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Positive expiratory pressure in postoperative cardiac patients in intensive care: A randomized controlled trial

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Abstract

Objective: To evaluate effectiveness of positive expiratory pressure blow-bottle device compared to expiratory positive airway pressure and conventional physiotherapy on pulmonary function in postoperative cardiac surgery patients in intensive care unit.

Design: A randomized controlled trial.

Settings: Tertiary care.

Subjects: 48 patients (16 in each group; aged 64.5 ± 9.1 years, 38 male) submitted to cardiac surgery.

Interventions: Patients were randomized into conventional physiotherapy (G1), positive expiratory pressure blow-bottle device (G2) or expiratory positive airway pressure, both associated with conventional physiotherapy (G3). G2 and G3 performed three sets of 10 repetitions in each session for each technique.

Main measures: Pulmonary function (primary); respiratory muscle strength, radiological changes, pulmonary complications, length of intensive care unit and hospital stay (secondary) assessed preoperatively and on the 3rd postoperative day.

Results: Pulmonary function (except for forced expiratory volume in one second/ forced vital capacity % predicted) and respiratory muscle strength showed significant reduction from the preoperative to the 3rd postoperative in all groups ($P < 0.001$), with no difference between groups ($P > 0.05$). Regarding radiological changes, length of intensive care unit stay and length of hospital stay, there was no significant difference between groups ($P > 0.05$).

Conclusion: Both positive expiratory pressure techniques associated with conventional physiotherapy were similar, but there was no difference regarding the use of positive expiratory pressure compared to conventional physiotherapy.

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Introduction

Patients undergoing cardiac surgery may present postoperative changes such as reduced lung volume and flow,[1–3] reduced respiratory muscle strength[3] and increased rate of pulmonary complications.[1,4,5] To minimize these changes, breathing exercises with positive expiratory pressure are used,[6–9] and can be offered by different devices, such as positive expiratory pressure blow-bottle device and expiratory positive airway pressure.[8,10]

Positive expiratory pressure blow-bottle device is a simple device built with a bottle and a tube. The bottle is partially filled with water, the distal tip of a tube is submerged in the water, and the patient exhales through the tube. Expiratory positive airway pressure is a system composed of a one-way valve coupled to a face mask, with a resistor that allows pressure adjustment and the breath is performed against the spring resistor.[10]

Studies have evaluated the efficacy of positive expiratory pressure blow-bottle device [7,9] or expiratory positive airway pressure[8,11] compared with other physiotherapy techniques. At present, it is not known if any of these positive expiratory pressure devices can be more effective than other strategies on pulmonary function after cardiac surgery,[7–9,11] and if there is difference between the two techniques in these patients.

In addition, this randomized controlled trial is justified by the fact that the blow-bottle device is a simple, low-cost technique, widely used in postoperative cardiac surgery. Therefore, the objective of this study was to evaluate effectiveness of positive expiratory pressure blow-bottle device compared to expiratory positive airway pressure and conventional physiotherapy on pulmonary function in postoperative cardiac surgery patients in intensive care unit.

Methods

This is a randomized controlled trial, single-centre, approved by the Research Ethics Committee of the Hospital de Clínicas de Porto Alegre (CAEE: 70213617.6.0000.5327). Signed informed consent was obtained from all patients. The study was registered on ClinicalTrials.gov, number NCT03639974.

The population consisted of subjects who underwent elective cardiac surgery at Hospital de Clínicas de Porto Alegre, from August 2018 to May 2019. Adult patients (over 18 years old) of both genders who undergo elective coronary artery bypass grafting and/or aortic, mitral, tricuspid valve surgery; on spontaneous ventilation with or without supplemental oxygen support. Exclusion criteria: patients with hemodynamic instability (heart rate $>$ 120 beats per minute, clinically important hypotension – vasopressor dose $\geqslant$ 0.1 mcg/kg/min), heart arrhythmia, decompensated heart failure, heart transplantation, angina at rest and/or minor efforts, mechanical ventilation for more than 24 hours, noninvasive mechanical ventilation, reintubated, re-operated, non-collaborative and with cognitive inability to understand the procedures. Patients with contraindications to pulmonary function and respiratory muscle strength tests, according to Pereira[12] and Souza,[13] respectively, were also excluded.

