Yoğun Bakım Derg 2017; 8 (3): 71-6
DOI: 10.5152/dcbybd.2018.1521

Original Investigation

Comparison of Effect of Noninvasive Pressure Techniques on Postoperative Pulmonary Functions in Patients Undergoing Major Abdominal Surgery

Mehmet Kılıç[2], Sema Şanal Baş[1], Sema Kultufan Turan[2]

[1]Department of Anesthesiology and Reanimation, Eskişehir Osmangazi University, School of Medicine, Eskişehir, Turkey
[2]Clinic of Anesthesiology and Reanimation, Türkiye Yüksek İhtisas Training and Research Hospital, Ankara, Turkey

Cite this article as: Kılıç M, Şanal Baş S, Kultufan Turan S. Noninvasive Pressure Techniques on Postoperative Pulmonary Function in Patients undergoing Major Abdominal Surgery. Yoğun Bakım Derg 2017; 8: 71-6.

Corresponding Author:
Sema Şanal Baş
E mail: drsemasa@gmail.com

©Copyright 2017 by Turkish Society of Medical and Surgical Intensive Care Medicine - Available online at www.dcyogunbakim.org

Author Contributions: Concept -S.K.T.; Design - S.Ş.B., M.K., S.K.T.; Supervision - S.K.T.; Resources - S.Ş.B., M.K.; Materials - S.Ş.B., M.K.; Data Collection and/or Processing - S.Ş.B., M.K.; Analysis and/or Interpretation - S.K.T., M.K.; Literature Search - S.Ş.B.; Writing Manuscript - M.K.; Critical Review - S.K.T., M.K.

Abstract

Objective: The objective of the study was to examine the superiority of postoperative noninvasive pressure techniques over each other in terms of pulmonary function tests (PFTs), arterial blood gas tests, and lung complication development in patients undergoing major abdominal surgery.

Material and Methods: In total, 45 patients aged between 20 and 80 years, with ASA (American Society of Anesthesiologists) I-III, and undergoing major abdominal surgery were equally and prospectively randomized into three groups in terms of the use of postoperative control (Group A), continuous positive airway pressure (Group B), and noninvasive pressure support ventilation (Group C). Preoperatively and at postoperative hour 0, hour 6, and hour 24, hemodynamic and arterial blood gas test data were recorded. Additionally, PFTs and chest radiography were performed using pre- and postoperative techniques.

Results: A statistically significant difference was found between the systolic and diastolic blood pressures at postoperative hour 6 among the groups in our study. However, when arterial CO_2 pressures at postoperative hour 6 in the groups were compared, they were determined to be higher in Group A than in Groups B and C. In groups of patients with and without the development of atelectasis, significant differences were found in terms of age, operation time, and duration of intensive care stay and hospital stay.

Conclusion: Postoperative noninvasive pressure techniques yielded better results in preventing the development of atelectasis than control techniques. However, we believe that assessment with arterial blood gas tests and PFTs is also important for preventing and predicting the development of atelectasis as well as considering a patient's age, smoking history, operation time, and duration of intensive care stay.

Keywords: Atelectasis, postoperative pulmonary complications, ventilation

Received: 15.08.2017 Accepted: 11.02.2018

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Türkiye Yüksek İhtisas Training and Research Hospital.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

Introduction

Pulmonary complications resulting from surgical interventions are important causes of mortality and morbidity (1-5). The incidence of postoperative pulmonary complication development varies from 6% to 80% (3-8). The most important respiratory complications include atelectasis, pneumonia, acute bronchitis, bronchospasm, pulmonary thromboembolism, pleural fluid, pneumothorax, prolonged postoperative hospitalization, prolonged mechanical ventilation, and acute respiratory distress syndrome (2-6). Various pulmonary physiotherapy practices are used to avoid the development of pulmonary complications and to treat these complications (2-7). There are few well-planned studies in this regard, and study data are conflicting (4-11). In the present study, we aimed to examine superiority of the postoperative noninvasive pressure techniques noninvasive pressure support ventilation (NIPSV)

and continuous positive airway pressure (CPAP) over each other in terms of pulmonary function tests (PFTs), arterial blood gas tests, and lung complication development in patients undergoing major abdominal surgery.

