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Role of Lung Recruitment Maneuvers in Elderly Post-operative Upper Abdominal Surgery

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ABSTRACT

Background: A significant catastrophic side effect of upper abdominal surgery is postoperative pulmonary complications (PPCs), which raise costs, morbidity, and mortality.
Objective: The aim of the present study is to assess how lung recruitment maneuvers (LRMs) affect both the ventilatory functions and frequency of PPCs in geriatric patients.
Patients and methods: A total of 80 geriatric patients from New Surgery Hospital in Zagazig University Hospitals for open upper abdomen surgery were recruited. The participants were randomly divided into two groups; 40 patients in the intervention group (preoperative LRMs training) and 40 patients in the control group (conventional perioperative care).
Results: When compared to the first postoperative day, the intervention group's forced expiratory volume in one second, forced vital capacity, and oxygen saturation were significantly improved throughout the ventilatory function tests ($p \leq 0.001$). Furthermore, the intervention group's reported lower PPCs incidence compared to the control group (15% vs. 30% on the 3rd postoperative day and 15% vs.37.5% on the 5th postoperative day, respectively).
Conclusion: By restoring the measured lung volumes, LRMs effectively improve the perioperative management of geriatric patients by preventing PPCs.
Keywords: Elderly, Lung recruitment maneuvers, Abdominal surgery, Pulmonary complications, Perioperative care.

INTRODUCTION

Upper abdominal surgery (UAS) is followed by a period of impaired respiratory muscle function and diminished physical capacity, both of which are linked to the emergence of postoperative pulmonary problems. These effects occur particularly in older patients due to the physiological changes brought on by ageing and the increased prevalence of comorbidities **(1).**

Patients' movement and respiratory mechanics are impacted by anaesthesia, the stress of surgery, and postoperative conditions (such incisions, drains, and catheters) **(2).**

The emergence of postoperative pulmonary complications following UAS are due to impaired diaphragmatic activity, atelectasis, early airway closure, impaired ventilation and perfusion matching, mucociliary dysfunction and an increase in bacterial colonization **(3).**

In worldwide, awareness of the value and necessity of lung recruitment maneuvers and physical rehabilitations for postoperative respiratory care has increased recently and has a favorable effect on the prognosis, quality of life, and ability to resume normal activities for patients **(4).**

By removing mucus from the airways, lowering the work of breathing, strengthening respiratory function, and increasing lung inflation, lung recruitment maneuvers tries to help postoperative patients regain voluntary breathing **(5).**

The effectiveness of these combined maneuvers in elderly patients following open major surgeries is still debatable **(4).**

Therefore, the aim of the present study was to evaluate the effect of lung recruitment maneuvers (LRMs) on ventilatory functions and length of hospital stay in postoperative UAS at geriatric patients.

PATIENTS AND METHODS

This experimental study included 80 elderly patients who admitted at inpatient Surgical Departments, the New Surgery Hospital in Zagazig University Hospitals within the period from May 2021 to December 2021.

Inclusion criteria:

The 80 patients aged 60 years or older who were undergoing open UAS, could communicate, had no cognitive impairment, no cerebrovascular illness, no decompensated cardiac issues, no postoperative peritonitis, and who agreed to participate in the study were included in this clinical trial.

Exclusion criteria:

Patients undergoing home oxygen therapy or those with a history of severe pulmonary illness were excluded from this research. Additionally, exclusion of those patients was done who met the criteria for the American Society of Anesthesiologists physical status (ASA PS) classification system with a score of four or above **(6).**

Sample size:

It was calculated according to the study of **Manzano *et al.*** **(7)** who reported that the mean oxygen saturation percentage before surgery was 96.4 (SD 1.9) versus 94.7 (SD 2.4) after surgery. At 80% power and a 95% level of confidence, using Open Epi software, the

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estimated sample size was 80. The enrolled patients who fulfilled inclusion criteria were randomly assigned in a 1:1 ratio to the intervention group (40 patients) or the control group (40 patients).

