. Patients who used the incentive spirometer generally showed the greatest improvement, followed by those who performed chest mobilisation exercises. These findings suggest that simple breathing exercises and devices can help patients breathe better and recover faster after upper

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abdominal surgery. This study shows that nurses and healthcare providers can use incentive spirometry and chest mobilisation exercises as safe, low-cost, and effective methods to improve breathing and oxygenation after surgery. These techniques may reduce the risk of postoperative lung complications and support better patient recovery.

Introduction

Upper abdominal surgical operations are associated with a 20% incidence of postoperative pulmonary problems, while lower abdominal surgeries have a lower prevalence, ranging from 2% to 8%. Percutaneous upper abdomen procedures trigger a sequence of pathological reactions that may result in postoperative pulmonary problems in individuals (1, 2).

Each year, over 300 million patients undergo surgical procedures globally, of whom 4·2 million die within 30 postoperative days. Postoperative mortality contributes to 7·7% of all deaths globally, making death as a result of surgical intervention the third leading cause of death worldwide after ischemic heart disease and stroke (3).

Recovery following surgery may be impeded by a range of symptoms, including physical discomfort, psychological distress, emotional instability, and pain. During surgery under general anaesthesia, a patient's lungs are unable to achieve complete ventilation. The discomfort resulting from the abdominal incision hinders inhalation, therefore limiting lung expansion. PPCs may arise, particularly when surgery is conducted in the upper abdomen region (4, 5).

Postoperative pulmonary complications were linked to various risk factors, including age, smoking, Chronic Obstructive Pulmonary Disease (COPD), type of surgical procedure, and serum albumin. Most of these risk factors are modifiable and improvable; consequently, identifying them is important for improving the quality of care for patients undergoing surgery (6).

The incidence of surgical complications rises with advancing age, obesity, smoking, and pre-existing lung disorders. Further variables, including the surgical site, duration of anaesthesia, and post-operative risk factors such as emergency operations, insufficient preoperative education, immobilisation, analgesics, and cation, have been documented to contribute to an elevated risk (7).

Techniques such as deep inspiration [DI], incentive spirometry [IS], and positive airway pressure exercises stimulate a large, sustained increase in transpulmonary pressure, with consequent expansion of collapsed alveolar units to prevent and/or treat postoperative pulmonary complications [PPCs] (8). The IS has been widely used in clinical practice (9), especially in the management of patients in the pre- and postoperative periods of major surgeries, due to its low cost, ease of application, and good patient adherence to the method (10). On the other hand, the evidence supporting the use of such equipment to reduce postoperative pulmonary complications is not yet established, and there are controversies regarding its effectiveness in the prevention and/or treatment of PPCs in abdominal, cardiac, and thoracic surgery (11, 12).

An incentive spirometer [IS] is a feedback device designed to motivate patients to inhale deeply and generate a prolonged maximum inspiration to primarily open and stabilise portions of the lung affected by atelectasis. It offers mild resistance exercise while minimising the risk of diaphragm fatigue (12, 13). In the context of physical activity aimed at enhancing chest expansion and ventilation, chest mobilisation is a component of the method. It is executed by raising the arms to their maximum extent while inhaling deliberately. The chest mobilisation technique facilitates the opening of individual rib cages in the upper, middle, and lower regions of the chest wall. It also enhances the mobility of the sternocostal and costovertebral joints, therefore positively impacting chest movement and ventilation (14).

The use of chest mobilisation and thoracic flexibility exercises to improve chest and vertebral deformations and, consequently, pulmonary function has been studied previously (15). By decreasing the stiffness of the intervertebral discs and surrounding tissues and increasing the stretch and endurance of the vertebral extensor muscles through thoracic flexibility exercises, these interventions improved respiratory muscle function, chest expansion, and diaphragm movement in addition to improving pulmonary function and thoracic mobility (16).