Material and Methods

Subjects

In this study, 45 patients aged between 20 and 80 years, with ASA I-III, and undergoing major abdominal surgery (stomach, liver, pancreas, colon, and small intestine surgery) were assessed. The trial was approved by an independent ethics committee (Türkiye Yüksek İhtisas Training and Research Hospital) and was conducted in accordance with the principles of the Declaration of Helsinki. All patients with their parents or legally acceptable representatives provided written informed consent. After obtaining written informed consent, the patients were prospectively equally randomized into three groups in terms of the use of control, CPAP, and NIPSV using the envelope method (Figure 1).

Patients who had a psychiatric disorder or maxillofacial anatomic defect hindering the operation, required emergency surgery, had a body mass index higher than 30 kg/m^2, had preoperative and postoperative hemodynamic instability, had myocardial infarction or had undergone cardiac surgery within the last 6 months, and had a cardiac and pulmonary disease were excluded from the study. Moreover, patients who experienced postoperative hemodynamic disturbances, chest pain, and changes in consciousness; cannot tolerate the operation; or develop surgical area complications (bleeding, anastomotic leakage, and ileus) were excluded from the study.

Assessment

Preoperative arterial blood gas measurement, direct posteroanterior chest radiography, and PFTs were performed. After peripheral vascular access in the operation room, noninvasive blood pressure, electrocardiograph, and peripheral O_2 saturation (SpO_2) were monitored and the values were recorded. Anesthesia was induced using 3-5 mg/kg thiopental (Pental, İ.E Ulagay, İstanbul, Türkiye), 0.6 mg/kg rocuronium (Esmeron, Organon, Netherlands), and 0.5 µg/kg fentanyl (Fentanyl, Johnson & Jonhson, Belgium); female patients were intubated using 7-7.5, and male patients were intubated using 8-8.5 mm inner diameter sizes of endotracheal intubation tube. Before the operation, patients underwent arteria radialis cannulation for invasive arterial blood pressure and blood gas monitoring. During the operation, the patients were put on a mechanical ventilator and maintained on volume controlled ventilation with a tidal volume of 8-10 mL/kg and respiration frequency of <10-14/min (end-tidal CO_2, 25-35 mmHg; pCO_2, 35-45 mmHg; peak inspiratory pulmonary pressure, <30 cm H_2O) using 50% O_2 and 50% air and minimum alveolar concentration (MAC) 1.3 sevoflurane (Sevorane, Baxter, Australia) as the inhalation agent. Upon the completion of surgery, 0.02-0.04 mg/kg neostigmine (Neostigmine, Adeka, Samsun, Türkiye) and 0.01-0.02 mg/kg atropine (Atropin sülfat, Galen, İstanbul, Türkiye) were administered to reverse the neuromuscular block. When a patient's spontaneous ventilation tidal volume was >5 mL/kg^{-1} the respiratory rate was less than 30/min, SpO_2 was more than 90%, end-tidal CO_2 was below 60 mmHg, and rapid shallow breathing index (respiratory frequency/tidal volume) was <105, the patient was extubated. For postoperative analgesia, patient-controlled analgesia was initiated using intravenous meperidine HCl (Aldolan, Liba, İstanbul, Türkiye) during surgical fascia closure and the visual analog scale was set at <4. When patients were transferred to the recovery room, no ventilation was performed (Group A) for 4 h starting from hour 2 after randomization, while CPAP 7.5 cm H_2O was given (Group B) and NIPSV (Group C) providing ventilation with a tidal volume of 8-10 mL/kg, breathing rate below 25, and SpO_2 above 90%. Preoperatively and at postoperative hour 0, hour 6, and hour 24, hemodynamic and arterial blood gas test data were recorded. In addition, PFTs were repeated preoperatively and at postoperative hour 6 and hour 24, and results were compared with chest radiographs preoperatively and at postoperative hour 24. While chest radiographs were evaluated in the Radiology Department, atelectasis and other pathological symptoms were recorded. Operation duration, smoking status, postoperative lung complications, recovery, and duration of intensive care and hospital stay were recorded.

