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Original Article

Effect of deep breathing exercise on oxygenation of patients under major abdominal surgery: randomized clinical trial

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Abstract

Introduction: The number of major abdominal surgical procedures is increasing around the world. A large number of the patients complain about postoperative pulmonary complications (PPCs) after abdominal surgery and show symptoms of breathing pattern disorder. Therefore, this study aimed to investigate the effect of deep breathing exercise on the oxygenation of patients undergoing major abdominal surgery.

Methods: This single-blind randomized clinical trial was conducted on 40 patients who needed major abdominal surgery in Qom, Iran, in 2014. The participants were divided into two equal experimental (n=20) and control (n=20) groups. The cases in both groups received routine care, however, those in the experimental group exercised repeated deep breathing four times per hour for two consecutive hours after the surgery as well. The condition of the patients in both groups was similar in terms of position, mobility, and oxygen therapy. The patient's oxygen saturation, respiratory rate (RR), heart rate, and the severity of pain in the surgery site were measured. The collected data were analyzed in SPSS software (Version. 18) using paired t-test, independent t-test, Mann-Whitney U test, Wilcoxon rank-sum test, Multiple regression analyses, Chi-square test, and Fischer's exact test. A p-value less than 0.05 were considered statistically significant.

Results: Based on the study findings, the deep breathing exercise significantly reduced the surgery site pain and mean blood pressure and increased O2 saturation in the experimental group after the intervention ($P<0.05$). Moreover, there was a statistically significant difference between the experimental and control groups, and a significantly higher O2 saturation was observed in the experimental group after deep breathing exercise post-operation ($\beta=2.01$, $P<0.001$).

Conclusion: Deep breathing exercise can reduce the severity of pain in the surgery site and mean arterial blood pressure and increase O2 saturation in patients after major abdominal surgery.

Key words: Breathing Exercise, Oxygen, Surgery

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Introduction

Millions of people around the world should tolerate major surgical procedures every year. Despite advances in anesthesia and surgical care, postoperative pulmonary complications (PPCs) are still a significant problem in modern practice. Moreover, PPCs increase morbidity and mortality following major upper abdominal surgery and contribute to the prolonged hospital stay and additional health costs (1-7). The risk of PPCs among patients who tolerate upper abdominal surgery is too high (about 17-88%). Upper abdominal surgery has a negative effect on lung volume, causes difficulty in coughing for as long as one week, and reduces arterial oxygen and oxygen-hemoglobin saturation by changing the lung function (8-9). It seems that post-surgery pulmonary complications are related to lung muscle dysfunction. The complications start with anesthesia induction and continue even after the surgery (10). Surgical procedures may affect the respiratory muscles by causing a change in a number of pathophysiological mechanisms, such as the phrenic nerve, thoracoabdominal mechanism (reduction of rib cage compliance), reflexes mechanisms (inhibition of phrenic nerve), the ratio of muscle length to its power (change of functional residual capacity), the aeromechanical coupling, and reduction of muscles integration (11-12).In addition, respiratory muscle dysfunction caused by the surgery may reduce vital capacity, tidal volume, total lung capacity, cough efficiency. Subsequently, the respiratory muscle dysfunction causes atelectasis in the main parts of the lung, reduces residual vital capacity, and eventually affects the exchange of respiratory gases by increasing the ventilation/perfusion ratio. These conditions may deteriorate with hypoventilation caused by different factors, such as sedatives, pain (related to surgery), and the increase of mechanical load (13-14). Several studies showed the importance of chest physiotherapy, including deep breathing exercise, in the improvement of lung function, as well as prevention and treatment of lung complications and diseases. Deep breathing exercise hyperventilates the alveolus and prevents their collapse, keeps the respiratory tubes open, helps the expelling of anesthesia gases and accumulated sputum, and facilitates oxygenation. It stimulates the cough reflex and expelling of sputum (15-17), decreases atelectasis, increases oxygenation, and facilitates the movement of sputum to the main airways (18-20). It should be mentioned that such factors as high prevalence of respiratory complications in patients after surgery, the potential effectiveness of respiratory exercise in the improvement of oxygenation, appropriate lung ventilation, reduction of respiratory distress, and prevention of lung pulmonary complications, as well as the lack of similar studies in Iran motivated the authors to investigate hemodynamics and respiratory effect of deep breathing exercise on oxygenation in patients after major abdominal surgery.