The interventions were applied by a single investigator, who had experience as physiotherapist in cardiac intensive care unit.

Patients were randomized into three groups, conventional physiotherapy (G1), positive expiratory pressure blow-bottle device associated to conventional physiotherapy (G2) and expiratory positive airway pressure associated to conventional physiotherapy (G3). Patients were randomized in

Table 1. Baseline patient characteristics, surgical and postoperative data.

	G1 ($n=16$)	G2 ($n=16$)	G3 ($n=16$)
Male gender – *n* (%)	16 (100)	11 (69)	11 (69)
Age (years)[a]	67.3 ± 9.5	60.8 ± 8.6	65 ± 8.2
BMI (kg/m^2)[a]	28 ± 3.9	28 ± 4.4	26.7 ± 4
Smokers			
No – *n* (%)	7 (44)	11 (69)	7 (44)
Abstinence – *n* (%)	9 (56)	1 (6.3)	6 (38)
Sedentary – *n* (%)	13 (81)	11 (69)	11 (69)
Hypertension – *n* (%)	11 (69)	13 (81)	11 (69)
DM II – *n* (%)	6 (38)	7 (44)	5 (31)
Dyslipidemia – *n* (%)	1 (6.3)	1 (6.3)	1 (6.3)
Physiotherapeutic care[a]	4.4 ± 0.5	4.6 ± 0.5	4.4 ± 0.5
Type of surgery			
CABG – *n* (%)	7 (43.8)	12 (75)	5 (31)
Mitral valve replacement – *n* (%)	1 (6.3)	2 (12.5)	2 (12.5)
Aortic valve replacement—*n* (%)	4 (25)	2 (12.5)	6 (37.5)
CABG + aortic valve replacement – *n* (%)	3 (18.8)	0 (0)	3 (19)
CABG + mitral valve replacement – *n* (%)	1 (6.3)	0 (0)	0 (0)
Surgery time[a] (min)	213 ± 25	210 ± 45	204 ± 41
ECC time[a] (min)	89 ± 18	80 ± 25	86 ± 25
Aortic occlusion time[a] (min)	69 ± 19	58 ± 21	67 ± 22
Postoperative mechanical ventilation time[b] (hr)	10.5 (4.3–19.8)	7.4 (3.5–21.5)	8.5 (3.5–19.5)

G1: conventional physiotherapy group; G2: PEP (positive expiratory pressure) blow-bottle device; G3: EPAP (expiratory positive airway pressure) group; BMI: body mass index; CABG: coronary artery bypass grafting; DM II: diabetes mellitus type II; ECC: extracorporeal circulation.

[a]Data expressed as mean ± standard deviation.

[b]Data expressed as median and interquartile range.

blocks of three, using data generated by a computer program containing coded distribution http://www.randomization.com/. The sequence generation of the numbers was performed by a blinded researcher and the sequence of the numbers used for randomization was kept confidential until the exact beginning of the intervention.

Conventional physiotherapy consisted of deep breathing exercises, bronchial hygiene techniques, active-assisted or active upper and lower limb exercises, lower limb stretching, ambulation, and cough guidance. The exercises were performed in bed, due to the presence of chest drains; as soon as they were removed and the patients were released to leave the bed, the exercises were progressed in the sitting and orthostasis positions.

Under the supervision of the physical therapist, the protocol of the three groups was performed twice a day on weekdays and once a day on the weekend, during the first three days of postoperative, totaling four to five sessions (Table 1). Three sets of 10 repetitions were performed in each session for the breathing exercises and randomized interventions, and one set of 10 repetitions for the motor exercises, with 30 to 60 seconds pauses between each set. The protocol was interrupted in case of hemodynamic instability and/or a fall of peripheral oxygen saturation above 90%.

Positive expiratory pressure blow-bottle device associated to conventional physiotherapy used 500 ml enteral nutrition bottle for the blow-bottle device, containing a hole in the side with a diameter greater than 8 ml, where two 203 silicone tubes were inserted, with total diameter greater than 8 ml, length of 20 cm, both with bevel-cut distal tips, bandaged to the neck of the bottle, according to the

standard operating protocol of the Hospital de Clínicas de Porto Alegre Physiotherapy service. To perform the exercise, the bottle was filled with 10 cm of water. The physiotherapist explained and instructed the performance of the exercises, correcting the main faults. These were uniformed to be used in all patients. Deep inspirations were requested at a volume greater than the tidal volume and lower than the total lung capacity that were performed nasally or orally. Then, the patient exhaled slowly, avoiding completely emptying the lungs.

