REVIEW ARTICLE

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Respiratory physiotherapy in the pulmonary dysfunction after cardiac surgery

Fisioterapia respiratória na disfunção pulmonar pós-cirurgia cardíaca

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Abstract

The aim of this study is to make a literature review about the different techniques of respiratory physiotherapy used after cardiac surgery and their effectiveness in reverting pulmonary dysfunction. It has been used as reference publications in English and Portuguese using as keywords thoracic surgery, respiratory exercises, physiotherapy modalities, postoperative complications and coronary artery bypass grafting, contained in the following databases - BIREME, SciELO Brazil, LILACS, PUBMED, from 1997 to 2007. A secondary study through list of references of identified articles also was performed. It has been selected eleven randomized trials (997 patients). Among the articles included in this study, incentive spirometry was used in three; deep breathing exercises in six; deep breathing exercises associated with positive expiratory pressure in four and positive expiratory pressure associated with inspiratory resistance in two. Three studies used intermittent positive pressure breathing. Continuous positive airway pressure and bi-level positive airway pressure has been used in three and two studies respectively. The protocols used in the studies were varied and the co-interventions were present in most of them. The different analyzed variables and the time of postoperatory follow-up make a comparative analysis difficult. Pulmonary dysfunction is evident in the postoperatory period of cardiac surgery. The use of non-invasive ventilation has been associated with good results in the first postoperatory days. Despite the known importance of postoperatory respiratory physiotherapy, until now, there is no consensus in the literature about the superiority of one technique over the others.

Descriptors: **Thoracic Surgery. Breathing exercises. Physical therapy modalities. Postoperative complications. Myocardial revascularization.**

Resumo

O objetivo deste trabalho é realizar uma revisão de literatura sobre as diferentes técnicas de fisioterapia respiratória utilizadas no pós-operatório de cirurgia cardíaca, assim como sua efetividade na reversão da disfunção pulmonar. Foram utilizadas como referências publicações em inglês e português, cujos descritores foram cirurgia torácica, exercícios respiratórios, modalidades de fisioterapia, complicações pós-operatórias e revascularização miocárdica, contidas nas seguintes fontes de dados: BIREME, SciELO Brazil, LILACS e PUBMED, de 1997 até 2007. Pesquisa secundária por meio de lista de referências dos artigos identificados foi também realizada. Foram selecionados onze ensaios clínicos randomizados (997 pacientes). Dos estudos incluídos, espirometria de incentivo foi utilizada em três, exercícios de respiração profunda em seis; exercícios de respiração profunda associados a pressão expiratória positiva em quatro e pressão expiratória positiva acrescida de resistência inspiratória em dois. Três trabalhos utilizaram respiração com pressão positiva intermitente. Pressão positiva contínua nas vias aéreas e pressão positiva em dois níveis foram empregados em três e dois, respectivamente. Os protocolos utilizados foram variados e as co-intervenções estiveram presentes em grande parte deles. As diferentes variáveis analisadas e o tempo de

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acompanhamento pós-operatório tornam difícil a análise comparativa. A disfunção pulmonar é evidente no pós-operatório de cirurgia cardíaca, e a utilização de ventilação não-invasiva tem sido associada a resultados positivos nos primeiros dias de pós-operatório. Apesar da conhecida importância da fisioterapia respiratória pós-operatória, não há, até o momento, consenso na literatura sobre a superioridade de uma técnica em relação às demais.

Descritores: **Cirurgia torácica. Exercícios respiratórios. Modalidades de fisioterapia. Complicações pós-operatórias. Revascularização miocárdica.**

INTRODUCTION

Cardiovascular diseases are among the main causes of death in developed countries, and their incidence has been increasing epidemically in developing countries [1]. Heart surgery procedures are still widely used worldwide for treatment of patients with these problems [2], and the rates of postoperative complications (PO) related to them are still significant, especially pulmonary complications [1,3-6]. In a review involving 115,021 heart surgeries (HSs), Ribeiro et al. [7] found an overall mortality rate of 8%, occurring most often during the postoperative (PO), with pulmonary complications as one of the prevalent causes.

For most patients, HS results in some degree of pulmonary dysfunction, and may or may not evolve into pulmonary complications. The presentation of pulmonary dysfunction after HS is secondary to the use of cardiopulmonary bypass (CPB), anesthetic induction and surgical trauma [4,5,8], in addition to factors related to the patient's preoperative condition, such as age [9,10] and smoking habits [10]. CPB is responsible for ischemia-reperfusion syndrome, which results in the release of proteolytic enzymes and free radicals, causing tissue injury [11]. Anesthetic induction is identified as a causal factor of ventilation-perfusion disturbance that is likely secondary to atelectasis and airway closure [12]. Moreover, median sternotomy contributes to threats to the patient's condition, because it reduces the stability and complacency of the chest wall [13-15]. In this context, PO pain and the presence of drains are directly involved in the maintenance of low lung volumes [16-20].

