SCIENTIFIC UPDATE

Rev Bras Cir Cardiovasc 2012;27(3):446-52

Noninvasive mechanical ventilation in the postoperative cardiac surgery period: update of the literature

Ventilação mecânica não-invasiva no pós-operatório de cirurgia cardíaca: atualização da literatura

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DOI: 10.5935/1678-9741.20120074

RBCCV 44205-1405

Abstract

This study aimed to update knowledge regarding to noninvasive ventilation (NVI) on postoperative of cardiac surgery in addition at investigating if exists superiority of any modalities NVI in relation to the others. The literature review was performed on the period between 2006 and 2011, on PubMed, SciELO and Lilacs databases crossing the keywords: artificial respiration, continuous positive airway pressure, intermittent positive-pressure ventilation, cardiac surgery and their corresponding in English. Based on the criteria adopted, nine articles were selected being six of them use NVI, through the modalities such as continuous positive airway pressure, positive pressure with bilevel pressure and intermittent positive-pressure ventilation in postoperative of cardiac surgery; only three of them performed comparisons between different modalities. The NVI modalities that were described on the literature had showed satisfactory results. A few studies compare different NVI modalities; however some of them showed superiority in relation to the others, such as the intermittent positive-pressure ventilation to threat hypoxemia and to positive pressure with bilevel pressure to increase oxygenation, respiratory rate and heart rate in these patients, when compared with other modalities.

Descriptors: **Continuous positive airway pressure. Respiration, artificial. Pulmonary ventilation. Postoperative period.**

Resumo

Este estudo objetivou atualizar os conhecimentos em relação à utilização da ventilação mecânica não-invasiva (VMNI) no pós-operatório de cirurgia cardíaca e identificar se há indícios da superioridade de uma forma de modalidade de VMNI em relação à outra. Foi realizada revisão da literatura entre 2006 a 2011, a partir das bases de dados

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Article received on June 11th, 2012
Article accepted on August 14th, 2012

Abbreviations, acronyms & symbols	
BiPAP®	Bi-level positive airway pressure
CS	Cardiac surgery
CPB	Cardiopulmonary bypass
CPAP	Continuous positive airway pressure
VC	Vital capacity
CO	Cardiac output
CVD	Cardiovascular diseases
DeCS	Descriptors in Health Sciences
HR	Heart rate
CRP	Conventional respiratory physioterapy
IS	Incentive spirometry
RespF	Respiratory failure
MeSH	Medical Subject Headings
RM	Recruitment maneuver
PO	Postoperative
CABG	Coronary artery bypass grafting
IPPB	Intermittent positive pressure breathing
VPR	Ventilation perfusion rating
MV	Mechanical ventilation
NIV	Noninvasive mechanical ventilation

PubMed, SciELO e Lilacs, utilizando os descritores respiração artificial, pressão positiva contínua nas vias aéreas, ventilação com pressão positiva intermitente e cirurgia cardíaca, e seus correspondentes na língua inglesa, os quais foram pesquisados em cruzamentos. A partir dos critérios adotados, foram selecionados nove artigos, dos quais seis demonstraram aplicações de VMNI, por meio de modalidades como pressão positiva contínua nas vias aéreas, pressão positiva com dois níveis pressóricos e respiração com pressão positiva intermitente, no pós-operatório de cirurgia cardíaca, e, três realizaram comparações entre as diferentes modalidades. As modalidades de VMNI descritas na literatura foram utilizadas com resultados satisfatórios. Estudos que comparam diferentes modalidades são escassos, contudo alguns demonstraram superioridade de uma modalidade de VMNI, como é o caso da respiração com pressão positiva intermitente na reversão da hipoxemia e da pressão positiva com dois níveis pressóricos na melhora da oxigenação, da frequência respiratória e frequência cardíaca desses pacientes, em comparação a outras modalidades.