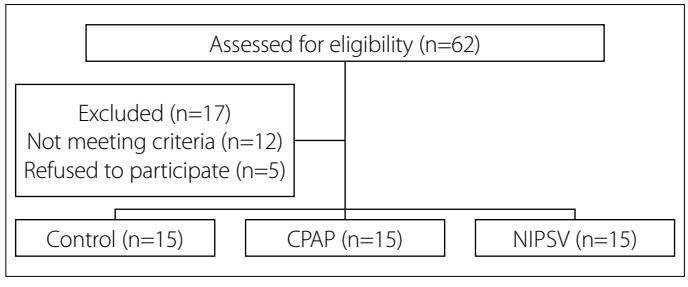

Figure 1. Participant flowsheet.
CPAP: continuous positive airway pressure; NIPSV: noninvasive pressure support ventilation

Statistical Analysis

Results were recorded on a computer, and the Statistical Package for Social Science (SPSS) software for Windows 17 (SPSS Inc.; Chicago, IL, USA) was used. Results are presented as mean±standard deviation. The chi-square test was used in cross tables. The age, operation time, duration of intensive care and hospital stay, PFT parameters, arterial blood gas parameters, hemodynamic symptoms, and average pulse oximetry findings in the groups were recorded; ANOVA was performed for parametric data, and the Kruskal-Wallis test was performed for nonparametric data. A p-value of <0.05 was considered statistically significant. When post hoc power analysis was performed using the values obtained at the end of our study, the power of the study was found to be 0.8 in case there are 15 patients in each group and an alpha value of 0.05 was considered.

Results

In total, 45 patients, 16 females (35%) and 29 males (65%), with a mean age of 48.2±12.4 years were included in the study. The patients were randomized into three groups. There was no difference among the groups in terms of distribution by gender. Among the groups, no statistically significant difference could be found in terms of durations of hospital stay, intensive care stay, and operation (Table 1). Among the groups, no statistically significant difference was found in terms of the development of atelectasis and the effect of gender and smoking on the development of atelectasis. A statistically significant difference was found between Groups A and B between systolic and diastolic blood pressures at postoperative hour 6 (Table 2).

Among the three groups, there was no difference in terms of average heart rate, forced vital capacity, forced expiratory value in 1 s (FEV_1), peak expiratory flow (PEF), and forced expiratory flow (FEF) 25-75% from PFTs;

pH in blood gas tests; arterial O_2 pressure; and SpO_2 values at all time points. However, when the arterial CO_2 pressure at postoperative hour 6 in the three groups was compared, it was determined to be higher in Group A than in the other two groups; this difference was statistically significant (Table 3).

Among 45 patients, atelectasis was observed in 9 patients; considering distribution by groups, there were 4 patients in Group A, 2 in Group B, and 3 in Group C. No statistically significant difference was determined in terms of the development of atelectasis among patients in the groups (p=0.659). No statistically significant difference was determined in terms of the development of atelectasis related to smoking among patients in the groups (p=0.659). In groups of patients with and without the development of atelectasis, statistically significant differences were found in terms of age, operation time, and duration of intensive care stay and hospital stay (Table 4).

When all patients were evaluated in terms of the development of atelectasis, the percentage values of FEV_1 at postoperative hour 24 in patients without the development of atelectasis (75.8±8.3) was found to be higher than in the group of patients with the development of atelectasis (66.8±6.8); this difference was statistically significant (p<0.001). The preoperative values and postoperative PEF values at hours 6 and 24 (89.5±7.2, 65±7.4, and 74±6.7, respectively) and the preoperative and postoperative FEF 25-75% values at hours 6 and 24 (89.9±6.4, 65.3±6.4, and 74.3±6.9, respectively) of the patients without the development of atelectasis were found to be higher than the preoperative and postoperative PEF and FEF 25-75% values at hours 6 and 24 in the group of patients with the development of atelectasis (82.7±5.7, 57.4±3.3, and 65.4±7.5, respectively vs. 79.6±5.2, 57.8±3.2, and 64.8±6, respectively); this difference was statistically significant (p<0.001). The PaO_2 values in blood gas test results and pH values on performing pulse oximetry preoperatively and at postoperative hours 0, 6, and 24 in patients without the development of atelectasis were found to be higher than those in patients with the development of atelectasis; this difference was statistically significant (Table 5).