Taking into account the presentation of pulmonary dysfunction associated with HS and its possible repercussions, respiratory physiotherapy has been requested in order to reverse or minimize such presentations, and to avoid the development of pulmonary complications [21-23], by using a great variety of techniques.

The aim of this study is to perform a literature review of the different techniques of respiratory physiotherapy used in heart surgery in the PO, as well as their effectiveness in the reversal of PO pulmonary dysfunction.

METHODS

Search Strategy

Using a primary and secondary search strategy, we performed a literature review of the different techniques of respiratory physiotherapy used in the PO of heart surgery and their effectiveness in the reversion of pulmonary dysfunction, using as publications in English and Portuguese as references. The descriptors used were thoracic surgery, respiratory exercises, physiotherapy modalities, postoperative complications and CABG, and were searched for in the following data sources: BIREME, SciELO Brazil, LILACS and PUBMED from 1997 until 2007. We avoided an excess of similar studies. A secondary search through the considered articles' list of references was also performed.

Criteria for the selection of studies

Randomized clinical studies were selected for analysis if they had more than 20 patients and adults who had undergone HS, and if they compared different techniques of respiratory physiotherapy, or if they compared these techniques to procedures without respiratory physiotherapy in the PO. We also selected articles about HS and its pulmonary repercussions in order to introduce the subject and provide a stronger theoretical base.

Variables analyzed

The analyzed variables included pulmonary oxygenation (oxygen saturation - $SatO_2$, partial pressure of oxygen in arterial blood - PaO_2, oxygenation index - PaO_2/FiO_2) [20,22-28]; lung function measured by spirometry (forced expiratory volume in the first second - FEV1, vital capacity - VC, forced vital capacity - FVC, peak expiratory flow - PEF, forced expiratory flow between 25 and 75% of FVC - FEF 25-75%) [20-22,24,26,29, 30]; chest x-rays, including signs of atelectasis [20,21,23,24,26]; time of hospital stay [20,23]; rates of lung infection [20.23], respiratory muscle strength (maximum inspiratory pressure - MIP, and maximal expiratory pressure - MEP) [27,29,30]. Two of the included studies analyzed the results of thoracic computed tomography (TCT) [22.28].

RESULTS AND DISCUSSION

In most cases, patients undergoing HS develop PO pulmonary dysfunction [32] with a significant reduction in lung volume [15,21,22,24,32,33], damage to respiratory mechanics [13,14], a decrease in lung compliance, and increased respiratory work [31.34]. The reduction in lung volume and capacity contributes to changes in gas exchange, resulting in hypoxemia [15,17,28,33,35] and decreasing diffusion capacity [21]. Restrictive presentation often persists over more than 116 days [32,36].

The most common radiological changes observed in the PO is atelectasis [22,26,28,36,37]. These findings were radiologically confirmed [21] by TCT [28], mainly in relation to the left lower lobe. Atelectasis is related to damage in gas exchange and reduction in lung volumes, and reduces functional residual capacity (FRC) and lung compliance. Atelectasis is considered clinically relevant when it grows or is persistent, when it is associated with hypoxemia, or when there is an increase in respiratory work or others signs of effort [37]. However, O'Donohue et al. [37] reported that only a small fraction of these patients will present severe clinical complications. Findings on pleural effusion are also frequent. It was found at a rate of 32% and 43.9% on the 2nd and 3rd postoperative day (POD), respectively [20]. Westerdahl et al. [21] found it in 63% of patients on the 4th POD, data similar to the study of Vargas et al. [38], on which the authors used TCT as preliminary tool.

A decrease in the expansion of lower lung lobes is often caused by a weak cough, a reduction in mobility, and muscle fatigue associated with physiological respiratory and diaphragmatic changes that result in superficial and predominantly thoracic breathing [39]. Lung damage in reinsufflation may maintain or worsen the patient's poor condition, which will contribute to the development of pneumonic processes [19].

Lung infections, whose prevalence ranges between 3.5% [23] and 10% [20], also contribute to the morbidity related to HS. Westerdahl et al. [22] found no signs of lung infection in any of the patients the authors included. It is important to note that there is no consensus about the diagnostic criteria being cited, including radiological changes [23], the presence of leukocytosis [23], elevated body temperature [20.23], and the isolation of pathogens in cultures or sputum microscopy [20.23].