Expiratory positive airway pressure associated to conventional physiotherapy used a Vital Signs® expiratory positive airway pressure kit, consisting of a one-way valve coupled to a face mask. To perform the exercise, the expiratory positive airway pressure mask, with pressure adjusted to 10 cmH_2O, was connected to the patient's face, and the physical therapist instructed how perform the exercise. Deep inspiration was requested at a volume larger than the tidal volume and below the total lung capacity; patient exhaled slowly, avoiding completely emptying the lungs.

For outcome measures, pulmonary function was adopted as the primary outcome, and secondary outcomes were respiratory muscle strength, radiological changes, pulmonary complications, intensive care unit length of stay and length of hospital stay. Data collection and outcome assessment were performed by blinded researchers. Blinding of therapist and patient was not possible due to the difference between the techniques.

Pulmonary function and respiratory muscle strength were assessed preoperatively and on the 3rd postoperative day. Chest X-ray was performed preoperatively, immediately postoperative and on the 3rd postoperative day; and length of intensive care unit and hospital stay were collected after patient was released.

Pulmonary function was assessed by spirometry (Sibelmed spirometer, Datospir Micro C model). The variables analyzed were forced vital capacity, forced expiratory volume in one second, and their ratios (forced expiratory volume in one second/ vital capacity and forced expiratory volume in one second/ forced vital capacity), measured in liters and predicted percentage,[12,14] following the guidelines of the American Thoracic Society[14] and the Brazilian Society of Pulmonology and Tisiology.[12] The values obtained in tests were compared to predicted normal values, appropriate for the population evaluated.[15]

Respiratory muscle strength was assessed by manovacuometry (Globalmed manovacuometer, MV300 model) and was performed according to the guidelines of the American Thoracic Society[16] and the Brazilian Society of Pulmonology and Tisiology.[13] Maximum inspiratory pressure and maximal expiratory pressure were measured and predicted values were calculated according to Neder et al.[17]

Pain was assessed by visual analogue scale with a scale from zero to ten, considering zero for no pain and ten for maximum pain.[18] The evaluation was performed preoperatively and on the 3rd postoperative day, before and after the pulmonary function and respiratory muscle strength tests. If pain equal to or greater than six, tests were not performed at this time. 30 minutes after, and after medicated as prescribed, patients were reevaluated and if they persisted with pain equal to or greater than six, no tests were performed.

Radiological changes were assessed by chest X-ray. Was examined the presence of atelectasis, pleural effusion, pulmonary edema, pulmonary consolidation and pneumothorax. According to the cardiac care routine of the intensive care unit, on immediately postoperative the chest X-ray was performed in bed in the intensive care unit. On the 3rd postoperative day the patient was transported to Radiology Service for a chest X-ray in two incidences (anteroposterior and side view). The scale proposed by Staton et al.[19] was used to quantify the radiological changes, assessed by blinded physician and physical therapist (Supplemental Table 1).

Pulmonary complications and length of stay in the intensive care unit were recorded after discharge from the cardiac intensive care unit; length of hospital stay was recorded after hospital discharge. This was collected by consulting the electronic medical record. Based on the definitions of the European Journal of Anaesthesiology,[20] were considered pulmonary complications: atelectasis, pleural effusion,

pneumothorax, pneumonia, respiratory infection and respiratory failure (Supplemental Table 2).

Data analysis

The sample size was calculated based on the study published by Westerdahl et al., 2005[7] to compare the forced vital capacity, in the postoperative moment, between the intervention group and the control group expecting to detect a difference of 7% and standard deviation of 13%, adopting a significance level of 5% and a power of 80%. The sample size required was 54 patients for each group. The calculation was performed in the software *Lee* http://www.lee.dante.br/pesquisa/amostragem/calculo_amostra.html.