Incentive spirometry and chest mobilisation exercises are commonly used after upper abdominal surgery to improve lung expansion and oxygenation, but they work through different physiological mechanisms. Incentive spirometry encourages deep, sustained inhalation and alveolar recruitment, while chest mobilisation improves thoracic mobility and respiratory muscle function. However, few studies have directly compared their effectiveness, and evidence remains inconsistent. Therefore, comparing these two interventions is necessary to identify the most effective method for improving postoperative oxygenation and chest expansion and to support evidence-based clinical practice (12, 13, 14). Previous research

has shown that thoracic mobility exercises can improve pulmonary function, chest expansion, and diaphragm movement by reducing thoracic stiffness and increasing respiratory muscle endurance. Similarly, incentive spirometry has been reported to increase inspiratory capacity and improve oxygen saturation, but controversy remains regarding its superiority over conventional breathing exercises. Therefore, a direct comparison between incentive spirometry and chest mobilisation is clinically important to guide evidence-based nursing and physiotherapy practices.

Objective and Hypotheses

The objective of this study was to compare the effects of incentive spirometry and chest mobilisation exercises on oxygenation and chest expansion in patients undergoing upper abdominal surgery.

H1: *Incentive spirometry and chest mobilisation exercises significantly improve postoperative oxygenation and chest expansion compared to standard postoperative care.*

H2: *Incentive spirometry results in greater improvement in postoperative oxygenation and chest expansion than chest mobilisation exercises.*

Materials and Methods

Research Design

This study was an interventional, prospective, randomised, controlled, single-blinded, parallel-group, multi-centre clinical trial. Patients were randomly assigned to incentive spirometry, chest mobilisation, or a control group. Outcome assessors were blinded to group allocation to reduce measurement bias, and participants were aware of their assigned intervention due to the nature of the interventions.

Population and Sampling

150 study samples were recruited from patients undergoing upper abdominal surgery attending the Al-Kende Government Hospital and the Baghdad Teaching Hospital. Data were collected from August 15th to October 15th in 2025. This setting was selected because it serves the most populated region and has a high prevalence of patients.

Sample & sampling procedures

A simple randomisation technique, which is a type of probability sampling, was used for the assignment of 129 subjects into a particular group. The flipping a coin method was chosen, where the side of the coin (i.e., heads - participant, tails - nonparticipant) determines the assignment of each subject. In this single sequence scheme, each member of the target population has an equal chance of being selected as a participant. This randomisation approach ensures simplicity, ease of assembling the sample, representativeness, and is best used for a population which is highly homogenous. Choosing this type was consistent with the current study design. The eligibility criteria for the study included adults aged 18> 60 years, who were scheduled to undergo upper abdominal surgery. Informed consent was duly signed by those willing to participate in the study in all included centres. The exclusion criteria of the study included: Patients exhibiting unstable hemodynamic parameters characterized by arterial pressure below 100 mmHg systolic and below 60 mmHg diastolic, and mean arterial pressure (MAP) below 80 mmHg, Patients needing mechanical ventilation, uncooperative patients, patients who lack intellectual capacity to demonstrate proper use of Incentive Spirometer, chest mobilization cases in which incentive spirometer is contraindicated such as thoracic, abdominal, or cerebral aneurysms (risk of rupture due to increased thoracic pressure).

Sample Size Calculation

The minimum sample size consisted of 129 patients. The sample size was estimated according to power analysis using the G power tool, based on an independent t-test with effect size 0.23, power 0.80, and α=0.05.