Taking into account the presentation of pulmonary dysfunction associated with HS and its possible repercussions, a better understanding and more research about the available resources today to reverse this situation is crucial. Within this context, respiratory physiotherapy has increasingly been requested [40], because it uses techniques capable of improving respiratory mechanics, pulmonary re-expansion and bronchial hygiene [22.41]. However, systematic review of the literature shows that there are controversies about the aforementioned subject, making it difficult to decide which resource would be more useful and less expensive in the management of these patients [42]. The techniques used in respiratory physiotherapy vary by country and practice.

In order to evaluate the different techniques of respiratory physiotherapy used in PO HS and their effectiveness in reversing pulmonary dysfunction, 11 randomized clinical trials (Table 1) were selected. These trials were performed in five countries with adults who had undergone HS. All trials included had samples larger than 20 patients. Among the studies included, incentive spirometry (IS) was performed in three of them [20,24,27], deep breathing exercises (DBE) were used in six [20,21,23,28-30]; DBE associated with positive expiratory pressure (PEP) was used in four [21,22,28,29] and PEP associated with respiratory resistance (PEP-IR) was used in two [21.28]. Breathing with intermittent positive pressure (BIPP) was used in three studies [25,27,30]; continuous positive airway pressure (CPAP) was used in two [24 , 26], bi-level positive airway pressure (BiPAP) was used in three studies [24-26]. Two clinical trials used a control group that didn't receive respiratory physiotherapy [22.23].

The studies included ranged from 21 [30] to 198 [23] patients, totaling 997 patients, and there was a variable of no uniformity among the analyzed studies (more specifically, among the patient profiles). Westerdahl et al. [21] restricted the studied population to males. Three studies [22,29,30] reported the inclusion of patients who underwent HS, not specifying the type of performed surgeries. Brasher et al. [23] included patients who underwent coronary artery bypass grafting (CABG) and valve replacement. Only five studies described the techniques of randomization used [20,21,23,26,27].

The use of IS in the U.S. has reached 95% in cases of atelectasis [43], and it is performed by slow and deep breaths starting at FRC and reaching total lung capacity, sometimes followed by sustained respiration [44], and provides a visual feedback for patients. Several studies have reported the use of IS in PO HS [20,24,27]. The technique provokes an increase in negative pleural pressure, thus increasing transrespiratory pressure and ultimately causing better gas flow between the airways to the alveoli, as well as increased lung expansion [44].

The studies compared the performance of incentive spirometry volume with different techniques, including CPAP [24], DBE [20], BIPP [27], BiPAP [24]. In one study [24], IS was associated with less favorable results in the improvement of VC, FEV1 and PaO2 when compared to other techniques (CPAP and BiPAP). In another randomized clinical trial [20], the addition of IS to respiratory physiotherapy (DBE, early mobilization and techniques of

