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Intermittent Positive Pressure Breathing (IPPB) Versus Incentive Spirometer (IS) Therapy in the Postoperative Period

J. Pfenninger and F. Roth

Department of Anesthesiology and Intensive Care, Inselspital, University of Berne, Berne, Switzerland

Abstract. The increase of the inflationary lung volume created by a respiratory maneuver is critical for preventing postoperative alveolar collapse. We measured this volume as achieved with IPPB or incentive spirometry (IS) in 20 postoperative surgical patients. Using IPPB, with gas flow and peak airway pressures carefully adjusted for each patient, a value of 2240 ± 630 cc (mean ± 1 SD) was obtained compared to 1960 ± 650 cc with IS. This difference is highly significant ($p < 0.0005$ by the Wilcoxon test).

We conclude that IPPB, by careful application, and with monitoring of tidal volumes, is likely to provide better prophylaxis of postoperative pulmonary complications, particularly in patients with compromised lung function and in an intensive care unit, where enough trained personel are available.

Key words: Prevention, Postoperative pulmonary complications, Intermittent positive pressure breathing (IPPB), Incentive Spirometer.

Introduction

Postoperative intermittent positive pressure breathing therapy (IPPB) to prevent pulmonary complications has been subjected to criticism [2, 12, 15, 16]. This form of treatment consists of the intermittent use of a mechanical ventilator via a mouth-piece or face mask. Theoretically it should prevent atelectasis by inflating the lungs with a high volume. Anderson et al. [1] were able to show a decreased incidence of postoperative pulmonary complications by the use of IPPB, but several authors have found that the postoperative course was not influenced by this form of treatment [7-9, 17]. The reason for the practical failure of IPPB may be due to the mode of its application. In most studies the inflating volume has not been measured and control of IPPB was exerted only by prescribing a peak airway pressure. Using this technique less than optimal volumes are delivered by the ventilator.

As a consequence other methods for preventing postoperative pulmonary complications have been developed. It is recognized that it is most important to achieve a maximum inspiratory volume [3,4]. The concept of a stimulated, deep, voluntary inspiration was realised by Bartlett in a device called an Incentive Spirometer (IS) [4]. The IS is a simple piston-type bellows with an adjustable volume. As the patient inhales, a light appears, when he has achieved the preset volume. There is also a constant leak in the system so that he must continue to inhale to keep the light on. This apparatus stimulates the patient to a sustained maximum inspiration. The use of an IS in the postoperative course has been shown to minimize pulmonary complications [3, 10, 18]. It also has several clear advantages over IPPB: it is cheap, no compressed gases are necessary, the risk of cross-infection is small, the venous return is enhanced by high negative intrathoracic pressures, the instruction is very easy and the patient can work independently with the in-built control mechanism.

Several recent articles [5, 6, 13] have analysed the different postoperative respiratory maneuvers (i. e. deep breath holding, blow bottles, hyperventilation, IPPB and sustained maximal inspiration by an IS), in an attempt to explain the different results in preventing postoperative atelectasis: with the IS the highest inspiratory volumes or transpulmonary pressures were achieved, which were higher

Table 1. Inflating volumes in postoperative surgical patients

patient	age yrs	sex	operation performed	IPPB (cc) (Pressure) (cmH_2O)		IS (cc)
1.	70	f	pancreatic cyst removed	2350	(25)	1200
2.	36	m	sigmoid resection	3200	(37)	2900
3.	68	f	drainage for peritonitis	1200	(32)	800
4.	68	m	prosthesis for abdom. aorta	2250	(40)	1750
5.	59	m	prosthesis for abdom. aorta	2300	(35)	1950
6.	69	f	cholecystectomy	1550	(40)	1450
7.	20	m	thoracotomy for pleural empyema	2050	(20)	1950
8.	30	m	gun shot wound upper abdomen	2700	(30)	2800
9.	64	m	esophageal resection (thor. -abd.)	2700	(40)	2600
10.	42	m	laparotomy, acute pancreatitis	1950	(35)	2300
11.	54	m	thoracotomy (diagnostic)	2650	(28)	2400
12.	7	f	correction of congenital heart dis.	850	(25)	650
13.	54	m	aorto-coronary bypass	2800	(30)	2600
14.	28	m	aortic valve replacement	2350	(32)	2300
15.	58	f	aortic valve replacement	2050	(28)	1800
16.	64	m	diagnostic thoracotomy	1650	(25)	1700
17.	66	m	aortic valve replacement	3050	(25)	2700
18.	40	f	aortic valve	3000	(40)	2100
19.	65	m	lobe resection for bronchial ca.	2500	(35)	2100
20.	48	m	prosthesis for abdom. aorta	1600	(35)	1200
			means ± 1 SD	2240 ± 630 average pressure 32		1960 ± 650

than with IPPB; however in these cases the pressures applied by IPPB were often low, in the range of 20 cm H_2O. This might be the reason why better clinical results were obtained by the IS than by IPPB.

Despite these reports, it is our opinion that by correct application of IPPB larger inflation volumes are achieved. We therefore compared IPPB and the IS, in the same patient in his postoperative period, by measuring maximum inspired volumes.