Study Protocol Algorithm

The flow of participants through the study is shown in Figure 1

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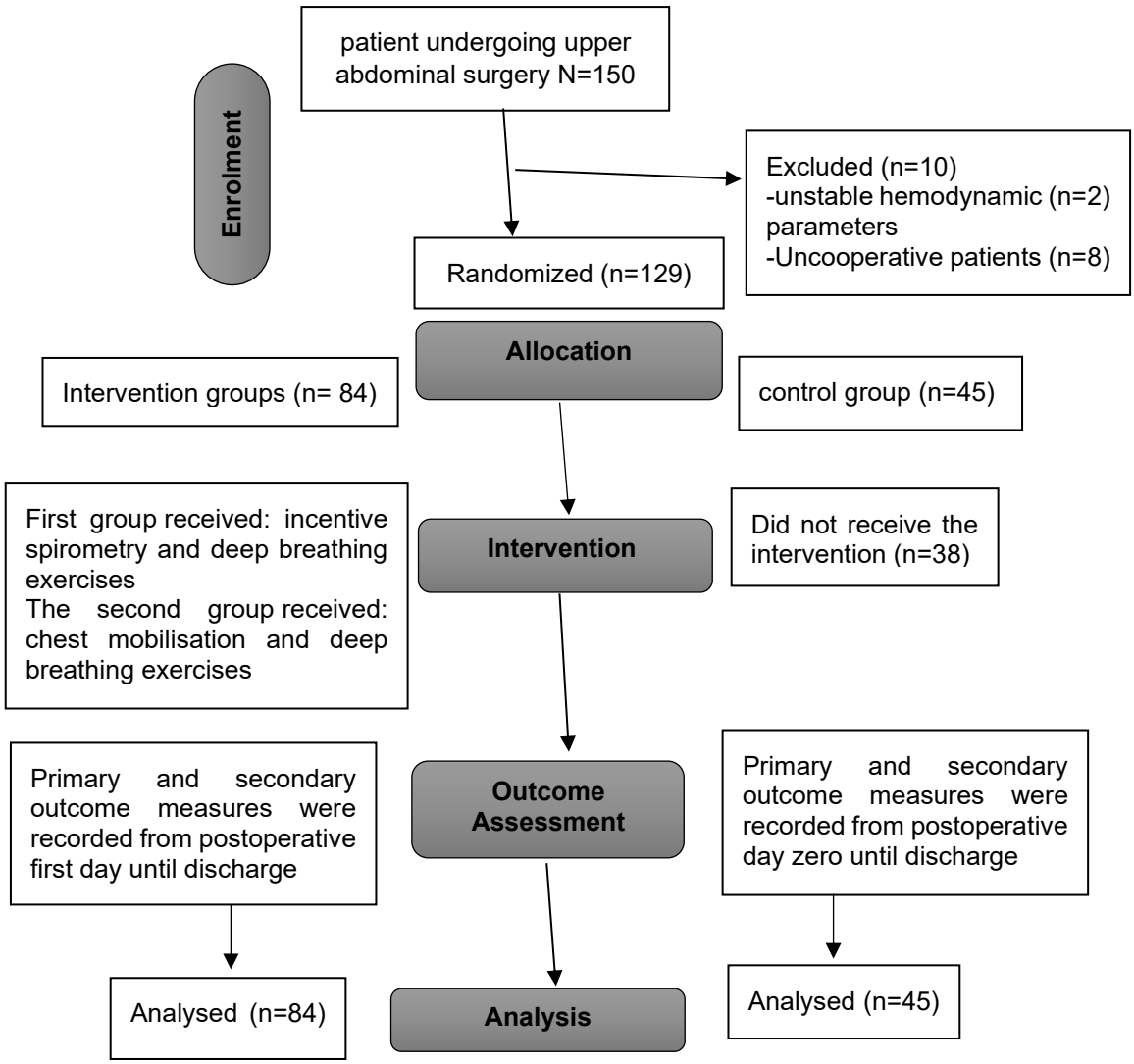


Figure 1: CONSORT Study Flow Diagram

Study Instruments

Demographic and Lifestyle Data

Information, including the following variables, was collected from patients' medical records and interview questionnaires: age, gender, area of residence, smoking status and Body Mass Index (BMI).

Clinical Data

The following variables were collected via chart review by the principal investigator: Medical Diagnosis, Comorbidities, Type of upper abdominal surgery, Duration of surgery (hours), and Previous surgeries. Primary and secondary outcome measures were SPO2 and Chest expansion (cm).