Descriptive statistics were used to present the data, according to the Shapiro-Wilk normality test, using mean and standard deviation for symmetrical data and median and interquartile range for asymmetric data. Categorical variables were presented as absolute and percentage values. Baseline characteristics between groups were compared using the Kruskal-Wallis test and ANOVA for quantitative variables, and Pearson's chi-square test for categorical variables. The mixed model ANOVA was used to compare the other variables between the groups and between the moments. The ordinal logistic regression model for correlated data was used to compare variables between groups and between moments regarding the outcome pulmonary changes (pulmonary edema) using the generalized estimating equations. Only a descriptive analysis was performed for the other pulmonary changes, due to the small number of changes observed. The analyses were performed by intention-to-treat, except for the outcome respiratory muscle strength. A value of $P < 0.05$ was considered significant. The Statistical Package for Social Sciences-SPSS version 18.0 was used for data analysis.

Results

One hundred and twenty-six patients were evaluated. Forty-eight were included and 16 were randomized to each group (Figure 1). Demographic, surgical and postoperative data did not significantly differ between the three groups, except for smoking ($P=0.02$). Regarding the number of physiotherapeutic care, 25 patients (G1 = 9, G2 = 7, G3 = 9) performed four sessions and 23 patients (G1 = 7, G2 = 9, G3 = 7) performed five sessions, with no difference between the three groups. Regarding the surgical and postoperative variables, there was no difference between groups (Table 1).

Forced vital capacity and forced expiratory volume in one second % predicted, showed significant reduction from the preoperative to the 3rd postoperative in all groups ($P < 0.001$), except for forced expiratory volume in one second/ forced vital capacity % predicted, with no difference between groups ($P > 0.05$) (Table 2).

Maximum inspiratory pressure and maximum expiratory pressure presented significant reduction from the preoperative to the 3rd postoperative day in all groups ($P < 0.001$), with no difference between them ($P > 0.05$) (Table 2).

Pain was assessed in 35 patients (G1 = 13, G2 = 12, G3 = 10). None of the patients had pain equal to or greater than six before pulmonary function and respiratory muscle strength tests. There was a significant increase in pain from the preoperative to the 3rd postoperative day, before and after the tests in all groups ($P < 0.001$), with no different between them ($P > 0.05$). There was no significant increase on the 3rd postoperative day before [G1: 1 (0–5), G2: 0 (0–5) e G3: 0 (0–4)] and after [G1: 1 (0–6), G2: 2.5 (0–5) e G3: 0 (0–4)] the tests in the three groups ($p>0.05$), with no difference between them ($P > 0.05$).

For radiological changes (except pulmonary edema) statistical comparison tests between groups could not be performed due to the small number of changes observed. Described analysis was performed. Pulmonary edema was the only change that could be compared between moments and groups. Significant increase was found in all groups from the preoperative to the immediately postoperative and to the 3rd postoperative day ($P < 0.001$), with no difference between them ($P > 0.05$) (Table 3).

About pulmonary complications, one patient (6.3%) from G3 had pleural effusion from the preoperative the 3rd postoperative day, and one patient (6.3%) from G1 developed pneumothorax on the

Table 2. Preoperative and 3rd postoperative pulmonary function and respiratory muscle strength.

	G1 ($n=16$)		G2 ($n=16$)		G3 ($n=16$)		*P*		
	Preoperative	3rd post-op	Preoperative	3rd post-op	Preoperative	3rd post-op	Group	Time	Interaction
FVC% predicted	70 ± 18	41 ± 12	84 ± 18	41 ± 20	83 ± 23	49 ± 22	0.30	<0.001	0.11
FEV_1% predicted	72 ± 15	42 ± 13	88 ± 22	42 ± 20	85 ± 24	51 ± 19	0.23	<0.001	0.21
FEV_1/FVC% predicted	108 ± 14	106 ± 17	109 ± 16	108 ± 20	106 ± 14	111 ± 10	0.88	0.71	0.42
MIP% predicted	52 (21–98)[a]	26 (13–43)[a]	64 (15–111)[a]	28 (6–75)[a]	64 (19–116)[a]	32 (8–61)[a]	0.34	<0.001	0.74
MEP% predicted	68 (33–107)[a]	46 (21–73)[a]	63 (30–123)[a]	42 (13–82)[a]	77 (16–134)[a]	41 (21–89)[a]	0.31	<0.001	0.25

G1: conventional physiotherapy group; G2: PEP (positive expiratory pressure) blow-bottle device; G3: EPAP (expiratory positive airway pressure) group; FVC: forced vital capacity; FEV_1: forced expiratory volume in the first second of expiration; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure, post-op: postoperative.
Data expressed as mean ± standard deviation.
[a]Median and interquartile range.