Preoperative LRMs in form of (1) prolonged maximal inspiration, (2) diaphragmatic breathing exercises, (3) costal expansion exercises, (4) pursed-lip breathing exercises, (5) coughing or puffing with splinting, and (6) early mobilization, were taught to the 40 elderly patients in the **Intervention** group. In the control group (40 elderly patients), conventional perioperative care was provided as usual without any instruction on these modalities.

Methods:

In the current study, Patients were subjected to the following:

1. The demographic and clinical characteristics of the patients in both groups. The demographic characteristics in geriatric patients of both groups were age, sex, residence, and level of education. While the clinical data involved the presence of comorbidities, postoperative prescribed medications, first postoperative ambulation, and postoperative clinical complications.
2. On the first, third, and fifth postoperative days (PODs), the assessment of LRMs among the patients in Intervention group were done by using practice observational checklist. LRMs were developed as the following: Prolonged maximal inspiration checklist by using flow-oriented incentive Spirometry (8 steps). Pursed-lip breathing (6 steps). Diaphragmatic (belly) breathing (6 steps). Costal expansion exercises (lateral, posterior and apical costal expansion) each one consisted of 5 steps. Coughing/ Huffing with splinting (5 steps), and early mobilization checklist (5 steps). Every step was evaluated accurately and scored one if done and scored zero if not done.

   For each maneuver in the practice checklist, the average scores of the steps were summed-up and the total was divided by the number of the steps. These were converted into percent scores for the three studied PODS (first, third, and fifth PODs). If the percentage score was 60% or higher, the practice was deemed adequate; if it was less than 60%, it was deemed inadequate.

   The patient's adherence was another factor that contributed to the intervention's success. A compliance rating record was used to evaluate the patient's compliance regarding to the frequency of doing every maneuver. The non-complied maneuvers received a score of zero, while the items complied with were scored one. The scores were added up for total compliance, which was then transformed into a percent score. If the percentage score was 60% or higher, the elderly patient was deemed compliant; if it was less than 60%, they were deemed non-compliant.
3. Ventilatory function tests by using (MiniSpir machine) the SpiroTube simply connects via a USB cable to laptop were done on the first, third, and fifth PODs in a standardized manner for all eligible elderly patients in the intervention and control groups. The following parameters have been recorded: forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), and FEV_1/ FVC ratio. Three consecutive measurements were done and the best value was accepted **[8].**
4. Peripheral arterial Oxygen saturation (SpO2) was measured by using a finger digital pulse oximetry device on the first, third, and fifth PODs for all elderly patients in both groups **[9].**
5. The Melbourne group scale version-2 was used as a diagnostic tool for detecting the incidence of pulmonary complications (atelectasis and pneumonia) on the first, third, and fifth PODs. This scale consisted of eight items that was classified into the two categories; (1) Clinical category (4 items) involve raising of body temperature >38ºC, SpO2 < 90% on room air on two consecutive days, yellow or green phlegm, and new abnormal breath sounds different to preoperative assessment. (2) Diagnostic category (4 items) include the patient's chest radiograph report of collapse or consolidation, unexplained WBCs count $>11x10^9$/L or prescription of an antibiotic specific for respiratory infection, infection report on sputum culture, and diagnosis of pneumonia or chest infection by a physician **[10].**

When 4 or more of the 8 clinical and diagnostic criteria listed above were present postoperatively, the diagnosis of postoperative pulmonary complications (PPCs) was considered to be made.

The fieldwork of the study included two stages detailed; (1) In the preoperative stage, the two groups were randomly assigned; (i) Patients in the intervention group received preoperative training, coaching, and prompting regarding LRMs along with perioperative standard hospital care. (ii) Patients in the control group received perioperative routine hospital care only without any training maneuvers. **(2)** In the postoperative stage, the effectiveness of the LRMs training program was evaluated by comparing the postoperative ventilatory functions, oxygenation and incidence of PPCs between the intervention and control group on the first, third, and fifth PODs.