Material and research tools

Chest expansion was assessed using a measuring tape with centimetre markings. Participants were measured for oxygen saturation using pulse oximetry

Incentive Spirometer

A flow-oriented incentive spirometer (FIS) was used in this trial. It is a plastic hand-held device that consists of a mouthpiece and corrugated tubing connected to a manifold composed of three flow tubes containing three colour coded light weight plastic balls for differing inhalation rates - from 600cc/sec, 900cc/sec, 1200 cc/ sec. If the first sphere rises to the top of the chamber, inhalation is 600cc/sec; if the second sphere rises to the top of the chamber, inhalation is an additional 900cc/sec; if the third sphere rises to the top of the chamber, inhalation is an additional 1200cc/sec, which all equal a total of 2700cc or 2.7 litres.

Chest mobilisation

The chest mobilisation was conducted 5 times per set, with 3 sets assigned to each session. Individual participants independently performed chest mobilisation under the guidance of a

physiotherapist for the first time. All participants received a booklet on the first postoperative day. The chest mobilisation technique involves pulling the arms upward to their maximum extent while inhaling appropriately during the movement.

Research Procedures

Informed consent and enrolment

The study was explained to patients undergoing upper abdominal surgery during the post-operative phase. Informed consent was obtained before participation in the study; the voluntary nature of participation was stressed. All study participants were advised that they could withdraw from the research process at any stage, and this was clearly stated in the written consent forms. Patients were allowed to read the informed consent and have all their questions answered before signing.

Data Collection

The data collection process was carried out from 15th August to 15th October 2025. The researcher provided a detailed explanation of the study and its objectives to the study sample. 129 patients undergoing upper abdominal surgery and fulfilling the inclusion criteria were selected for the study. They were randomly assigned to three groups: Group A, Group B, and Group C. All subjects were preoperatively informed of the purpose of the study and educated on the respective treatment procedures. A prior written consent was obtained. Ethical clearance was attained. A detailed subjective assessment of the subjects was done preoperatively to rule out any other abnormalities.

Intervention

Upon signing the consent forms, two hours following surgery, once patients were fully conscious, those in the intervention group received preoperatively individualised training. All the subjects received basic postoperative respiratory physiotherapy, including breathing exercises and coughing techniques. Patients were mobilised as early as possible by nursing staff in accordance with the hospital protocol. The patients were instructed to sit out of bed on the first postoperative day, stand on the second day, and walk in the room or a short distance in the corridor on the third postoperative day.

For Group incentive spirometry(A): 43 Patients were asked to maintain a sitting position on the edge of bed, hold the IS in an upright position, place the lips tightly around the mouthpiece and perform slow and deep inhalation, allow the first ball in the 600cc chamber to rise to the top, enhance breathing by allowing the second ball in the 900cc chamber to rise to the top, and keep enhancing breathing to set the target of 1.200 cc. At maximum inhalation, the mouthpiece is removed, followed by a breath-hold and normal exhalation, allowing the three balls to fall to the bottom of the column. After ensuring proper demonstration of steps, patients were asked to repeat the manoeuvre in a set of ten times hourly while awake until the day of the surgical operation. The patients were trained twice a day, with each session lasting for 15 to 20 minutes till Day 3.

For Group chest mobilisation (B): 41 was conducted 5 times per set, with 3 sets assigned to each session. Individual participants independently performed chest mobilisation under the guidance of a physiotherapist for the first time. All participants received a booklet on the first postoperative day. The chest mobilisation technique involves pulling the arms upwards to their maximum extent while inhaling appropriately during arm movement

Day 1 Position 1: Positioned on their back, withdraw both hands from the neck and then elevate the elbows, extending them as much as feasible, while inhaling deeply and gently. Subsequently, release the breath gradually and elevate the elbows while keeping the hands situated behind the neck.

Position 2: Lying on the side with the operated side facing upwards, retract a hand from the neck and elevate the arm as far as possible while inhaling deeply and gently. Subsequently, exhale gradually and lower the arm while keeping the hands positioned behind your neck.

Day 2 Position 1: Take an upright seated position, retract both hands behind the neck, then elevate the elbows and extend them as far as feasible while inhaling deeply and gently. Subsequently, exhale gradually and extend the elbows forward while keeping the hands positioned behind the neck.