Materials and Methods

This study was conducted as a single-blind randomized clinical trial after the study protocol was approved by the Ethical Committee of Qom University of Medical Sciences (12050.34), Qom, Iran, and written consent was obtained from the participants in 2014. The study was registered at the Clinical Trial Center of Iran (IRCT.201011012560N5). The participants in this study included 40 patients admitted in surgical wards of Shahid Beheshti Hospital, Tehran, Iran, for elective major abdominal surgeries including cholecystectomy and laparotomy (non-laparoscopic digestive surgeries), kidney, urethral and gynecologic surgeries. The inclusion criteria included admission for elective major abdominal surgery, the state of consciousness for patients, the lack of respiratory and cardiovascular system problem, the ability to do deep breathing exercise, having SPO2>90%, no history of previous surgery, the lack of allergic reaction to latex gloves and general anesthesia, having American society of anesthesiologists I and II, and no history of pulmonary medicine usage. However, patients with a history of renal dysfunction and metabolic disorders (Hyperbilirubinemia, anemia), unstable angina (reduction of blood pressure by 15 mm Hg after a postural change, heart rate over 130 beats per min), liver transplantation, aneurysm surgery, those with severe bleeding after surgery who may need reoperation or administration to ICU or CCU wards, those with hypothermia (T<340), hyperthermia (T≥380), respiratory aspiration, cigarette consumption during the study, and the patients who did not cooperate were excluded from the study. A trained nurse was used as a questioner in this study. A minimum sample of 18 patients per group was required based on the formula through which α=0.05, β=0.80, the standard deviation in the intervention group (SD1) =2.4, the standard deviation in the control group (SD2) =1.9, and minimal clinical difference=2 (21). However, considering the attrition rate, 20 patients were included in each group. Data collection and the selection of study population technique were performed using simple random sampling technique over a three months period. The informed consent was obtained from the participants after providing them with enough information about the trial and randomization procedure. The patients were randomly allocated into two groups of experimental (n=20) and control (n=20), using a randomized block design. The patients of each group were hospitalized in separate wards to conceal the allocation and prevent communication between the two groups. The deep breathing exercise was practically educated to the patients in the experimental group the day before the surgery, and they were requested to repeat the exercise several times to make sure that they have understood it completely (Figure 1).

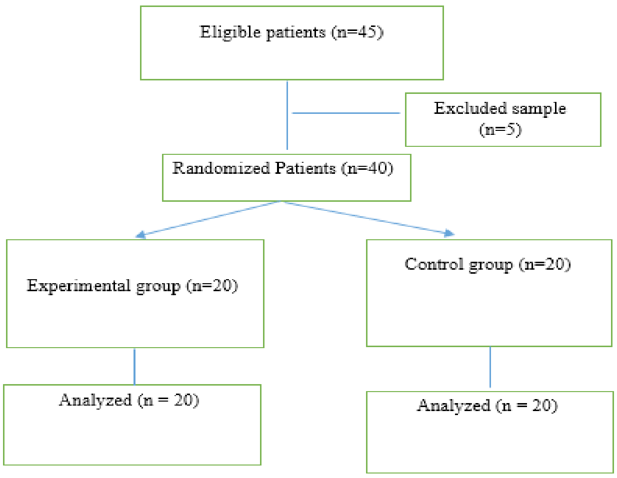

Figure 1: Flow diagram of patient recruitment and data collection during the study

Intervention in the experimental group included the breathing exercise 2 hr following the surgery when the patients were fully conscious. The patients were encouraged to respire deeply and gently, keep it for 3 sec and exhale gently via the mouth, in a semi-sitting position. During the expiration, the patients were asked to cough two times efficiently (patients were educated to keep a pillow in the area of incision when they were coughing). The questioner encouraged the patients to taken 10 deep breaths and to perform motivational spirometry for 2 min using latex gloves without powder afterward. This circle was repeated four times and each time it was practiced for two consecutive hours. After and before eight sessions of deep breathing exercises, the hemodynamic symptoms were measured which included heart rate and blood pressure, respiratory parameters, such as RR and Oxygen saturation (SpO2), and the severity of pain in the surgery site. No nurse was involved in the breathing exercise in this study. It should be mentioned that the control group did not receive deep breathing intervention and only received routine care. The same questioner measured the respiratory symptoms, the severity of surgery site pain, and hemodynamic symptoms before and 2 hr after the intervention.

The patients' arrangement, mobility, position, oxygen intake, and measurement devices were the same. The blood pressure was measured according to The Seventh Report of the Joint National Committee on Prevention Detection, Evaluation, and Treatment of High Blood Pressure instruction using a mercurial manometer and stethoscope in a semi-sitting position after resting for 3 min. Mercurial manometer and Richter stethoscope were prepared after consultation with medical experts and their stability was confirmed after retesting with another standard device and calculation of Pierson stability factor of these two measurements(rdiastol =0.90,rsystol=0.93). A newly calibrated Abadis BC pulse oximeter was utilized in this study. All of the interfering factors in the correct function of SPO2 measurement, including the right position of the sensor, the same finger in all patients, non-visible anomaly in the nail bed, uncovered nail bed, and indirect radiation to the sensor was under control. All data were collected and analyzed using SPSS software (Version 18). Univariate and multiple analyses of two group's variables were conducted. Categorical data were presented as numbers and percentages and were compared using the Chi-square test or Fischer exact test. In addition, continuous data were introduced as a Mean±SD and were compared using a t-test. Moreover, paired t-test, as well as Wilcoxon rank-sum test along with Mann-Whitney U test, was utilized to compare normally distributed variables and nonparametric data, respectively. Multiple regression analyses were performed using the generalized linear models (GLM). A p-value less than (0.05) were considered statistically significant.