Ethical consent:

The study was approved by the institutional review board of faculty of Nurse, Zagazig University (M.D. Zu. NuR/ 68/13/10/2020). Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of

the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data collected and encoded using Microsoft Excel software. Data were then imported into Statistical Package for Social Sciences (SPSS version 20.0) software for analysis. Qualitative variables were presented in the form of frequencies and percentages, quantitative variables were presented in the form of means and standard deviations. The normal distributed quantitative data were compared using Student's t-test and one-way analysis of variance test (ANOVA). In contrast, the non-parametric data were analyzed by using Mann-Whitney or Kruskal-Wallis tests. The Qualitative categorical variables were compared using Chi-square test. In order to assess the inter-relationships among quantitative variables and ranked ones, Spearman rank correlation was used. Partial correlation analysis was used to modify for the time and group effects. Moreover, to recognize the independent predictors of patients' tests' results and scores, multiple linear regression analysis was used. Statistical significance was considered at p-value $\leq$0.05.

RESULTS

Table 1 showed that the mean age of elderly patients in the intervention and control groups were 64.3 (SD 5.3) and 63.1 (SD 3.3) years, respectively. Moreover, about half of patients in intervention and control groups were males. Also, majority of them in both groups lived in rural areas. Regarding the education level and comorbidity, about half of patients were educated and majority of them were suffering of comorbid diseases.

Table (1): The demographic and clinical characteristics of elderly patients in both intervention group and control group.

Variable	Intervention group (N=40)		Control group (N=40)		X^2 test	P-value
	No.	%	No.	%		
Age: (years)						
60- <65	**24**	**60**	**26**	**65**		
≥65	**16**	**40**	**14**	**34**	**0.21**	**0.64**
Mean ± SD	**64.3 ± 5.3**		**63.1 ± 3.3**		**t=1.21**	**0.23**
Sex:						
Male	**20**	**50**	**22**	**55**		
Female	**20**	**50**	**18**	**45**	**0.201**	**0.65**
Residence:						
Rural	**28**	**70**	**27**	**67.5**		
Urban	**12**	**30**	**13**	**32.5**	**0.058**	**0.80**
Educational level:						
Uneducated	**19**	**47.5**	**21**	**52.5**		
Educated	**21**	**52.5**	**19**	**47.5**	**0.20**	**0.65**
Comorbid diseases:						
No	**16**	**40**	**15**	**37.5**	**0.053**	**0.81**
Yes	**24**	**60**	**25**	**62.5**		

No; number, **χ^2,** Chi-squared test

Table 2 revealed that occurrence of post-operative complications were significantly higher among patients in control group compared to intervention group (62.5% and 40%, respectively). Moreover, the duration of hospital stay among patients in intervention group was highly significant shorter compared to the patients in control group. Also, the post-operative ambulation among patients in intervention group was significantly shorter than that in control group with 70% of the elderly in the intervention group were ambulated on the first day after surgery.

Table (2): postoperative complications, ICU admission, length of hospital stay and postoperative ambulation among studied groups.

Variable	Intervention group (N=40)		Control group (N=40)		X^2 test	P-value
	No.	%	No.	%		
Postoperative complications:						
No	24	60	15	37.5	4.05	0.04*
Yes	16	40	25	62.5		
Wound infection	4	25	5	20	7.42	0.28
Blood collection	2	12.5	0	0		
Respiratory complications	5	31.1	14	56		
Wound hernia	2	12.5	2	8		
UTI	2	12.5	1	4		
Respiratory and Wound	1	6.3	3	12		
ICU admission:						
No	20	50	23	57.5	0.45	0.50
Yes	20	50	17	42.5		
ICU hours:						
<24 hr	8	40	5	29.4	0.45	0.50
≥24 hr	12	60	12	70.6		
Mean ± SD	18.2 ± 7.7		20.0 ± 7.7		t=0.72	0.47
Post-operative days:						
<8	29	72.5	16	40	8.584	0.003*
≥8	11	27.5	24	60		
Length of hospital stay (days)						
<8	6	15	3	7.5		
≥8	34	85	37	92.5	1.13	0.28
Mean ± SD	9.4 ± 2.0		11.9 ± 4.0		t=3.51	<0.001*
Day of 1st postoperative ambulation:						
1	28	70	16	40	7.27	0.007*
≥2	12	30	24	60		
Mean ± SD	1.4 ± 0.6		1.7 ± 0.7		t=2.09	0.04*