Descritores: **Pressão positiva contínua nas vias aéreas. Respiração artificial. Ventilação pulmonar. Período pós-operatório.**

INTRODUCTION

Cardiovascular diseases (CVD) are among the leading causes of death in developed countries and their incidence has increased in epidemic form in emerging countries [1]. Among the options for the treatment of these diseases, cardiac surgery (CS) has shown good results, contributed to rising expectations and improving the quality of life of patients with CVD [1-3].

Changes in lung function may occur after CS, which are responsible for increased postoperative (PO) morbidity and mortality [4] and are resulting from multifactorial interaction between anesthesia, surgical trauma, cardiopulmonary bypass (CPB), cardiac arrest, time of surgery, duration of mechanical ventilation (MV) and pain, which may lead, among others, to decrease in functional residual capacity, increased intrapulmonary shunt and enlargement of the alveolar-arterial oxygen [4,5].

In this context, noninvasive ventilation (NIV) has been important in the treatment of POCS, because its use improves alveolar ventilation and gas exchange, decreases ventilatory work, increases lung volumes and decreases the duration of mechanical ventilation, avoiding reintubation and, as a consequence, reducing the length of permanence in intensive care units [6-10].

Furthermore, the application of NIV reduces preload by reducing the venous return, reduces afterload in the left ventricle by reducing its transmural pressure and increases cardiac output (CO), which leads to improved heart performance as a pump [6.11].

The modalities of NIV with positive pressure used in the treatment of postoperative pulmonary complications in the POCS described in the literature are ventilation with continuous positive airway pressure (CPAP), BI-level Positive Airway Pressure (BiPAP ®) and intermittent positive pressure breathing (IPPB) [12,13]. The superiority of one modality over another NIV has not been clearly established in the literature [13].

In view of the above considerations, we understand the importance of studies that add new elements in the literature regarding this issue. Therefore, we aimed to update the literature regarding the use of NIV in the POCS and to identify if there is evidence of the superiority of NIV modality.

METHODS

Search strategy

The revisions were performed on April 2012, the references used were situated between January 2006 and December 2011. The Pubmed, Lilacs and SciELO databases were searched using the following subject keywords: artificial respiration, continuous positive airway pressure, intermittent positive-pressure ventilation, cardiac surgery. These words were defined by the Health Sciences Descriptors (DeCS) and their corresponding in English - Medical Subject Headings (MeSH).

The term noninvasive ventilation, while not considered a descriptor by the NLM - MESH, was included due to its wide use as a keyword. All references were also reviewed for completion of the research. The studies were selected by a reviewer and supervised by a senior reviewer.

Exclusion and Inclusion Criteria

We included studies published in the last five years, in English and Portuguese, with humans over 18 years old with heart diseases who have undergone some type of surgical intervention. We included randomized and nonrandomized controlled trials.

Abstracts of dissertations or academic thesis, studies in children and adolescents, and studies using NIV in other pathological conditions other than heart were excluded.

Selection Strategy

We initially performed the screening of titles related to the topic. This selection was based on titles that dealt as main idea: the application of NIV in POCS, several types of NIV used, the performances of physiotherapy on cardiac patients undergone CS and, finally, to present evidence of some NIV term information related to this word such as ventilation with continuous positive airway pressure, BI-level Positive Airway Pressure. At the end of the search, we excluded repeated titles, as this was performed in several databases. Then we read detailed summaries of articles in order to select those that addressed only the application of NIV in POCS. We excluded abstracts not related to the issue, the full texts were assessed and those that did not fit the exclusion criteria were included as the final result of the search.

Data Analysis

Data were qualitatively assessed and presented in tabular form with the description of the following profile: author and year of study, clinical characteristics of the population, the study objectives, ventilatory mode applied, variables and conclusions found.

RESULTS

The search in the databases resulted in 1447 titles. The first selection eliminated 1398 titles. Then we proceeded to assess the content of the summaries of the remaining 49 studies, of which 38 were eliminated for not meeting the criteria previously established. The 11 remaining articles were read in full and composed the review.