Table 1. Summary of the Included Studies

Author/ Date/ Type of study	Population	Groups/protocol	Variable analyzed	Results
Crowe and Bradley[20] / 1997/ RCT	PO high-risk CABG(n= 185)	RCT + EM (n= 95); RCT + IS + EM (n=90)*	TCT/ PFT (FVC, VEF_1) / $SatO_2$/ pulmonary infection/ hospital stay	No significant difference between the groups
Matte et al.[24] / 2000/ RCT	PO CABG (n= 90)	IS + EM (n=30) 20x every 2 hours; CPAP + EM (n=30) 5 cmH_2O 1hour every 3 hours; BiPAP+ EM (n=30) 12-5 cmH_2O 1 hour every 3 hours	Blood gas/ PFT (VC, VEF_1) / TCT	BiPAP and CPAP showed superior to IS in blood gas assessment and PFT, between 1st e 2nd DPO (*P*<.001)
Westerdahl et al.[21] / 2001/ RCT	PO CABG (n=98)	PEP 3 x 10+ EM (n=36); PEP-IR 3x 10 + EM(n=30); DBE 3 x 10 + EM (n=32)	PFT (VC, CI, VEF_1, FRC, VR, TPC) / diffusion of carbon dioxide / VAS/ TCT	No significant difference between the groupsPEP showed less reduction in TPC(*P*=.01)
Brasher et al.[23] / 2003/ RCT	PO CABG and valve replacement (n=198)	DBE 4 x 5*+ EM (n=97); EM (n=101)	$SatO_2$/ verbal pain scale/ temperature/ TCT/ pulmonary complications/ hospital stay	No significant difference between the groups
Westerdahl et al.[28] / 2003/ RCT	PO CABG (n=61)	DBE 3 x 10 + EM (n=21); PEP 3 x 10 + EM (n=20); PEP-IR 3 x 10 + EM (n=20)	TCT/ PaO_2 / $PaCO_2$ before and immediately after intervention	Reduction in atelectatic areas (*P*<.001) and improvement of oxygenation (*P*<.05) in the three groups (no significant difference between the groups)
Pasquina et al.[26] / 2004/ RCT	PO heart surgery (n=150)	CPAP (n=75) 5 cmH_2O 4x 30 min; BiPAP(n=75) with PSV adjusted for VC 8-10 ml/kg and PEEP 5 cmH_2O 4x 30 min	PFT (VC, VEF_1) / TCT/ arterial gasometry/ VAS	BiPAP is superior to CPAP compared to atelectasias resolution (*P*=.02)/ no significant difference between the groups compared to PFT
Borghi-Silva et al.[29] / 2005/ RCT	PO heart surgery (n=24)	PEP 3x 20 + DBE 5x 20 + EM (n=8);DBE + EM (n=16) 5x 20	PFT (VC, FVC, VEF_1, PEF, $FEF_{25-75\%}$)/ PImax/ PEmax	PEP + DBE was more effective in recovery of pulmonary function and RMS (*P*<.05)
Westerdahl et al.[22] / 2005/ RCT	PO CABG (n= 90)	PEP + EM 3 x 10* (n=48); EM (n=42)	PFT (VC, FVC, VEF_1, CI, FRC)/ TCT/ PaO_2/ body temperature	Patients who performed exercises with PEP showed smaller atelectatic areas (p<.05)and less reduction in VEF_1 and FVC (*P*=.01)
Mendes et al.[30] / 2006/ RCT	PO heart surgery (n=21)	BIPP 20-30 cmH_2O - PEP 10 cmH_2O +DBE 5x 20 + EM (n=8);DBE 5 x20 + EM (n=13)	PFT (FVC, VEF_1, $FEF_{25-75\%}$, PEF) / PImax/ Pemax	No significant differences between groups
Muller et al.[25] / 2006/ RCT	PO CABG (n=40)	CPAP 5 cmH_2O 15 min/ h at 3 1as hs and 30 min at 24th e 48th h (n=20); BIPP 20-30 cmH_2O 15 min/ h at 3 1st hs and 30 min at 24th e 48th h (n=20)	VC,FR,dispnea index, the use of acessory muscle, chest X rays/ arterial gasometry	More effective BIPP with improvement in dyspnea levels,FR and use of accessory muscle (*P*<.01) and chest X rays. Both resources equally effective for gasometric variables (*P*<.05)
Romanini et al. [27] / 2007/ RCT	PO CABG (n=40)	IS 2 x 10 min (n=20); BIPP 2 x 10 min (n=20)	FR/ MV/ VC/ $SatO_2$/ VC/ PImax/ PEmax	More efficient BIPP to hypoxemia reversion (*P*<.01) / IS to improve respiratory muscle strength (*P*<.05)

*TPC: Total pulmonary capacity; VAS:Visual analogic scale; RCT: Randomized clinical trial; EM: Early mobilization; TCT: Thoracic computed tomography; PFT: Pulmonary function test; *. Guidance to perform; independently throughout the day* bronchial hygiene) was not more effective than the respiratory physiotherapy alone in reducing the occurrence of pulmonary complications, the length of hospital stay, radiological pulmonary function or $SatO_2$ improvement. In the early days of PO HS, the use of such resources was associated with greater difficulty in lung expansion due to restrictive factors such as pain [27], with questionable potential to prevent subsequent damage in lung function [24]. Romanini et at. [27] showed that IS was more effective than BIPP in strengthening the respiratory muscles, because it provides greater recruitment of motor units. However, it was less effective when used to reverse hypoxemia [27].

There were a variety of study protocols. There was no uniformity among the number of breathing treatments, the time of sustained respiration, or the number of series performed throughout the day, making it difficult to compare results. Some authors have suggested the treatment time [27]; others, the number of repetitions [24]. One of the studies did not provide this data; however, patients were instructed to perform exercises every hour [20]. The number of repetitions recommended by Matte et al. [24] was 20 every 2 hours. When using the time as parameter, two series of 10 minutes with an interval of five minutes between them were used [27].