Position 2: Assume an upright sitting posture, lift both hands behind the neck and extend the elbows outward during exhale. Then, move the elbows forward with a deep and slow inhalation while keeping the hands behind the neck

Day 3 Position 1: Side-lying with the operated side on top with a roll tower or pillow under the thoracic region. Take the hand back of the neck, then raise the arm as much as possible, deeply and slowly inhale. After that, slowly exhale, lower the arm, and keep the hands behind the neck.

Position 2: Upright sitting, take the hands of both sides behind the neck, then bend the trunk to the other non-operated side as far as possible, taking deep, slow inhalations. After that, slowly exhale and return to the start position.

For Group control (C): 45 patients received standard hospital care as the control group.

Data analysis: Data were analysed using SPSS version 26. Continuous variables were

summarised as mean ± SD, and categorical variables as frequencies and percentages. Normality of continuous data was tested using the Shapiro–Wilk test. Within-group comparisons were conducted using the Wilcoxon signed-rank test for non-normal data. And Between-group comparisons by Mann–Whitney U tests for non-normal data. $p < 0.05$ was considered statistically significant.

Result

The results in Table 1 show significant improvements in chest expansion scores among participants in all study groups following the interventions. In the incentive spirometry group, the mean chest expansion increased markedly from 3.05 ± 0.21 cm at the pre-test phase to 4.98 ± 0.15 cm at the post-test phase, with a Wilcoxon value of –6.410 ($p = 0.000$). Similarly, in the chest mobilisation group, there was a statistically significant improvement in chest expansion, as reflected by a Wilcoxon value of –4.243 ($p = 0.000$). In contrast, the control group showed only a minor change, with mean chest expansion values of 3.27 ± 0.69 at pre-test and 2.29 ± 1.16 at post-test and the Wilcoxon test (–1.138, $p = 0.076$) (Table 2).

Table 1: Statistical Comparison of Chest Expansion Scores among Study Groups at Pre- and Post-Test Phases

Groups	N	Chest expansion	Mean	SD	Wilcoxon	Sig
Incentive spirometry	43	Pre-test Phase	3.04	0.21	-6.41	0.000
		Post-test Phase	4.97	0.15		
chest mobilization and deep breathing	41	Pre-test Phase	3.58	0.86	-4.24	0.000
		Post-test Phase	5.56	0.91		
Control	45	Pre-test Phase	3.26	0.68	-1.13	0.076
		Post-test Phase	2.28	1.16		

n: Number of Participants, M: Mean, SD: Standard Deviation, Sig: Significance

Table 2: Inferential Statistical Comparison of Oxygenation between Study Groups at Pre- and Post-Test Phases

Groups	n	Spo_2	Mean	SD	Wilcoxon	Sig
Incentive spirometry	43	Pre-test Phase	94.79	1.16	-5.86	0.000
		Post-test Phase	98.25	1.07		
chest mobilization	41	Pre-test Phase	94.58	1.43	-5.64	0.000
		Post-test Phase	97.07	1.66		
Control	45	Pre-test Phase	94.89	1.99	-0.98	0.317
		Post-test Phase	94.77	1.98		

Table 3 presents the pairwise inferential statistical differences in peripheral oxygen saturation (SpO_2) between the experimental groups (Incentive Spirometry and Chest Mobilisation) and the Control group at the post-test phase. In the post-test phase, a significant difference was observed between the Incentive Spirometry group, with a higher Mean Rank of 51.71, and the Chest Mobilisation group, with a Mean Rank of 32.84 ($U = 485.5$, $p = 0.000$). When comparing the Chest Mobilisation group with the Control group, the post-test comparison revealed a highly significant difference ($U = 294.000$, $p = 0.000$), with the Chest Mobilisation group achieving a higher Mean Rank (58.83) than the Control group (29.53). The comparison between the Incentive Spirometry and Control groups showed a higher Mean Rank for the Incentive Spirometry group (65.19) than for the Control group (24.73).