Results

The mean (Age±SD) of the participants (n=40) was estimated at 55.60±15.1 years and 60% of the participants were female. Before intervention two groups had no significant difference in terms of demographic characteristics, intermediary factors in oxygenation, the severity of pain in the surgery site, heart rate, mean blood pressure, and SPO2 (Table1). The (mean±SD) of pain severity in the surgery site was estimated at1.45±0.55 (1-3%) before intervention; therefore, no analgesia was used. The preoperative SPO2 showed no significant difference between the two groups.

A significant increase in SPO2 was observed post-operation up to 96.45±1.32 in the experimental (deep breathing exercise) group, compared to that in the control group (94.45±1.57; P=0.001, Table 2). Furthermore, a significant decrease was observed in the severity of surgery-site pain down to 1.20±0.41 in the experimental group, compared to that in the control group (1.85±0.88, P=0.005, Table 2). The paired t-test results revealed that deep breathing exercise could reduce mean blood pressure in the experimental group (Table2).

Table 1. Baseline clinical, biochemical, and procedural characteristics of the study patients

Variable	Experimental Group Mean± SD	Control GROUP Mean± SD	P-Value
Age (years) *, #	56.10±13.55	55.70±15.82	0.930
Length of hospitalization (day)	1.80±1.58	2.10±1.89	0.680
Length of anesthesia (min)	123.50±54.56	128.25±50.61	0.780
Hb (%)	12.77±1.19	13.18±1.50	0.340
BMI(kg/m2)	26.07±3.99	26.19±4.40	0.920
Number of cigarette consumption	10.75±6.99	18.33±2.88	0.140
Length of cigarette consumption (year)	27.75±15.28	26.67±13.01	0.920
Temperature before intervention	36.99±0.42	36.98±0.30	0.880
Severity pain site-surgery	1.55±0.61	1.35±0.49	0.170
HR (bpm)	89.35±14.29	92.50±13.32	0.450
Respiratory Rate (breaths/min)	20.00±3.52	20.90±3.14	0.400
MAP (mm Hg)	97.50±10.66	95.00±11.76	0.480
Spo2 (%)	93.35±1.69	94.20±1.74	0.120
Gender (Female) N (%) +, $	13(65)	11(55)	0.750
Uneducated	11(55)	10(50)	<0.999
Hypertension	2(10)	6(30)	0.240
Diabetes mellitus	5(25)	6(30)	<0.999
Cholecystectomy	16(80)	10(50)	0.090
Laparotomy	4(20)	10(50)	0.090
Cigarette consumption	4(20)	3(15)	<0.999

*: Mean±SD for Continues variables
#: T- test
+: Number and Percent for categorical variables
$: χ^2 test
Hb: Hemoglobin; BMI: Body Mass Index; HR: heart rate; bpm: beats per minute; MAP: mean arterial pressure; SpO2: Oxygen saturation.
P-value was statistically significant at p≤0.05.

Hemodynamic and respiratory parameters measured after deep breathing exercise in two groups are presented in (Table 3). In this comparison, a significant difference was found between the patients' SPO2 in the experimental and control groups, up to 96.45±1.32 and 94.45±1.57, respectively (Table 2).

Other hemodynamic and respiratory parameters were not significantly different. A significant difference was observed post-operative between the experimental and control groups in terms of O2 saturation after deep breathing exercise. Therefore, there was a significantly higher O2 saturation following deep breathing exercise in the experimental group (β=2.01; P<0.001; Table 3).

Table 2. Hemodynamic and respiratory parameters before and after DBE in two groups of patients

Variable	Groups	Mean±SD		P-Value
		BDBE	ADBE	
The severity of pain in the surgery site	Experimental	1.55±0.61	1.30±0.47	0.008*
	Control	1.35±0.49	1.75±0.91	0.010
	P-value	0.070	0.060	0.060♦
RR (breaths/min)	Experimental	20.00±3.52	18.05±2.72	0.001+
	Control	20.90±3.14	19.35±2.89	0.004
	P-value	0.11	0.14	0.150♦
HR (bpm)	Experimental	89.35±14.29	86.50±16.59	0.110
	Control	92.50±13.32	89.85±10.61	0.070
	P-value	0.44	0.46	0.450♦
MAP (mm Hg)	Experimental	97.50±10.66	93.42±9.15	0.049+
	Control	95.00±11.76	95.92±9.44	0.590
	P-value	0.400	0.41	0.400♦
SpO2 (%)	Experimental	93.35±1.69	96.45±1.32	0.001+
	Control	93.35±1.69	94.45±1.57	0.290
	P-value	0.001	0.001	<0.001 ■