3rd postoperative day, with no significant difference between groups ($P > 0.05$).

Regarding length of intensive care unit stay and length of hospital stay, there was no significant difference between groups. The median values were (length of intensive care unit stay: G1: 3 (3–8), G2: 3 (3–8), G3: 3 (2–8) days, $P = 0.89$, and length of hospital stay: G1: 8.5 (5–22), G2: 7 (6–20) e G3: 7(6–20) days, $P = 0.19$).

Discussion

In the present study we have shown that there was no difference regarding the use of positive expiratory pressure (blow-bottle device and expiratory positive airway pressure) compared to conventional physiotherapy on pulmonary function, respiratory muscle strength, pulmonary complications, presence of radiological changes, lengths of intensive care unit stay and hospital stay. Thus, the use of positive expiratory pressure did not bring additional effects on conventional physiotherapy and both positive expiratory pressure techniques were similar. We emphasize that the reduced sample size in our study suggest new studies with larger numbers of patients to increase the study power.

Our study observed reduction in pulmonary function after cardiac surgery, in agreement with other studies[8,21] even after positive expiratory pressure increased.[9,22,23] Other studies have shown different results.[7,8] According to Westerdahl et al., the group that performed exercises with positive expiratory pressure blow-bottle device had better pulmonary function on the 4th postoperative day, compared to the control group.[7] Comparing our data with this study, we observed that the favorable findings in the intervention group may have been due to the longer follow-up and higher number of sets and repetitions. We emphasize that in our study all groups performed pulmonary expansion techniques, this could justify the fact that we did not find difference between groups, since the literature demonstrates the beneficial effect of respiratory physiotherapy on pulmonary function without superiority between the techniques.[24]

In our study, respiratory muscle strength decreased from the preoperative to the 3rd postoperative day in all groups.[3,8] We emphasize that in our study there