Table 3: Pairwise Inferential Statistical Differences in Oxygenation between Experimental Group(s) and Control Group at Post-Test Phases

Variable	Group	n	Mean Rank	Mann-Whitney	Sig
		Spo_2			
Post-test Phase	Incentive spirometry	43	51.71		
	chest mobilization and deep breathing	41	32.84		
	Total	84		485.57	0.023
Post-test Phase	chest mobilization and deep breathing	41	58.83	294.00	0.000

	Control	45	29.53		
	Total	86			
	Incentive spirometry	43	65.19	78.00	0.000
Post-test Phase	Control	45	24.73		
	total	88			

Table 4 presents the pairwise inferential statistical analysis of differences in chest expansion between the experimental groups (Incentive Spirometry and Chest Mobilisation) and the Control group in the post-test phase. The Incentive Spirometry group showed a substantially higher Mean Rank (62.52) than the Chest Mobilisation group (21.50), with a Mann–Whitney U value of 20.5 and a highly significant p-value (p = 0.000). When comparing the Chest Mobilisation group with the Control group during the post-test phase (U = 328.000, p = 0.000), the Chest Mobilisation group's Mean Rank (58.00) was higher than the Control group (30.29). The comparison between the Incentive Spirometry and Control groups revealed significant differences at post-intervention, as the Incentive Spirometry group (Mean Rank = 64.86) exceeded the Control group (Mean Rank = 25.04), with a Mann–Whitney U value of 92.000 (p = 0.000).

Table 4: Pairwise Inferential Statistical Differences in Chest expansion between Experimental Group(s) and Control Group at Post-Test Phases

Variable	Group	n	Mean Rank	Mann-Whitney	Sig
		Chest expansion			
Post-test Phase	Incentive spirometry	43	62.52		
	chest mobilization	41	21.50		
	Total	84		420.56	0.003
Post-test Phase	chest mobilization	41	58.00	328.00	0.000
	Control	45	30.29		
	Total	86			
	Incentive spirometry	43	64.86	492.00	0.000
Post-test Phase	Control	45	25.04		
	total	88			

Discussion

The findings of this study indicate that incentive spirometry and chest mobilisation exercises are effective non-pharmacological interventions for improving postoperative oxygenation and chest expansion in patients undergoing upper abdominal surgery, with superior outcomes observed in the incentive spirometry group.

Study findings regarding Statistical Differences in Spo_2 for the study groups and the control group during the pre- and post-interventional phases. When comparing the incentive spirometry group and the control group in terms of Spo_2 saturation across the post-test period, the findings demonstrated that incentive spirometry had a significant effect compared to the control group. The comparison between the Incentive Spirometry and Control groups showed a higher Mean Rank for the Incentive Spirometry group (65.19) than for the Control group (24.73). The experimental group had significantly higher oxygen saturation levels than the control group (U=78.000, P=0.000). This finding indicates that the incentive spirometer is an effective nurse-led non-pharmacological intervention post-upper abdominal surgery for improving Spo_2 levels. This finding is consistent with and agrees with the findings of the previously published studies (17, 18, 19). Similarly, a study conducted by Apriliana et al on the Role of Incentive Spirometry for Patients with Chemotherapy concluded that using this technique improves SpO2, which is consistent with our findings (20).

Upper abdominal surgery commonly results in reduced lung expansion due to postoperative pain, diaphragmatic dysfunction, and shallow breathing patterns, which can impair alveolar ventilation and decrease oxygen saturation (SpO_2). Incentive spirometry promotes slow, deep inhalation that increases lung inflation, opens collapsed alveoli, and improves ventilation–perfusion matching. Enhanced oxygen diffusion subsequently elevates arterial oxygen saturation levels. Additionally, incentive spirometry reduces the risk of postoperative atelectasis, a major contributor to hypoxemia, thereby supporting sustained oxygenation. Through these physiological benefits, incentive spirometry effectively maintains and improves postoperative SpO_2 levels, contributing to overall respiratory stability and recovery.