ICU; Intensive Care Unit, UTI; Urinary tract infection, No; number, t; student t test., **χ^2;** Chi-squared test * significant

Table 3 demonstrated that the breathing rate is significantly declined among patients in the intervention group **(P=0.025)**, while there was no significant difference in the control group. Moreover, the FEV1 and FVC in the the intervention group were improved significantly throughout the studied days **(P≤0.001)**. As regard arterial oxygen saturation (SPO2), there was high significant increase in Spo2 among the intervention group on the third and fifth postoperative days **(P<0.001)**. In contrast, there was a sharp drop on Spo2 among patients in control group during the third postoperative day, which tended to increase on the fifth postoperative day with no statistically significant difference **(P=0.833)**.

Table (3): The effect of lung recruitment maneuvers on measured respiratory parameters for intervention group compared to control group throughout the postoperative studied days.

Respiratory parameters	Intervention group (N=40)			P-value	Control group (N=40)			P-value
	1st POD	3rd POD	5th POD		1st POD	3rd POD	5th POD	
Respiratory rate	22.2±4	20.9±3.6	19.8±3.7	0.025*	21.9±2.9	22.5±4.2	22.4±4.6	0.74
FEV_1 (Liter)	0.8±0.2	1.1±0.3	1.4±0.3	<0.001*	0.8±0.2	0.86±0.2	0.94±0.2	0.49
FVC(Liter)	1.2±0.2	1.5±0.3	1.8±0.3	<0.001*	1.18±0.2	1.18±0.2	1.24±0.2	0.79
FEV_1/ FVC (%)	91.6±20.8	93.9±16.9	96.3±18.9	0.54	91±21.1	92.1±20.5	93±22.2	0.91
Oxygen saturation (SPO_2)	92.3±3.08	93.9±2.3	94.98±2.9	<0.001*	92.1±3.2	82.2±2.9	92.5±3.1	0.83

POD; postoperative day, FEV_1; Forced expiratory volume in 1 sec, FVC; Forced vital capacity, SPO_2; Arterial oxygen saturation & (*) Statistically significant at p<0.05.

Figure 1 showed that the incidence of PPCs among the patients in the intervention group was lower than in control group with constant percent on the third and fifth postoperative day. Conversely, there is progressive increase of PPCs among the patients in control group on the third and fifth day after surgery (30% and 37.5%, respectively).