Material and Methods

Twenty co-operative, surgical patients were tested during their postoperative course. IPPB was performed with a Bird Mark VII[1] respirator attached to the patient via a mouth piece. The normal circuit with the regular humidifier and only compressed air were used, no bronchodilator drug was used in the nebulizer. For the IS we used the Bartlett-Edwards Incentive Spirometer[2]. Both techniques were explained in detail to each patient. For the patient to gain familiarity with IPPB, we commenced the instruction with low pressures, gradually adjusting pressure and flow to the position, where maximum volumes were breathed with a long inspiratory time. The IS was preset near to the vital capacity of a given patient as predetermined with a Wright Spirometer. After these instructions, volumes were measured with a Wright Spirometer under verbal stimulation to increase the patients' efforts (i. e. to total lung capacity with IPPB and IS). In IPPB the spirometer was placed on the expiratory nozzle of the Bird Mark VII. The patient was asked to inhale as much as possible and then to exhale completely. This test was repeated immediately at least three times in order to obtain three values within 100 cc of each other. During the same session the volumes with the IS were also controlled. The Wright Spirometer was placed between the mouthpiece and the connecting tube in inspiratory and expiratory direction (i. e. inspiratory: maximal inhalation from the position of residual volume to total lung capacity; expiratory: complete exhalation after maximal sustained inhalation stimulated by the machanism of the IS). The larger volume, usually expiratory, was taken for comparison with IPPB. Again at least three cycles not differing by more than 100 cc were measured. The IPPB volumes were corrected by subtraction of the compression volume of the ventilator. This varied from 50 cc with 25 cm H_2O pressure to 110 cc with 40 cm H_2O.

The data of IPPB and the IS were compared statistically by means of the Wilcoxon matched-pairs signed-ranks test.

Results

The results of the spirometers are summarized in Table 1.

IPPB yielded inflating volumes of 2240 ± 630 cc (mean ± 1 SD) versus 1960 ± 650 cc with IS. The difference is highly significant ($p < 0.0005$, Wilcoxon Test).

[1] Bird Corp., Palm Springs, California.
[2] Edwards Laboratories, California.

The simultaneously determined vital capacity was 1800 ± 610 cc (mean ± 1 SD).

From these results the majority of patients (14/20 = 70%) achieved greater volumes with IPPB, 5 (25%) did not show any important difference and only one (# 10) had a relatively higher volume with the IS.

Discussion

In contrast to Bartlett [5, 6] and McConnell [13], we were able to demonstrate that under optimal instruction IPPB yields higher inflation volumes than an IS. Optimal instruction includes the careful detection of the best pressure and flow for the individual patient by accurate spirometry. Usually the inflation volume increases in a given patient by increasing the airway pressure to a maximum. As the optimal pressure is passed, it may subsequently decrease, as the patient feels too much pain and terminates inspiration by splinting his thoracic and abdominal wall or closuring his glottis. The flow rate should be as low as possible. In this manner high inflating volumes are produced with a long inspiratory time. Because functional residual capacity, lung compliance and chest wall and abdominal wall compliance are decreased (due to pain) and airway resistance is often increased in the postoperative period, relying only on a pressure setting of the respirator is no guarantee of a high volume.

A high inspiratory volume or transpulmonary pressure gradient (airway pressure minus pleural pressure) is the most important factor in keeping the small airways and alveoli open and thus preventing atelectasis [5, 13]. Mc Connell et al. [13] have shown that there is no difference between IPPB and an IS in creating a certain transpulmonary pressure. Whether the lung is expanded by reduction of pressure around it or by increasing pressure within it, the identical physical forces are acting on bronchi and alveoli. Thus with our technique, IPPB should be more effective than IS. This should be particularly true in patients with compromised respiratory function due to certain neurologic disorders (Guillain-Barré Syndrome, Myasthenia gravis, phrenic nerve palsy), decreased compliance (left heart fialure, distended abdomen) or chest wall instability.

However we do not know what happens to gas distribution during IPPB. As during artificial ventilation in the paralyzed subject, it may well be possible that zone I regions of the lung are preferentially expanded leaving the dependent parts relatively underventilated [11]. Airway closure is more likely to develop in these dependent areas. With the IS, during a deep spontaneous inspiration, the gas is preferentially distributed to zone III regions of the lung [11, 14].

The widespread practical failure of IPPB vs the IS is due to

1)prescribing only a maximal airway pressure without regard to the individual patient nor control of the inflating volume.

2) lack of careful application as compared to the simplicity of the IS

3) the inflating pressure is usually set too low (15 - 25 cm H_2O); our pressures ranged from 20 - 40 cm H_2O (mean 32).

For IPPB to be successful it should be carried out in an intensive care unit or by specially trained physiotherapists. If after the first instruction and subsequent sporadic control by a nurse or physiotherapist, the patient is left to continue his own respiratory therapy an IS may be superior to this form of IPPB.

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Dr. F. Roth
Abt. f. Reanimation und Intensivbehandlung
Inselspital
CH-3010 Bern
Switzerland