DBEs, an easy-to-perform technique in which mechanical resources were not used, is also frequently preferred, consisting of slow and uniform nasal breathing followed by relaxed and uniform oral exhaling, aiming to increase lung expansion [22.41]. It is common to add positive expiratory pressure (PEP) to DBEs [22]. The provided expiratory resistance allows for slower emptying of the lungs and increased lung volume, preventing or reducing alveolar collapse and favoring expectoration [21.28]. The association of the respiration resistance with PEP (PEP-IR) focuses on active breathing, increasing the diaphragmatic demand and improving recovery [21].

Borghi-Silva [29] found better recovery of pulmonary function in the group that used PEP associated with DBEs and early mobilization (n=8), when compared to DBE and early mobilization alone (n=16). The authors noted that the use of PEP was more effective in restoring inhalation muscle strength. Using TCT, Westerdahl et al. [22] noted smaller areas with atelectasis in patients who underwent the DBE program associated with PEP compared to the control group, which had not performed breathing exercises, or which underwent only early mobilization. Spirometric variables were also close to the preoperative values; however, no differences were noted in terms of hospital stay and fever [22]. Some authors reported a significant decrease of the areas with atelectasis [28] and improvement in PaO_2 [28] after performing DBE, PEP-IR and PEP, with no significant difference between the groups.

Other studies were performed in order to compare the effectiveness of DBE with other forms of respiratory physiotherapy [20,30] or with groups that did not receive respiratory physiotherapy during PO HS [23]. These studies failed to prove any superiority of DBEs. This may have occurred due to the patients' questionable adherence to the proposed treatment. It is crucial to fully perform the exercises in order to achieve effective treatment. For example, the deeper the breaths, the greater the chances for curing atelectasis will be [21].

Regarding this technique, there was also no uniformity in exercise time or the number of series. The DBEs were performed in four series of five breaths with 3 seconds of sustained breathing [23], five series of 20 exercises with a diaphragmatic breathing pattern and with fractionated breaths [29.30]. In Westendalh et al.'s studies [21,22,28], there were three series of 10 exercises with all the proposed techniques - DBE, PEP and PEP-IR. Most authors monitored the patients' exercises throughout the day [20-23].

CPAP, BiPAP and BIPP are ways to achieve non-invasive ventilation (NIV). Either a nasal or facial mask is used, which serves as an interface between the patient and the ventilator [45,46]. Such methods of ventilation serve to reduce respiratory function and improve respiratory gas exchange [45,46]. Positive effects were observed with the use of NIV, including improvements in BIPP [25,27], BIPP associated with PEP [30], CPAP [24-26] and BiPAP [24,26] in the first days after HS, when the breathing is characterized by low tidal volume, offset by increased respiratory rate [24]. The adoption of this pattern of breathing tends to favor the development and continuity of atelectasis and changes in gas exchange [25,26]. Compared to CPAP [25] and IS [27], BIPP was considered more effective in increasing tidal volume, providing pulmonary re-expansion with less ventilation function [25,27]. When compared to global mobilization and DBE, no additional effects related to the technique were observed [30].

It is important to point out that, despite the need for more intensive supervision, NIV does not depend on the patient's cooperation, and causes less pain [24,27]. Matte et al. [24] noted the superiority of BiPAP on CPAP due to the decrease in pulmonary shunts. Pasquini et al. [26] showed that BiPAP is better when compared to CPAP in promoting the reduction of atelectatic areas under chest radiography. However, the authors concluded that the resources are equally effective in reducing the negative effects of HS on lung function [24,26]. There were no studies comparing BiPAP to BIPP.

Commonly, CPAP was performed with pressure of 5 cmH_2O [24-26], lasting 1 hour in each 3-hour period [24], 15 minutes every hour in the first three hours after extubation [25], and for 30 minutes in the 24^{th} and 48^{th} hours [25], or for 30 minutes four times a day [26]. Bi-PAP was used for 1 hour in each 3-hour period, with breathing pressure of 12

cmH_2O and expiratory pressure of 5 cmH_2O [24], and four times daily for 30 minutes (expiratory pressure of 5 cmH_2O and breathing pressure sufficient to maintain the appropriate current volume) [26]. The BIPP technique was performed with pressure from 20 to 30 cmH_2O [26,31] for 15 minutes every hour in the first three hours after extubation, and for 30 minutes in the 24th and 48th hours [25], or three sets of 20 associated with a positive expiratory pressure of 10 cmH_2O [30]. Romanini et al. [27] applied BIPP in two sets of 10 minutes, with an interval of 5 minutes between them; however, the authors did not report the value of the pressure used. Hemodynamic effects associated with the application of positive pressure were not observed in any of the studies.