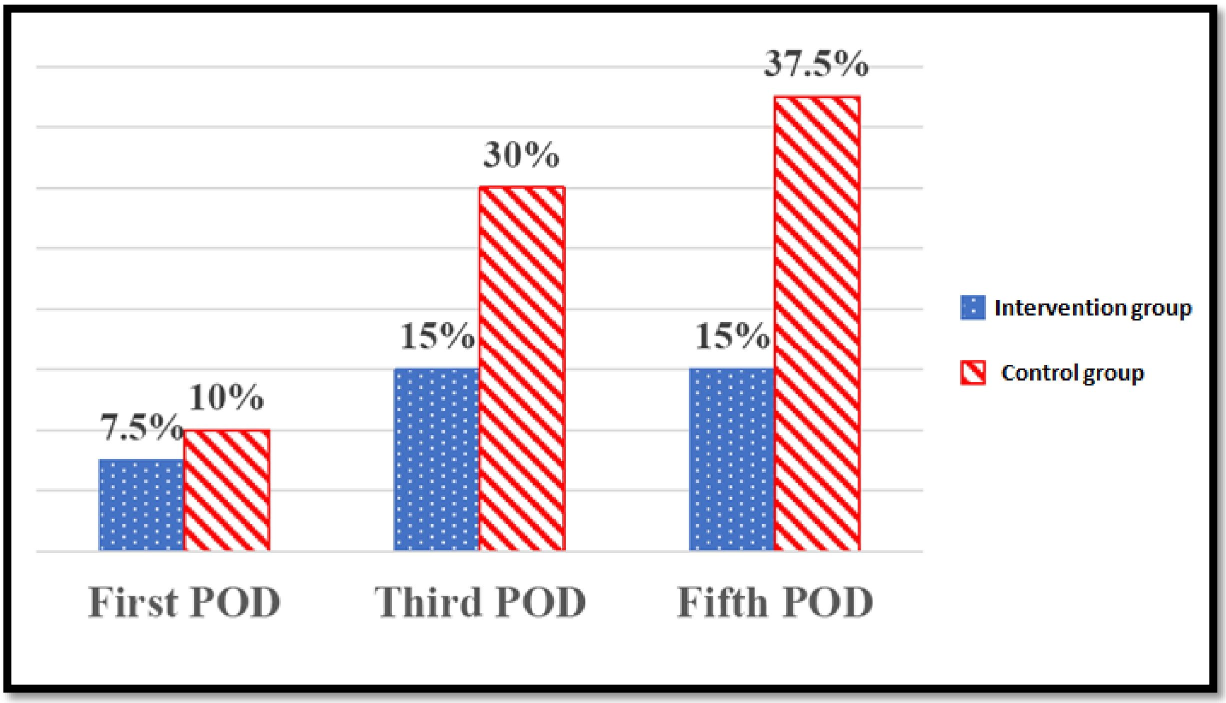

Figure (1): The incidence of postoperative pulmonary complications among studied patients in both groups (Melbourne) throughout the postoperative studied days.

Figure 2 Portrayed that the total practice score of LRM among elderly patients in the intervention group during the first five postoperative days were (70%, 85%, and 87.5%) respectively. Specifically, the percent of patients who performed these maneuvers adequate were increased by (17.5%) from first to fifth postoperative day.

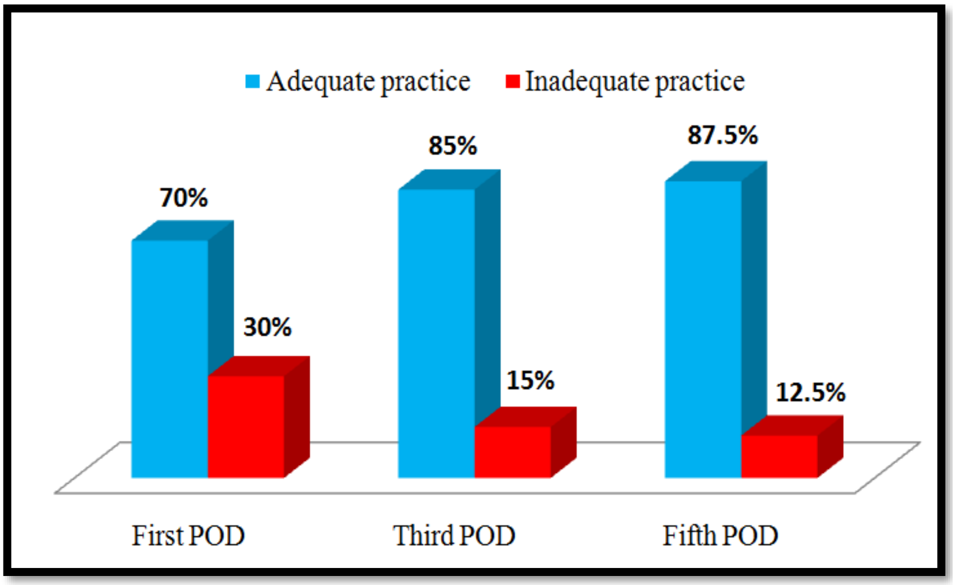

Figure (2): Total practice Lung recruitment maneuvers scores among elderly patients in the intervention group during the studied postoperative days (N= 40)

Figure 3 illustrated that the patients in intervention group who were complaint to the maneuvers adequately during the three studied postoperative days were (87.5%, 92.5%, and 95.0%, respectively).