Table 1. Demographic characteristics

	Group A	Group B	Group C	p
Gender (F/M)	7/8	4/11	5/10	
Age (years) (mean±SD)	47.4±13.3	49±11.3	49.5±12.9	0.89
Operation time (h) (mean±SD)	3.5±0.8	3.8±0.8	3.6±0.9	0.514
Intensive care stay (h) (mean±SD)	10.1±7.7	8.8±2.9	8.27±2.2	0.9
Hospital stay (days) (mean±SD)	5.6±1.9	5.7±1.9	5.4±1.2	0.87

Group A: control group; Group B: CPAP group; Group C: NIPSV group
F: female; M: male; SD: standard deviation; CPAP: continuous positive airway pressure; NIPSV: noninvasive pressure support ventilation

Table 2. Distribution of systolic and diastolic blood pressures among the groups

Variables[a]		Group A	Group B	Group C	p
Blood pressure Systolic (mmHg)	T0	126.63±14.471	133.53±19.390	128.60±16.088	0.507
	T1	143.07±11.423	148±16.410	141.40±16.418	0.46
	T2	128.00±14.036	143.07±13.812	136.93±11.003	0.011
	T3	124.27±14.754	130.60±17.033	129.33±9.529	0.474
Blood pressure (mmHg) Diastolic (mmHg)	T0	74.27±10450	78.33±9.940	76.67±7.403	0.495
	T1	82.8±8.777	86.8±6.805	83.73±6.933	0.327
	T2	75.67±9.969	85.00±6.655	80.73±4.436	0.007
	T3	74.33±8.829	76.27±8.713	77.44±5.598	0.558

Group A; control group; Group B: CPAP group; Group C: NIPSV group
[a]Values: mean±SD
T0: preoperatively; T1: postoperative hour 0; T2: postoperative hour 6; T3: postoperative hour 24
CPAP: continuous positive airway pressure; NIPSV: noninvasive pressure support ventilation

Table 3. Distribution of blood gas values among the groups

Variables[a]		Group A	Group B	Group C	p
$PaCO_2$	T0	30.93±2.520	32.75±2.622	31.8±2.731	0.18
	T1	34.6±2.261	35.53±1.727	35.13±1.302	0.37
	T2	32.93±2.434	30.07±1.624	30.4±1.298	0.012
	T3	32.93±2.434	32.67±1.676	32.47±1.598	0.805

Group A: control group; Group B: CPAP group; Group C: NIPSV group
[a]Values: mean±SD
T0: preoperatively; T1: postoperative hour 0; T2: postoperative hour 6; T3: postoperative hour 24
CPAP: continuous positive airway pressure; NIPSV: noninvasive pressure support ventilation

Table 4. Factors affecting the development of atelectasis

	Atelectasis		
Variables[a]	**Yes (n=9)**	**No (n=36)**	**p**
Age (years)	61.5±5.9	45.4±11.4	0.00
Operation time (h)	4.2±0.71	3.5±0.88	0.026
Intensive care stay (h)	13.8±8.4	7.8±2.5	0.00
Hospital stay (days)	7.5±1.5	5±1.3	0.00