Co-interventions were present in most of the studies [21-24,26,28-30] and were not mentioned in only two of them [25,27]. The evaluators were blinded in five studies [21,22,25,26,28] and the patients in only one [26]. In Brasher et al's study [23] and Crowe and Bradley's study [20], only the radiologist was not aware of the allocation of patients.

A record of patient adherence to the treatment was maintained in some of the studies [20,23], which reported that only 15 of the 90 patients who underwent IS (16.6%) recorded its use. In another study, 79.4% of patients filled out the documentation form [23].

The use of effective methods of patient self-documentation may help to improve the reliability of results. It is important to ensure that the resources are within the patient's reach, allowing for its use throughout the day as recommended in the intervention protocols. Such care can ensure a higher rate of adherence. The variability in the studies' results may therefore arise from different frequencies of exercises performed, as well as the change in cooperation and commitment of the patients and professionals involved.

There was no uniformity among the days on which the patients underwent PO evaluation, ranging from 3 hours after extubation [25] to the 5th POD [25,29,30]. In one study, the evaluation was performed at the hospital [20]. This finding may be another contributing factor to the range of results. When no complications occur, the variables available tend to gradually return to preoperative levels, and favor the differences observed.

The variables analyzed were diverse, and the criteria used to evaluate a given variable were not homogeneous. The use of more sensitive diagnostic tests could have helped the analysis of the effects of respiratory physiotherapy in some of the studies included [22,28]. Using TCT, Westherdahl et al. [28] found significant improvement in oxidation levels and a reduction of atelectasis areas with only one set of breathing exercises.

We have observed that, despite the frequent recommendation of respiratory physiotherapy in the PO of HS and the wide range of techniques used to reverse the frequent pulmonary dysfunction in this period, there is no consensus about the best method to use. Studies [24-27] demonstrate the positive effects of NIV, especially BIPP [25,27] and BiPAP [24,26] in the first PO days. PEP showed positive results when compared to no breathing exercises [22] and DBE [29]. However, studies using TCT and gasometric analysis [21,28] and with more representative samples did not prove their superiority to DBEs. The results of these analyses suggest equality among DBE, PEP and PEP-IR. It is important to emphasize the importance of the professionals' experience and the exactness of the techniques, as well as the dedication of the patients and the teams involved in their care.

CONCLUSION

It is clear that HS commonly causes changes in lung function, as well as the use of respiratory physiotherapy intervention in reversing such changes. In the early PO days, when the pain is frequent, and there is the presence of drains and little cooperation from the patient, NIV - mainly BIPP and BiPAP - has been proven effective in the reversal of pulmonary dysfunction and prevention of complications. However, there is no consensus in the literature on the most appropriate physiotherapy technique in this period. There is need for well-designed studies and with comparable methods and techniques, including combined applications, performed with the aim of establishing effective programs for different practices and patient profiles.

REFERENCES

1. Reddy KS, Yusuf S. Emerging epidemic of cardiovascular disease in developing countries. Circulation. 1998;97(6):596-601.

2. Gelape CL, Sanches MD, Teixeira AL, Teixeira MM, Bráulio R, Pinto IF, et al. Preoperative plasma levels of soluble tumor necrosis factor receptor type I (sTNF-RI) predicts adverse events in cardiac surgery. Cytokine. 2007;38(2):90-5.

3. Babik B, Azstalos T, Peták F, Deák ZI, Hantos Z. Changes in respiratory mechanic during cardiac surgery. Anesth Analg. 2003;96(5):1280-7.

4. Cox CM, Ascione R, Cohen AM, Davies IM, Ryder IG, Angelini GD. Effect of cardiopulmonary bypass on pulmonary gas exchange: a prospective randomized study. Ann Thorac Surg. 2000;69(1):140-5.

5. Ng CS, Wan S, Yim AP, Arifi AA. Pulmonary dysfunction after cardiac surgery. Chest. 2002;121(4):1269-77.

6. Staton GW, Williams HW, Mahoney EM, Hu J, Chu H, Duke PG, et al. Pulmonary outcomes of off-pump vs on-pump coronary artery bypass surgery in a randomized trial. Chest. 2005;127(3):892-901.

7. Ribeiro AL, Gagliardi SP, Nogueira JL, Silveira LM, Colosimo EA, Lopes do Nascimento CA. Mortality related to cardiac surgery in Brazil, 2000-2003. J Thorac Cardiovasc Surg. 2006;131(4):907-9.