Tables 1 and 2 were formulated to investigate statistical differences in chest expansion between the study and control groups in the

present study. When comparing the Incentive spirometer group and the control group in terms of chest expansion, the findings revealed a significant difference (post-test: U=492.000, p=0.000). The incentive spirometry group had a notably higher post-test mean rank than the control group (25.14 vs. 64.86). This finding supports the use of the incentive spirometer as an effective post-upper abdominal surgery intervention for improving chest expansion. This finding was consistent with those of many previously published studies (21, 22, 23). Similarly, a study by 18. Zeng, Pingping et al. on the effects of spirometry on lung capacity after upper abdominal surgery, which concluded that using the incentive spirometer enhanced lung capacity, agreed with these study findings (18). Also, another study approved our findings by Eltorai et al. on the use of an incentive spirometer with a visual obstruction for indicating flow concluded that a cover for the flow indicator during incentive spirometers significantly increased achieved inspiratory volumes in the study sample (24).

The significant improvement in chest expansion in the incentive spirometry group can be explained physiologically. After upper abdominal surgery, patients often experience shallow breathing and reduced lung volumes due to pain and diaphragmatic dysfunction. Incentive spirometry promotes deep, sustained inhalations, which increase lung volumes, enhance chest wall mobility, and prevent post-operative pulmonary complications. These mechanisms rationalise why patients using the device achieved greater chest expansion than those in the control group.

Also, findings regarding Statistical Differences in Spo_2 for the study groups and the control group during the post-interventional phases. When comparing the chest mobilisation group and the control group in terms of Spo_2 saturation across the post-test period, the findings showed that chest mobilisation had a significant effect. The comparison between the Incentive Spirometry and Control groups showed a higher Mean Rank for the Incentive Spirometry group (58.83) than for the Control group (29.53). The experimental group had significantly higher oxygen saturation levels than the control group (U=294.000, P=0.000). This finding indicates that Chest mobilization is an effective nurse-led non-pharmacological intervention post-upper abdominal surgery for improving Spo_2 levels. This finding is consistent with the findings of the previously published studies (23, 25). Similarly, a study by Lima et al. (2021) was consistent with these findings, concluding that using this technique improves Spo_2 saturation (26).

Upper abdominal surgery commonly results in reduced lung expansion due to postoperative pain, diaphragmatic dysfunction, and shallow breathing patterns, which can impair alveolar ventilation and decrease oxygen saturation (SpO_2). The significant improvement in Spo_2 levels observed in the Chest mobilization group compared to the control group can be explained by the intervention's ability to enhance lung expansion and facilitate more efficient oxygen exchange. Chest mobilisation helps reduce post-surgical respiratory restrictions, which are common following upper abdominal surgery, by encouraging deeper, more effective breathing. This leads to improved oxygenation and, as a result, higher Spo_2 levels.

Tables 3 and 4 were formulated to investigate the statistical differences in chest expansion between the study and control groups in the present study. When comparing the Chest mobilization group and the control group in terms of chest expansion, the findings revealed that Chest mobilization had a significant difference in (post-test: U=328.000, p=0.000). The chest mobilisation group had a notably higher post-test mean rank than the control group (58 vs. 30.29). This finding supports the effectiveness of chest mobilisation as an intervention following upper abdominal surgery in improving chest expansion. This finding was consistent with findings from many previously published studies (27, 28). Similarly, a study by Sakuna M et al. on the Effect of chest wall mobilisation after upper abdominal surgery concluded that using chest wall mobilisation enhances mobilisation of the chest wall (41). Another study concurred with our results by Jung JH. et al. on the use of chest mobilisation for chest expansion and hemodynamic parameters significantly increased achieved inspiratory volumes (29).

The significant improvement in chest expansion observed in the chest mobilisation group compared with the control group can be explained by the physiological and mechanical effects of chest wall mobilisation following upper abdominal surgery. This improvement may be attributed to chest mobilisation's ability to facilitate better synchronisation between rib cage and diaphragmatic movements, thereby promoting more effective inspiratory efforts. Additionally, mobilisation techniques may reduce postoperative pain and fear of movement, encouraging deeper breathing patterns and greater thoracic excursion.