[a]Values: mean±SD

Table 5. Relationship of atelectasis with other parameters

Variables[a]		**Atelectasis**	**Total**	**Mean**	**SD**	**p**
Saturation	T0	No	36	97.42	1.663	0.001
		Yes	9	94.44	2.297	
	T1	No	36	94.67	2.318	0.001
		Yes	9	91.89	2.088	
	T2	No	36	97.17	1.859	0.003
		Yes	9	94.89	1.764	
	T3	No	36	96.22	1.588	0.001
		Yes	9	93.44	1.424	
PaO_2	T0	No	36	93.75	6.026	0.001
		Yes	9	86.33	5.315	
	T1	No	36	87.42	4.854	0.001
		Yes	9	81.67	4.243	
	T2	No	36	93.25	6.500	0.02
		Yes	9	87.56	4.640	
	T3	No	36	89.25	4.358	0.01
		Yes	9	85.00	4.500	
$PaCO_2$	T0	No	36	31.39	2.555	0.03
		Yes	9	33.56	2.555	
	T1	No	36	35.00	1.639	0.520
		Yes	9	35.44	2.455	
	T2	No	36	30.75	2.034	0.31
		Yes	9	31.33	1.658	
	T3	No	36	32.33	1.757	0.01
		Yes	9	34.11	1.900	
pH	T0	No	36	7.4252	0.02400	0.11
		Yes	9	7.4100	0.02828	
	T1	No	36	7.3981	0.02040	0.05
		Yes	9	7.3833	0.01658	
	T2	No	36	7.4239	0.02032	0.02
		Yes	9	7.4067	0.01000	
	T3	No	36	7.4142	0.01697	0.02
		Yes	9	7.3979	0.02204	

T0: preoperatively; T1: postoperative hour 0; T2: postoperative hour 6; T3: postoperative hour 24
SD: standard deviation

Discussion

Pulmonary complications following major abdominal surgery are important causes of mortality and morbidity. During anesthesia induction, pulmonary complications still pose a problem, despite advances in surgical practices and postoperative care (3, 4). The incidence of postoperative pulmonary complication development seen varies widely and depends on the type of surgery and risk factors (2-7). Various pulmonary physiotherapy practices are frequently used to treat these complications and prevent their development. The superiority of different techniques over each other remains controversial in the literature (2-9). In these studies, it was determined that pre- and postoperative pulmonary physiotherapy practices are effective in patients with a high risk of developing complications (4-8). In the present study, no difference was found in terms of the development of atelectasis, although CPAP and NIPSV yielded better results in some postoperative pulmonary functions than the control technique.

In our study, while the averages of arterial O_2 saturation at postoperative hour 6 were significantly low in the Group A than the B and C Groups, the averages of arterial CO_2 pressure at postoperative hour 6 were observed to be significantly higher. At postoperative days 1 and 2, it was observed that the PaO_2 value was better in the PEEP and CPAP groups than in the control group in a study (12). In another study, the superiorities of noninvasive mechanical ventilation techniques were compared in stable chronic obstructive pulmonary disease (COPD) patients, and while CPAP was administered at different pressures in a group, CPAP and NIPSV were administered at low pressures to patients in the other group. In conclusion, PaO_2 and PCO_2 values were found to be better in each group than the baseline values (13). In the literature, there are several publications indicating that noninvasive pressure techniques further improve arterial blood gases and decrease PCO_2 and increase PaO_2 values (8-12). Our study also supports these statements, and the blood gas values of the patients in the CPAP and NIPSV groups were better than those of the patients in the control group.

Of the 45 patients in total, 9 developed atelectasis, and no statistically significant difference was found in terms of the frequency of the development of atelectasis by group. The results differ from those in similar studies present in the literature. In a study by Carlsson et al. (14) CPAP was given to 13 of 24 patients and only O_2 was given to 11 patients for 4 h on the postoperative first day, and atelectasis was detected in 10 of 13 patients in the CPAP group and 10 of 11 patients in O_2 group. We believe that the frequency of the development of atelectasis is higher than that in our study because the patient population in this study (15) has a higher average age, which is an important risk factor in terms of postoperative pulmonary complication development. In a study by Stock et al. (15) atelectasis was found in 5 of 23 patients in the CPAP group and in 8 of 20 patients in the control group, and the frequency of the development of atelectasis following CPAP was similar to that in our patients.