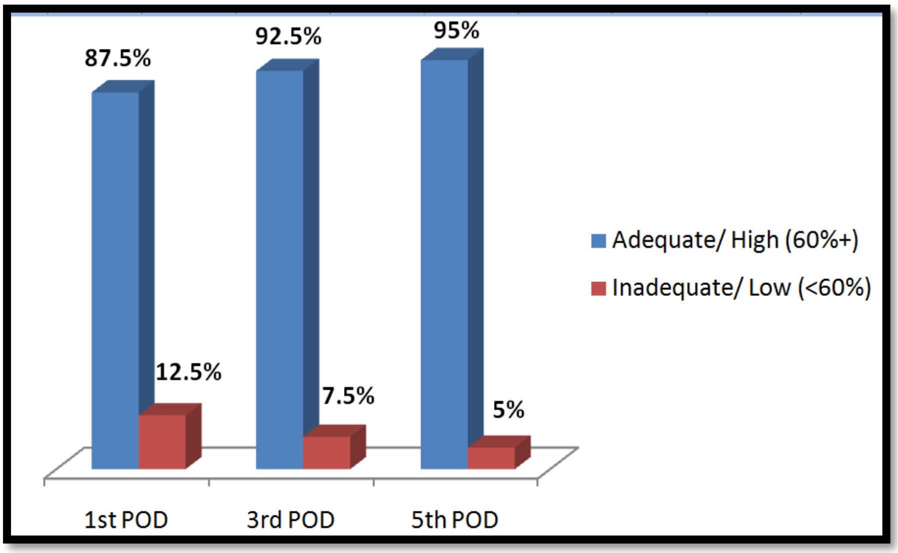

Figure (3): Total compliance of Lung recruitment maneuvers scores among elderly patients in the intervention group during the studied postoperative days (N= 40)

Table 4 revealed that there was a statistical significant positive correlation between elderly practice level and each of FEV_1, and FVC and SpO2%. Furthermore, there was a statistical significant positive correlation between elderly compliance to recruitment maneuvers and their respiratory parameters (FEV_1, FVC and SpO2%). On the other hand, there was a negative statistical significant correlation between patient practice and compliance scores with the incidence of PPCs (Melbourne score) and respiratory rate.

Table (4): Correlations between the practise and compliance scores in patients of intervention group regarding to their respiratory parameters and Melbourne score.

Parameters	Practice score		Compliance score	
	r	P-value	r	P-value
Respiratory rate	-0.213	0.020*	-0.666	<0.000*
FEV_1 (Liter)	0.206	0.024*	0.485	<0.001*
FVC(Liter)	0.217	0.018*	0.440	<0.001*
FEV_1/ FVC(%)	0.032	0.729	0.014	0.880
Oxygen saturation (SPO_2)	0.240	0.009*	0.471	<0.001*
Melbourne score	-0.370	<0.001*	-0.669	<0.001*

FEV_1; Forced expiratory volume in 1 sec, FVC; Forced vital capacity, SPO_2; Arterial oxygen saturation (*) Statistically significant at $p \leq 0.05$

Table 5 showed that time (postoperative days) and intervention maneuvers were statistically significant independent positive predictors of FEV_1 value (P<0.001). Conversely, chronic diseases and ambulation days were statistically significant independent negative predictors of FEV_1 value (P<0.001). The model explains 27% of the variation in this score, as the value of r-square indicates.

Table (5): Best fitting multiple linear regression model for FEV_1 among studied patients in the intervention group.

Items	Unstandardized Coefficients		Standardized Coefficients	P-value	95% Confidence Interval for B	
	B	Std. Error			Lower	Upper
Constant	1.51	0.14		<0.001	1.24	1.77
Time(postoperative days)	0.21	0.05	0.25	<0.001	0.12	0.31
Intervention	0.19	0.05	0.24	<0.001	0.10	0.29
Female gender	-0.16	0.05	-0.19	0.001	-0.25	-0.07
Chronic diseases	-0.17	0.05	-0.21	<0.001	-0.27	-0.08
Ambulation days	-0.15	0.04	-0.24	<0.001	-0.22	-0.08

r-square = 0.27, Model ANOVA: F=18.93, p<0.001.