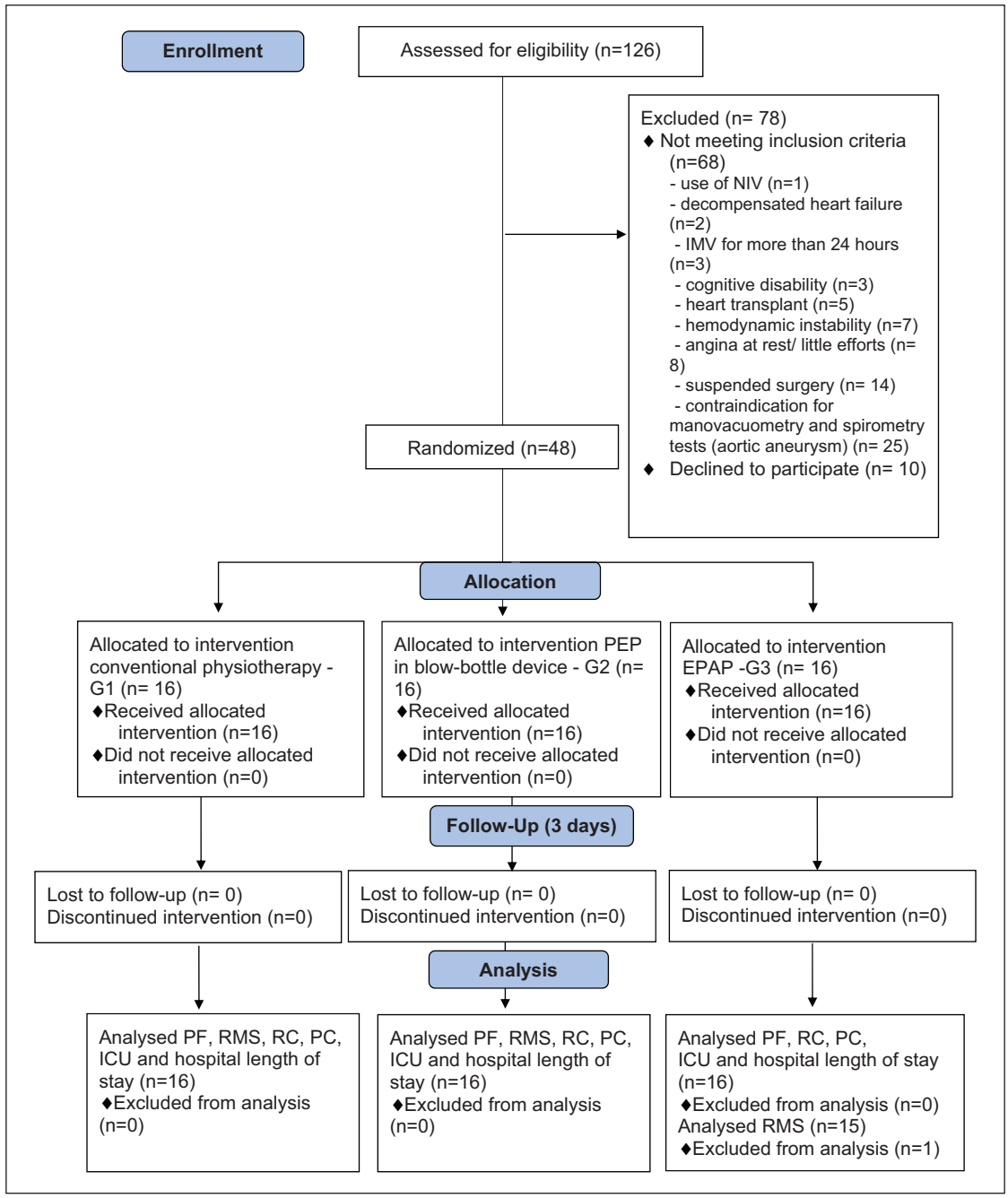

Figure 1. Flow diagram of eligible patients.
NIV: noninvasive ventilation; IMV: invasive mechanical ventilation; EPAP: expiratory positive airway pressure; PEP: positive expiratory pressure; PF: pulmonary function; RMS: respiratory muscle strength; RC: radiological changes; PC: pulmonary complications; ICU: intensive care unit.

Table 3. Radiological changes in the preoperative, immediate postoperative and 3rd postoperative periods.

Score	G1 ($n=16$)			G2 ($n=16$)			G3 ($n=16$)		
	pre-op *n* (%)	1 post-op *n* (%)	3rd post-op *n* (%)	pre-op *n* (%)	1 post-op *n* (%)	3rd post-op *n* (%)	pre-op *n* (%)	1 post-op *n* (%)	3rd post-op *n* (%)
Pleural effusion									
0	13 (81.3)	6 (37.5)	4 (25)	16 (100)	10 (62.5)	2 (12.5)	15 (93.7)	4 (25)	3 (18.8)
1	2 (12.5)	7 (43.7)	9 (56.2)	0 (0)	6 (37.5)	14 (87.5)	0 (0)	10 (62.5)	9 (56.2)
2	0 (0)	3 (18.8)	3 (18.8)	0 (0)	0 (0)	0 (0)	1 (6.3)	2 (12.5)	3 (18.8)
3	1 (6.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (6.3)
Atelectasis									
0	14 (87.5)	5 (31.3)	3 (18.8)	16 (100)	7 (43.7)	3 (18.8)	16 (100)	3 (18.8)	1 (6.3)
1	2 (12.5)	11 (68.7)	13 (81.2)	0 (0)	8 (50)	12 (75)	0 (0)	13 (81.2)	15 (93.7)
2	0 (0)	0 (0)	0 (0)	0 (0)	1 (6.3)	1 (6.3)	0 (0)	0 (0)	0 (0)
Consolidation									
0	16 (100)	16 (100)	16 (100)	16 (100)	16 (100)	16 (100)	16 (100)	15 (93.8)	16 (100)
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (6.3)	0 (0)
Pulmonary edema									
0	14 (87.4)	5 (31.2)	9 (56.1)	15 (93.7)	4 (25)	8 (50)	13 (81.2)	2 (12.4)	7 (43.8)
1	1 (6.3)	5 (31.2)	3 (18.8)	0 (0)	4 (25)	4 (25)	1 (6.3)	3 (18.8)	5 (31.2)
2	1 (6.3)	3 (18.8)	3 (18.8)	1 (6.3)	6 (37.5)	4 (25)	2 (12.5)	8 (50)	2 (12.5)
3	0 (0)	3 (18.8)	1 (6.3)	0 (0)	2 (12.5)	0 (0)	0 (0)	3 (18.8)	2 (12.5)
Pneumothorax									
0	16 (100)	16 (100)	15 (93.7)	16 (100)	16 (100)	16 (100)	16 (100)	16 (100)	16 (100)
1	0 (0)	0 (0)	1 (6.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