In previously conducted studies, although a large number of patients who smoked had normal PFT results or demonstrated minimal changes, most smokers had mucus hypersecretion or deterioration in mucociliary clearance. It is known that patients who smoke have difficulties in clearing secretions that accumulate on the airways during the postoperative period, causing the frequency of atelectasis and bronchopneumonia to increase (16, 17). In a study conducted by Stolz et al. (18) the development of postlobectomy atelectasis was retro-

spectively investigated in 412 patients undergoing pulmonary lobectomy; a statistically significant difference could not be found, although smoking and the frequency of the development of atelectasis were higher than non-smokers. In our study, smoking frequency was higher in patients developing atelectasis, even though there was no significant difference when the postoperative development of atelectasis was analyzed between smokers and non-smokers. Hence, we believe that quitting smoking before undergoing an operation will prevent the development of this complication.

We observed that the operation times are longer in patients developing atelectasis than in those not developing atelectasis. In a study that investigated postoperative pulmonary complication development with regard to operation times in patients with COPD undergoing surgery, Kroenke et al. (19) found that the postoperative pulmonary complication rate increases in patients with an operation time longer than 3.5 h. In a study, the postoperative pneumonia frequency was found to be 5 times higher in patients undergoing surgeries exceeding 4 h than in those undergoing surgeries less than 2 h (20). In the literature, the relationship between patients having an operation time exceeding 3-4 h and postoperative pulmonary complication development was significant (19-22). We believe that performing postoperative respiratory physiotherapy in patients with longer operation times would cause few pulmonary complications.

In our study, significant differences were found in the postoperative development of atelectasis in terms of FEV_1, PEF, and FEF 25-75% values. In a prospective study on patients undergoing upper abdominal surgery, Kocabas et al. (23) showed that the incidence of respiratory complications was higher in patients with low preoperative PFTs. The relationship between PFTs and pulmonary complication development is not clear in the literature; however, it is known that FEV1 values lower than 70% are risk factors for pulmonary complication development (9, 24). We revealed that spirometry values are good indicators of the development of postoperative pulmonary complications; this finding supports those present in most studies in the literature.

In our study, significant differences were found in terms of arterial O_2 saturation and arterial O_2 pressure, arterial CO_2 pressure, and arterial blood pH values with the development of atelectasis. In a study conducted by Fuso et al. (25) the authors revealed a more frequent pulmonary complication patients in which low preoperative PaO_2 values and emphasized that it is important in the prediction of pulmonary complication development. We believe that the assessment of arterial blood gas results is an important indicator of the development of atelectasis.

We believe that a few limitation of this study are worthy of discussion. Patients were monitored from the postoperative period to the time of discharge. Accordingly, we obtained information on early postoperative complications. If the patients were followed up for a longer period, the development of long-term complications could have been reported. Another limitation is that the power of our study is limited due to the size of the sample.

Conclusion

We showed that postoperative noninvasive pressure techniques yielded better results in terms of blood gas values and in terms of preventing the development of atelectasis than the control technique. However, we believe that assessment with arterial blood gas and PFTs is also important in preventing and predicting the development of atelectasis that a patient's age, smoking history, operation time, and duration of intensive care stay. Further studies with a larger number of subjects and longer follow-up periods are needed.