The findings of the study supported the hypothesis that incentive spirometry and chest mobilisation exercises significantly improved postoperative oxygenation and chest expansion compared to standard care. The findings also supported the hypothesis that incentive

spirometry led to greater improvement in postoperative oxygenation and chest expansion than chest mobilisation exercises.
Clinical Implications: The results suggest that both incentive spirometry and chest mobilisation exercises can be safely integrated into routine postoperative care to improve oxygenation and chest expansion after upper abdominal surgery. Incentive spirometry showed greater benefits and may be prioritised, especially for high-risk patients. Implementing structured respiratory physiotherapy protocols and patient education may help reduce postoperative pulmonary complications and enhance recovery.
Strengths of the study: These include its randomised controlled design, multi-centre recruitment, objective outcome measures, and a direct comparison of two widely used postoperative respiratory interventions. These features enhance the validity and clinical relevance of the findings.

Conclusion

In summary, this study provides compelling evidence that the incentive spirometer and chest mobilization is an effective, non-pharmacological interventions for stabilising hemodynamic parameters and improving chest expansion in post-upper abdominal surgery patients. The significant differences observed between the interventional groups and the control group reinforce the physiological benefits of using an incentive spirometer and chest mobilisation in improving chest expansion.
Limitations of the Study: This study has several limitations. The follow-up period was short and limited to the early postoperative phase, preventing assessment of long-term outcomes. Blinding of participants was not possible due to the nature of the interventions, and outcome assessors may not have been fully blinded, which could introduce measurement bias. Potential confounding factors, such as pain levels, analgesic use, baseline pulmonary function, adherence to interventions, and variations in surgical and anaesthetic procedures, were not fully controlled for. Additionally, although conducted in multiple centres, the findings may have limited generalizability to other populations and healthcare settings, and larger multicentre studies are recommended.

List of Abbreviations

IS: Incentive Spirometry
PPCs: Postoperative Pulmonary Complications
SpO_2: Peripheral Oxygen Saturation
BMI: Body Mass Index
MAP: Mean Arterial Pressure
COPD: Chronic Obstructive Pulmonary Disease
ERAS: Enhanced Recovery After Surgery
IRB: Institutional Review Board
RCT: Randomised Controlled Trial
FIS: Flow-Oriented Incentive Spirometer
Cm: Centimetre
Cc: Cubic Centimetre
U: Mann–Whitney U Test Statistic
SD: Standard Deviation
N: Number of Participants

Declarations

Ethics Approval and Consent to Participate
Upon submission of the study protocol, ethical approval was sought and granted from the Institutional Review Board (IRB)-Scientific Committee of the Nursing Faculty, University of Baghdad. The reference number is 21 dated 27/2/2025. The researchers pledge to keep the details of the participants confidential, using the collected data without causing any actual or potential harm to the study subjects. The study tool was designed to preserve the subject's right to anonymity. Subjects were given the right to freely participate in the study by signing the consent form. Of equal importance, after getting the approval of the Council of Nursing College, University of Baghdad, for the study protocol, and before data collection, the researcher submitted a detailed description of the study, including problem statement, objectives, and questionnaire, to the Ministry of Planning (Central Statistical Organisation) and to the Medical City Directorate. The Rusafa Health Directorate (Human Development and Training Centre), to obtain official permission to carry out the study. Upon approval by the committees, the study was registered with the Clinical Trial Registry at register@clinicaltrials.gov (PRS NCT07109934). Date of registration: 6/8/2025

Consent for publication
All authors gave consent for publication of the work under the Creative Commons Attribution-Non-Commercial 4.0 license.

Data Availability
Available from the corresponding author upon reasonable request.

Competing Interests
The authors declare that they have no competing interests

Funding
The research is self-funded.

Author contributions
JMK: Conceptualisation, Software, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Visualisation, Project administration, and Funding acquisition.

MAM: Methodology, Validation, Writing - Review & Editing, and Supervision.

Acknowledgements
The authors are grateful to all participants involved in the study

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