G1: conventional physiotherapy group; G2: PEP (positive expiratory pressure) blow-bottle device; G3: EPAP (expiratory positive airway pressure) group; pre-op: preoperative; 1 post-op: immediate postoperative; post-op: postoperative.
Data expressed as absolute values and percentage.

was no specific training for respiratory muscles, which could justify these results. However, other studies that used expiratory positive airway pressure suggest an additional effect on recovery of respiratory muscle strength. These divergent data can be explained by differences in the intervention protocol, like longer follow-up and higher number of sets and repetitions.[8,25] One justification for improving respiratory muscle strength is the stimulation of the respiratory muscles by training with expiratory positive airway pressure exercises, which stimulate deeper inspirations and allow greater alveolar recruitment.[25]

Another outcome assessed was radiological changes. The most frequent were atelectasis, pleural effusion and pulmonary edema. According to literature data, atelectasis is present in 50% to 90% of chest x-Rays[1] and pleural effusion in at least 40% after cardiac surgery.[26] These pulmonary changes may be associated with surgical factors, endothelial injury and inflammatory response secondary to the use of cardiopulmonary bypass. In addition, postoperative-related factors such as difficulty coughing, shallow inspirations and immobility contribute to pulmonary changes.[1,27]

Only two patients had pulmonary complications such as pleural effusion and pneumothorax. The low incidence can be explained due to advances in the surgical area, care in the postoperative, and physiotherapy from the beginning of the postoperative.[21] Still, length of intensive care unit stay and total length of hospital stay were similar, with no significant difference between groups. This may be explained by the low incidence of pulmonary complications, which could prolong the length of stay.

In the literature, there is no consensus on the number of sets, repetitions and frequency of physiotherapeutic care.[7,9,22] We emphasize that in our study the time of follow-up, three days, was chosen because it is the average length of stay of these patients in the intensive care unit of the hospital, so the protocol was performed according to the routine of care. Despite the protocol being performed twice a weekday and once a weekend, no difference was found between the groups. We chose not to perform the techniques unsupervised, due to the difficulty of objectively measuring their performance, besides the fact that improperly performing the techniques may not promote pulmonary expansion.

As strengths of the study: is the first study that compares the two techniques of positive expiratory pressure (blow-bottle device and expiratory positive airway pressure) in the postoperative cardiac; the blinding of outcome assessors; and allocation concealment. Therapists and patients could not be blinded, since the techniques were different.

Limitations include: reduced sample size, which generated a power of 35% to detect the differences described in the sample calculation, suggesting the need for new randomized controlled trials with larger numbers of patients to increase the study power; inclusion of different types of cardiac surgeries; short follow-up until the 3rd postoperative day; number of sets and repetitions of the techniques, since there is no consensus in the literature as to the ideal number to be performed; difficulty in generalizing the findings for patients undergoing emergency surgery.

In conclusion, both positive expiratory pressure techniques associated with conventional physiotherapy were similar, but there was no difference regarding the use of positive expiratory pressure compared to conventional physiotherapy alone in patients on the 3rd postoperative day of cardiac surgery regarding pulmonary function, respiratory muscle strength, pulmonary complications, presence of radiological changes, length of intensive care unit stay and length of hospital stay. New, expanded randomized controlled trials are needed to increase the power of the information.

Clinical messages

- There was no difference regarding the use of positive expiratory pressure compared to conventional physiotherapy regarding pulmonary function, respiratory muscle strength, pulmonary complications, radiological changes, length of intensive care unit and hospital stay.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics approval

Research Ethics Committee of the Hospital de Clínicas de Porto Alegre (CAEE: 70213617.6.0000.5327) approved this study.

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Supplemental material

Supplemental material for this article is available online.

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