8. Taggart DP. Respiratory dysfunction after cardiac surgery: effects of avoiding cardiopulmonary bypass and the use of bilateral internal mammary arteries. Eur J Cardiothorac Surg. 2000;18(1):31-7.

9. Feier FH, Sant'Anna RT, Garcia E, De Bacco FW, Pereira E, Santos MF, et al. Modificações no perfil do paciente submetido a cirurgia de revascularização do miocárdio. Rev Bras Cir Cardiovasc. 2005;20(3):317-22.

10. Hulzebos EH, Van Meeteren NL, De Bie RA, Dagnelie PC, Helders PJ. Prediction of postoperative pulmonary complications on the basis of preoperative risk factors in patients who had undergone coronary artery bypass graft surgery. Phys Ther. 2003;83(1):8-16.

11. Clark SC. Lung injury after cardiopulmonary bypass. Perfusion. 2006;21(4):225-8.

12. Rothen HU, Sporre B, Engberg G, Wegenius G, Hedenstierna G. Airway closure, atelectasis and gas exchange during general anaesthesia. Br J Anaesth. 1998;81(5):681-6.

13. Berrizbeitia LD, Tessler S, Jacobowitz IJ, Kaplan P, Budzilowicz L, Cunningham JN. Effect of sternotomy and coronary bypass surgery on postoperative pulmonary mechanics. Comparison of internal mammary and saphenous vein bypass grafts. Chest. 1989;96(4):873-6.

14. Van Belle AF, Wesseling GJ, Penn OC, Wouters EF. Postoperative pulmonary function abnormalities after coronary artery bypass surgery. Respir Med. 1992;86(3):195-9.

15. Locke TJ, Griffiths TL, Mould H, Gibson GJ. Rib cage mechanics after median sternotomy. Thorax. 1990;45(6):465-8.

16. Giacomazzi CM, Lagni VB, Monteiro MR. A dor pós-operatória como contribuinte do prejuízo na função pulmonar em pacientes submetidos à cirurgia cardíaca. Rev Bras Cir Cardiovasc. 2006;21(4):386-92.

17. Guizilini S, Gomes WJ, Faresin SM, Carvalho ACC, Jaramillo JI, Alves FA, et al. Efeitos do local de inserção do dreno pleural na função pulmonar no pós-operatório de cirurgia de revascularização do miocárdio. Rev Bras Cir Cardiovasc. 2004;19(1):47-54.

18. Milgrom LB, Brooks JA, Qi R, Bunnell K, Wuestfeld S, Beckman D. Pain levels experienced with activities after cardiac surgery. Am J Crit Care. 2004;13(2):116-25.

19. Taylor GJ, Mikell FL, Moses HW, Dove JT, Katholi RE, Malik SA, et al. Determinants of hospital charges for coronary artery bypass surgery: the economic consequences of postoperative complications. Am J Cardiol. 1990;65(5):309-13.

20. Crowe JM, Bradley CA. The effectiveness of incentive spirometry with physical therapy for high-risk patients after coronary artery bypass surgery. Phys Ther. 1997;77(3):260-8.

21. Westerdahl E, Lindmark B, Almgren SO, Tenling A. Chest physiotherapy after coronary artery bypass graft surgery: a comparison of three different deep breathing techniques. J Rehabil Med. 2001;33(2):79-84.

22. Westerdahl E, Lindmark B, Eriksson T, Friberg O, Hedenstierna G, Tenling A. Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary artery bypass surgery. Chest. 2005;128(5):3482-8.

23. Brasher PA, McClelland KH, Denehy L, Story I. Does removal of deep breathing exercises from a physiotherapy program including pre-operative education and early mobilisation after cardiac surgery alter patient outcomes? Aust J Physiother. 2003;49(3):165-73.

24. Matte P, Jacquet L, Van Dyck M, Goenen M. Effects of conventional physiotherapy, continuous positive airway pressure and non-invasive ventilatory support with bilevel positive airway pressure after coronary artery bypass grafting. Acta Anaesthesiol Scand. 2000;44(1):75-81.

25. Muller AP, Olandoski M, Macedo R, Costantini C, Guarita-Souza LC. Estudo comparativo entre pressão positiva intermitente (reanimador de Muller) e contínua no pós-operatório de cirurgia de revascularização do miocárdio. Arq Bras Cardiol. 2006;86(3):232-9.

26. Pasquina P, Merlani P, Granier JM, Ricou B. Continuous positive airway pressure versus noninvasive pressure support ventilation to treat atelectasis after cardiac surgery. Anesth Analg. 2004;99(4):1001-8.