Table 6 indicated that the length of hospital stay and ambulation days were statistically significant independent negative predictors of oxygen saturation **(P<0.001)**. The model explains 25% of the variations in the SPO_2 percent.

Table (6): Best fitting multiple linear regression model for SpO_2 among studied patients in the intervention group.

Items	Unstandardized Coefficients		Standardized Coefficients	P-value	95% Confidence Interval for B	
	B	Std. Error			Lower	Upper
Constant	**95.72**	**0.85**		**<0.001**	**94.03**	**97.40**
Time (postoperative days)	**1.18**	**0.37**	**0.18**	**0.002**	**0.45**	**1.90**
LOS	**-0.27**	**0.06**	**-0.30**	**<0.001**	**-0.39**	**-0.16**
Ambulation days	**-1.17**	**0.30**	**-0.25**	**<0.001**	**-1.77**	**-0.58**

LOS; length of hospital stay, r-square=0.25 Model ANOVA: F=26.60, P<0.001.

DISCUSSION

Undoubtedly, as the geriatric population expands, so will the number of older persons who are referred for surgical procedures increase. Age-related structural and functional impairments, comorbidities, and increased vulnerability in this population have made aged patients' anaesthesia a serious concern [11].

Numerous age-related changes occur gradually in the respiratory system, reducing the function and reserve with time. Mechanically, the intercostal muscles weaken, the diaphragm flattens, and the chest wall stiffens, all of which diminish the inspiratory capacity. These modifications raise the possibility of pulmonary exhaustion in elderly individuals, particularly when paired with ongoing opioid usage and neuromuscular inhibition [12].

Upper abdominal surgery unquestionably impairs pulmonary function, which, through a variety of processes, contributes to PPCs. Shallow breathing, malfunction of the diaphragm, extended recumbent positioning; decreased mucociliary function, inefficient coughing, and retention of secretions are the main causes of PPCs [2].

The most frequent significant problems following surgery are pulmonary complications in nature. According to reports, it affects 2 to 40% of surgical patients, with the incidence following UAS being the greatest at 12.2% [13].

PPCs increase morbidity, lengthen hospital stays, and cause early mortality, all of which have a detrimental effect on postoperative recovery [14]. Contrarily, preoperative instruction in lung recruitment exercises gets elderly patients mentally and physically ready for the next procedure. The intention is for the elderly to demonstrate how to conduct the exercises while understanding their purpose in the postoperative period [15].

Therefore, the current study's objectives were to assess how geriatric patients' ventilatory functions and the likelihood of problems following upper abdomen surgery were affected by these recruitment maneuvers.

In the present study there was no significant differences between both studied groups regarding to the demographic characteristics of studied geriatric patients, which is similar to a previous study by **Jalil *et al.*** [16] in Jordan. The absence of selection bias between the intervention and control groups as a result of random allocation may account for these findings.

Regarding to the age of the studied patients (Table 1), it was in concordance to **Deepak *et al.*** [17] **and Sorour *et al.*** [18] results that revealed nearly two thirds of elderly patients in the intervention and control groups were young old (60- <65 years). The fact that elderly patients over 65 are considered a high-risk group may be the cause for this result. Therefore, a conservative strategy is favored over a surgical one for older individuals who are at high risk. In addition, due to the high risk of postoperative complications, elective abdominal procedures may be postponed.

Less than half (40%) of the intervention group and less than two thirds (62.5%) of the control group, in this study had various postoperative problems with a significant difference between them (Table 2). The likelihood of serious postoperative complications may be increased by advanced age, which is typically accompanied by significant comorbidity and a decreased functional reserve. In the same stream, **Simões *et al.*** [3] study revealed that 34.4% of studied patients developed major complications during the postoperative period. In agreement with the current research, **Pang *et al.*** [19] and **Barakat *et al.*** [20] reported that the exercise group had significantly lower postoperative complications compared to the control group. Such finding might be due to the period of preoperative supervised exercise training.