We found eight studies that used some modality of NIV in the POCS, which are described in Table 1.

Only three of the articles compared different NIV modalities in the POCS and were used to assess possible evidence of superiority of one NIV technique. These studies are described in Table 2.

DISCUSSION

Application of NIV in the CSPO.

Regarding the application of NIV in the POCS, eight studies demonstrated its application through the following modalities: CPAP, BiPAP ®, IPPB + PEEP and PSV, and most of the studies assessed showed positive evidence of the implementation of those modalities in the cardiac PO patients.

Figueiredo et al. [14] compared the rates of gas exchange after surgery in patients undergoing coronary artery bypass grafting (CABG) with or without CPAP during cardiopulmonary bypass (CPB) and found that the use of CPAP, although it resulted in better values in PaO_2/FiO_2 30 minutes after CPB, it showed no significant sustained effect on postoperative pulmonary gas exchange. The authors reported that was not possible to demonstrate that the application of CPAP during CPB prolonged beneficial effect on gas exchange during the PO. The authors cited as limitation the small population sample used, which may have influenced the results.

Other authors [15] assessed the efficacy of prophylactic CPAP, performed with a nasal mask at a pressure of 10 cmH_2O airway for six hours, compared with standard treatment in patients undergoing elective CS, and found that the prophylactic CPAP improved oxygenation pressure, reduced the incidence of pulmonary complications and decreased the rate of readmission in the intensive care unit. The authors attributed these results to airway pressures high enough (10 cmH_2O) throughout the respiratory cycle and maintaining such pressure for longer periods of time (six hours), which led to reduction in atelectasis.

The pulmonary effects of CPAP with or without intermittent recruitment maneuver (RM) in patients after CABG surgery were assessed by a randomized clinical trial, in which it was found that the RM provided higher blood oxygen level during the MV and after extubation compared

Table 1. Studies using NIV in PO CS, according to year of publication, from January 2006 to December 2011, in the Pubmed, Lilacs and SciELO databases.