BDBE: Before deep breathing exercises; ADBE: After deep breathing exercises; HR: Heart rate; bpm: Beats per minute; MAP: Mean arterial pressure; SpO2:Oxygen saturation; RR: Respiratory rate. P-value is statistically significant.
* Wilcoxon rank-sum test
+ Paired t-test
♦ Mann-Whitney U test
■ t-Test

Table 3. Changes in O2 saturation following deep breathing exercise, monitored by generalized linear models

Variable	β	SE	P-value	95% Confidence Interval	
				Lower Bound	Upper Bound
(Constant)	93.93	1.12	<0.001	91.67	96.19
Experimental vs. Control	2.01	0.45	<0.001	1.104	2.92
Age	-0.03	0.02	0.090	-0.06	0.005

Discussion

The respiratory complication is the major cause of mortality after upper abdominal surgery which prolongs hospitalization and increases medical care costs. The reported risk rate of PPCs in upper abdominal surgery is estimated at 17%-88% (2-4-6-7-22). Respiratory muscle dysfunction is related to respiratory complications after the surgery, since it may cause atelectasis in the basal lung segments and reduce functional residual capacity by the defective cough and reduction of vital capacity, tidal volume, and total lung capacity (2-23). In addition, during anesthesia, the microatelectasis was formed in the lung and developed by shallow breathing and reduction of sputum clearance due to drowsiness. These changes occur even in the presence of good analgesia due to temporary dysfunction of the diaphragm following the application of anesthesia (24-26).

General anesthesia in the supine position during the surgery caused a high volume exchange between the chest and peritonea. These high volume exchanges affected the diaphragm curvature by moving it up from its natural resting position which decreases the diaphragm's efficiency as a pressure generator, as reflected by a decrease in FRC from 200 to 300 ml (27).

In order to maintain the minute ventilation volume, the patients must increase the RR, since it is easier to increase the RR than to increase the minute volume. Therefore, deep breathing exercise improves the ventilation capacity and reverses postoperative hypoxemia which in turn results in the reduction of respiratory complications after surgery (8-15-28).

Deep breathing exercise improves pulmonary compliance, alveolar ventilation, oxygenation, and respiratory effort by relaxation through increasing chest movement and surfactant secretion and expelling of sputum. In the present study, there was a significantly higher O2 saturation after deep breathing exercise in the experimental group. Lederer et al., also reported that regular and hourly deep breathing exercise is more efficient than special tools (29-30).

The studies conducted by Vesterdahi, Shaban, Jonk, and others revealed that deep breathing exercise reduced atelectasis, improved oxygenation in a patient undergoing major brain and heart surgeries (31-34).

The results obtained in this study were in line with those of the aforementioned studies and revealed that deep breathing exercises are effective in the reduction of surgery-site pain and mean blood pressure and the increase of SPO2. Some studies have not approved the effect of deep breathing exercise on the significant reduction of surgery-site pain. A randomized clinical trial conducted in São Paulo, Brazil, regarding the effect of chest physiotherapy on patients undergoing upper abdominal surgery, demonstrated that no difference was observed in the measured pain during, before, and after the intervention in two experimental and control groups (13). In the present study, deep breathing exercise improved respiration rate, and the patients in the experimental group experienced a significant pain reduction. The results of some previous studies are consistent with these results. The findings of a study performed by Tripathi et al., in India in 2017, revealed that unlike the control group, the patients in the intervention group experienced a significantly decreased respiratory rate (20-35-36).

Furthermore, the findings of this study showed that simple and short procedures, such as deep breathing exercises can be an effective nursing intervention for the reduction of pain in the surgery site and the improvement of respiratory parameters that have no interference with cardiovascular parameters, such as heart rate and blood pressure. Regarding the limitation of this study, one can refer to the fact that it included only the participants with upper major abdominal surgery which limits the generalizability of this study to other types of surgeries including lower abdominal and minor abdominal surgeries.

Conclusion

Based on the results of this study, deep breathing exercise is effective in the treatment of hypoxemia following major abdominal surgery. Deep respiratory exercise can be started safely 2 hr after abdominal surgery without the risk of increasing the surgery site pain.

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Conflict of Interest

The authors have no conflicts of interest to declare.

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کارگاه آموزشی
آموزش نرم افزار Word برای پژوهشگران


کارگاه آموزشی
روش تحقیق کمی


کارگاه آموزشی
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