27. Romanini W, Muller AP, Carvalho KA, Olandoski M, Faria-Neto JR, Mendes FL, et al. The effects of intermittent positive pressure and incentive spirometry in the postoperative of myocardial revascularization. Arq Bras Cardiol. 2007;89(2):105-10.

28. Westerdahl E, Lindmark B, Eriksson T, Hedenstierna G, Tenling A. The immediate effects of deep breathing exercises on atelectasis and oxygenation after cardiac surgery. Scand Cardiovasc J. 2003;37(6):363-7.

29. Borghi-Silva A, Mendes RG, Costa FS, Di Lorenzo VA, Oliveira CR, Luzzi S. The influences of positive end expiratory pressure (PEEP) associated with physiotherapy intervention in phase I cardiac rehabilitation. Clinics. 2005;60(6):465-72.

30. Mendes RG, Borghi-Silva A. Eficácia da intervenção fisioterapeutica associada ou não à respiração por pressão positiva intermitente (RPPI) após cirurgia cardíaca com circulação extracorpórea. Rev Movimento. 2006;19(4):73-82.

31. Wynne R, Botti M. Postoperative pulmonary dysfunction in adults after cardiac surgery with cardiopulmonary bypass: clinical significance and implications for practice. Am J Crit Care. 2004;13(5):384-93.

32. Braun SR, Birnbaum ML, Chopra PS. Pre and postoperative pulmonary function abnormalities in coronary artery revascularization surgery. Chest. 1978;73(3):316-20.

33. Guizilini S, Gomes WJ, Faresin SM, Bolzan DW, Alves FA, Catani R, et al. Avaliação da função pulmonar em pacientes submetidos à cirurgia de revascularização do miocárdio com e sem utilização de circulação extracorpórea. Rev Bras Cir Cardiovasc. 2005;20(3):310-6.

34. Weissman C. Pulmonary function after cardiac and thoracic surgery. Anesth Analg. 1999;88(6):1272-9.

35. Andrejaitiene J, Sirvinskas E, Bolys R. The influence of cardiopulmonary bypass on respiratory dysfunction in early postoperative period. Medicina. 2004;40(Suppl 1):7-12.

36. Westerdahl E, Lindmark B, Bryngelsson I, Tenling A. Pulmonary function 4 months after coronary artery bypass graft surgery. Respir Med. 2003;97(4): 317-22.

37. O'Donohue WJ Jr. Prevention and treatment of postoperative atelectasis. Can it and will it be adequately studied? Chest. 1985;87(1):1-2.

38. Vargas FS, Uezumi KK, Janete FB, Terra-Filho M, Hueb W, Cukier A, et al. Acute pleuropulmonary complications detected by computed tomography following myocardial revascularization. Rev Hosp Clin Fac Med São Paulo. 2002;57(4):135-42.

39. Carvalho ACC, Oliveira EM, Souza JAM. Pós-operatório em cirurgia cardíaca. In: Knobel E, ed. Condutas no paciente grave. 2a ed. São Paulo:Atheneu;1998. p.1031-42.

40. Jerre G, Beraldo MA, Silva TJ, Gastaldi A, Kondo C, Leme F, et al. Fisioterapia no paciente sob ventilação mecânica. Rev Bras Ter Inten. 2007;19(3):399-407.

41. Azeredo CAC. SMI - Sustentação máxima da inspiração. In: Azeredo CAC, ed. Fisioterapia respiratória moderna. São Paulo:Manole;2002. p.121-42.

42. Pasquina P, Tramer MR, Walder B. Prophylactic respiratory physiotherapy after cardiac surgery: systematic review. BNJ. 2003;327(7428):1379.

43. O'Donohue WJ Jr. National survey of the usage of lung expansion modalities for the prevention and treatment of postoperative atelectasis following abdominal and thoracic surgery. Chest. 1985;87(1):76-80.

44. Wilkins RL, Scanlan CL. Terapias de expansão pulmonar. In: Scanlan CL,Wilkins RL, Stoller JK, eds. Fundamentos da terapia respiratória de Egan. 7a ed. São Paulo:Manole;2000. p.797-843.

45. Peñuelas O, Frutos-Vivar F, Esteban A. Noninvasive positive-pressure ventilation in acute respiratory failure. CMAJ. 2007;177(10):1211-8.

46. Valipour A, Cozzarini W, Burghuber OC. Non-invasive pressure support ventilation in patients with respiratory failure due to severe acute cardiogenic pulmonary edema. Respiration. 2004;71(2):144-51.