The reason for the highly significant shorter duration of hospital stay in intervention group compared to the patients in control group (9.4±2.0 and 11.9±4.0, respectively) in this study (Table 2) may be attributable to the improvement of postoperative pulmonary functioning and lower incidence of respiratory problems. In the same context, **Kabir *et al.*** [21] concluded that the mean length of hospital stay in the experimental group was 7.90 (SD 2.078) days and 11.50 (SD 3.75) in the control group, proving that early mobilization and breathing exercises together greatly shortened the length of hospital stay following abdominal operations.

The preoperative counseling along with training can foster early mobilization among elderly patients undergoing abdominal surgery, which explain the significant results between both groups in the present study regarding to first postoperative ambulation (Table 2). This result is consistent with **Samnani *et al.*** [22]**,** which found that preoperative counselling and staff assistance from healthcare providers increase adherence to early mobilization.

The geriatric patients in the intervention group show statistically significant improvement in FEV1 and FVC compared to the control group (Table 3). The elderly patients in intervention group may have had better pulmonary functions because they were closely watched by their caregivers and monitored by the researcher for the first five postoperative days. This may have been the main factor in increasing pulmonary volumes by maintaining the accuracy of modality application as well as the patient's interest in and compliance with the lung recruitment programme. In agreement with the current study, there are many previous studies confirmed that improvement in pulmonary function (FVC and FEV1) showed statistically significant differences between the exercise group as compared to the control group [23, 24, 25]**.**

In current study, the elderly patients in intervention group had significantly improved oxygen saturation compared to the control group, that in concordance with the results of **Gbiri *et al.*** [26]**, Devecel *et al.*** [27] and **Svensson-Raskh *et al.*** [28]. High saturation results could be seen as yet another benefit and a sign of the success of preoperative instruction. Additionally, the older patients' adherence to the LRM showed promise for enhancing pulmonary function, expanding lung capacity, and subsequently improving oxygenation.

The incidence of PPCs among the patients in the intervention group was lower than in control group (Figure 1). This finding is consistent with **Abd-Elal *et al.*** [25] and **Sum *et al.*** [29]**,** who revealed that more than half developed pulmonary complications, which were more prevalent in the control group. This outcome might be attributed to the planned program's early implementation in the preoperative stage. The researcher also monitored geriatric patients postoperatively to support them, confirm their good performance, and verify their adherence to the lung expansion techniques that were taught to them.

A statistical significant positive correlation between elderly practice and compliance to LRMs and ventilatory functions and SpO2% in the present study (Table 4) was in agreement with many previous studies [4,26,30]. On the other hand, a negative statistical significant correlation between patient practice and compliance scores with the incidence of PPCs (Melbourne score) and respiratory rate was in concordance with the result of **Kaur *et al.*** [31]. Such a finding may be attributable to the fact that post-operative pulmonary complications, such as atelectasis, pneumonia, or pulmonary dysfunction, continue to be the main factor in patients' outcomes getting worse during their hospital stay or after discharge, which in turn leads to post-operative morbidity and mortality.

The present study reveals some predictors affecting respiratory parameters. Precisely, the intervention of lung recruitment maneuvers predicts higher values of FEV_1.Moreever, The presence of multiple chronic diseases and late postoperative mobilization, on the other hand, predict lower FEV_1 values (Table 5). Furthermore, longer hospitalization and late postoperative mobilization predict lower oxygen saturation percentage (Table 6). This finding might be due to the significant role of these breathing and coughing exercises, besides early mobilization postoperatively in enhancing chest clearance, increasing lung volumes and improving the oxygenations.

Finally, the study's findings, which showed a significant difference between intervention group patients and those in the control group on the first, third, and fifth days after upper abdominal surgery, validated the hypothesis. The small study sample and short-term postoperative follow-up were considered limitations of this research.

In conclusion, the application of various lung recruitment techniques proved to be effective in improving ventilatory functions for elderly patients, which further decreased the incidence of pulmonary complications post-upper abdominal surgery.

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