References

1. Lawrence VA, Dhanda R, Hilsenbeck SG. Risk of pulmonary complications after elective abdominal surgery. Chest 1996; 110: 744-50. [CrossRef]
2. Hall JC, Tarala RA, Tapper J, et al. Prevention of respiratory complications after abdominal surgery: A randomized clinical trial. Br Med J 1996; 312: 148-53. [CrossRef]
3. Arozullah AM, Conde MV, Lawrence VA. Preoperative evaluation for postoperative pulmonary complications. Med Clin North Am 2003; 87: 153-73. [CrossRef]
4. Thompson JS, Baxter BT, Allison JG. Temporal patterns of postoperative complications. Arch Surg 2003; 138: 596-602. [CrossRef]
5. Matte P, Jacquet L, Van Dyck M, et al. Effects of conventional physiotherapy, continuous positive airway pressure and non-invasive ventilatory support with bi level positive airway pressure after coronary artery bypass grafting. Acta Anaesthesiol Scand 2000; 44: 75-81. [CrossRef]
6. Kindgen-Milles D, Müller E, Buhl R, et al. Nasal continuous positive airway pressure reduces pulmonary morbidity and length of hospital stay following thoroco abdomianl aortic surgery. Chest 2005; 128: 821-8. [CrossRef]
7. Zarbock A, Mueller E, Netzer S, et al. Prophylactic nasal continuous positive airway pressure followingcardiac surgery protects from postoperative pulmonary complications: a prospective, randomized, controlledtrial in 500 patients. Chest 2009; 135: 1252-9. [CrossRef]
8. Smetana GW. Postoperative pulmonary complications: an update on risk assessment and reduction. Cleve Clin J Med 2009; 76: 60-5. [CrossRef]
9. Lawrence VA, Cornell JE, Smetana GW. American College of Physicians. Strategies to reduce postoperative pulmonary complications after noncardio thoracic surgery: systematic review for the American College of Physicians. Ann Intern Med 2006; 144: 596-608. [CrossRef]
10. Brueckmann B, Villa-Uribe JL, Bateman BT, et al. Development and validation of a score for prediction of postoperative respiratory complications. Anesthesiology 2013; 118: 1276-85. [CrossRef]
11. Severgnini P, Selmo G, Lanza C, et al. Protective mechanical ventilation during general anesthesia for open abdominal surgery improves postoperative pulmonary function. Anesthesiology 2013; 118: 1307-21. [CrossRef]
12. Ricksten SE, Bengtsson A, Soderberg C, et al. Effects of periodic positive airway pressure by mask on postoperative pulmonary function. Chest 1986; 89: 774-81. [CrossRef]
13. Neme JY, Gutiérrez AM, Santos MC, et al. Physiologic Effects of Noninvasive Ventilation in Patients With Chronic Obstructive Pulmonary Disease. Arch Bronconeumol 2007; 43: 150-5. [CrossRef]
14. Carlsson C, Sonden B, Thylen U. Can postoperative continuous positive airway pressure (CPAP) prevent pulmonary complications after abdominal surgery? Intensive Care Med 1981; 7: 225-9.
15. Stock MC, Downs JB, Gauer PK, et al. Prevention of postoperative pulmonary complications with CPAP, incentive spirometry, and conservative therapy. Chest 1985; 87: 151-7. [CrossRef]
16. Arozullah AM, Khuri SF, Henderson WG, et al. Development and validation of a multi factorial risk index for predicting postoperative pneumonia after major noncardiac surgery. Ann Intern Med 2001; 20: 847-57. [CrossRef]
17. Arozullah AM, Daley J, Henderson WG, et al. Multifactorial risk index for predicting postoperative respiratory failure in men after major noncardiac surgery. Ann Surg 2000; 232: 242-53. [CrossRef]
18. Stolz AJ, Lischke R, Schutzner J, et al. Predisposing factors of atelectasis following pulmonary lobectomy. Acta Chir Belg 2009; 109: 81-5. [CrossRef]
19. Kroenke K, Lawrence VA, Theroux JF, et al. Operative risk in patients with severe obstructive pulmonary disease. Arch Intern Med 1992; 152: 967-71. [CrossRef]
20. Ferguson MK. Preoperative assessement of pulmonary risk. Chest 1999; 115: 58-63. [CrossRef]

21. BrooksJo-Ann. Predictors of postoperative pulmonary complications following abdominal surgery. Chest 1997; 111: 564-71. [CrossRef]
22. Smetana GW. Preoperative pulmonary evaluation. N Engl J Med 1999; 340: 937-44. [CrossRef]
23. Kocabas A, Kara K, Ozgur G, et al. Value of preoperative spirometry to predict postoperative pulmonary complications. Respir Med 1996; 90: 25-33. [CrossRef]
24. Williams-Russo P, Charlson ME, MacKenzie CR, et al. Predicting postoperative pulmonary complications. Arch Intern Med 1992; 152: 1209-13. [CrossRef]
25. Fuso L, Cisternino L, Di Napoli A, et al. Role of spirometric and arterial gas data in predicting pulmonary complications after abdominal surgery. Respir Med 2000; 94: 1171-6. [CrossRef]