Author and year	Population profile	Modality	Objectives	Variables analyzed	Conclusions
Franco et al. [17] 2011	26 patients (17 males). BIPAP group (n = 13) with respiratory physiotherapy associated with BIPAP for 30 min. Control group (n = 13): only respiratory physiotherapy.	BIPAP	To evaluate compliance, safety and efficacy of NIV related to respiratory physiotherapy in the immediate CABG PO.	Hemodynamic parameters (HR, BP, SpO2), respiratory variables (VC, MV and TV), blood gas and spirometric variables (MIP and MEP).	The use of BIPAP associated with respiratory physiotherapy was safe and well accepted by patients and increased VC.
Mazullo Filho et al. [6] 2010	32 patients in the immediate PO CS. Control Group (n = 18): aged 61.0 ± 16.2 years old, 11 male. Experimental Group (n = 14): aged 61.5 ± 9.4 years old, 8 males.	PSV+PEEP	To verify the effect of preventive NIV on the immediate PO CS following its impact until the sixth day of hospitalization.	Hemodynamics (HR, BP, SpO_2);Blood gas analysis (pH, PaO_2, PCO_2, HCO_3);FR;Spirometric variables (VC, MV and TV)	The NIV was effective on the PO CS group studied, because it increased VC, decreased RR, prevented the RF post extubation and reduced rates of reintubation.
Zarbock et al. [15] 2009	468 patients of both genders: Prophylactic CPAP group (n = 232): 10 min for nasal CPAP at 10 cmH2O for 6h. Control group (n = 236): 10 min of intermittent nasal CPAP at 10 cmH2O every 4h.	CPAP	To evaluate the efficacy of CPAP with a nasal mask compared with standard treatment in patients undergoing elective CS.	Pulmonary complications, PaO2/FiO2, nosocomial pneumonia, reintubation rate, readmission to the ICU or coronary care unit.	The administration of CPAP after CS improved arterial oxygenation, reduced the incidence of pulmonary complications and readmission rate in the ICU, it was suggested as a useful tool to reduce pulmonary morbidity following elective CS.
Figueiredo et al. [14] 2008	30 adult patients of both genders; CPAP group (n = 15) received CPAP during ECC. Control group (n = 15) did not receive CPAP.	CPAP	To compare the rates of gas exchange in the PO period in patients who received or not CPAP during ECC.	PaO_2/FiO_2;P (A-a)O_2;4 moments:Pre (immediatelly after ECC), Pos (30 min after ECC), POI (12h pos-surgerya) and 1.º PO (24h).	The use of CPAP improved PaO2/FiO2, 30 minutes after ECC, however, did not result in lasting benefits in gas exchange during the PO period.
Celebi et al. [16] 2008	RM group (n = 25): RM during MV in the PO period. RM-NIV group (n = 25): CPAP applied for 30 min every 6 h in a PO associated with RM. NIV group (n = 25): CPAP applied for 30 min every 6 h in the PO period. Control group (n = 25) received no MR nor NIV.	CPAP	To evaluate the pulmoary effects of NIV with or without RM post CABG.	Lung function tests;oxygenation index;Atelectasia through thorax x-ray.	The NIV associated with RM provided better oxygenation after CABG, it is recommended to prevent postoperative atelectasis and hypoxemia.
Mendes e Borghi-Silva [18] 2006	21 patients (14 male) GPPI (n=8): respiratory exercises with RPPI associates with PI; GIF (n=13): only PI.	RPPI	To evaluate changes in LF and RMS and efficacy of two protocols on patients submitted to ECC CS.	Spirometric variables (VC, FVC, FEV1, PF, FEF25-75, PImáx and PEmáx)	Patients submitted to CS with ECC presented reduced FP and RMS. None of the treatments applied (BIPP + IF or IF) showed better results.

N = number of subjects; CABG = coronary artery bypass grafting; HR = heart rate; BP = blood pressure; RR = respiratory rate; SpO_2 = oxygen saturation; TV = tidal volume; MV = minute volume; VC = vital capacity; FVC = forced vital capacity; FEV1 = forced expiratory volume at the first second; FEF25-75 = forced expiratory flow between 25 e 75%; MIP = maximal inspiratory pressure, MEP = maximal expiratory pressure; PO = postoperative day; CS = cardiac surgery; CABG = cardiopulmonary bypass grafting; VRS = valve replacement surgery, ASD = atrial septal defect; AN = aneurysm, pH hydrogen potential, O_2 = oxygen, PaO_2 = arterial partial pressure of O_2, PCO_2 = arterial partial pressure of carbon dioxide, HCO3 = bicarbonate, P (Aa) O2 = alveolar-arterial O2; ARF = acute respiratory failure; ICP = intracranial pressure; CT = computed tomography; U.S. = ultrasonography; h = hours; ICU = intensive care unit; DM = diabetes mellitus; HBP = hypertension; CAD = coronary artery disease; ECG = electrocardiography; RM = recruiting maneuver; GPPI = positive pressure group intermittent; PI = physiotherapy intervention; GIF = group physiotherapy intervention; LF = lung function, RMS respiratory muscle strength; NIV = noninvasive ventilation; BIPAP = pressure bi-level positive airway; PEEP + PSV = pressure support ventilation more positive end expiratory pressure; CPAP = continuous positive airway; IPPB = intermittent positive pressure breathing; ECC: Extracorporal circulation.

Table 2. Studies comparing different types of NIV in post-cardiac surgery, according to year of publication, from January 2006 to December 2011, in the Pubmed, Lilacs and SciELO databases.

Author and year	Population profile	Modality	Objectives	Variables analyzed	Conclusions
Romanini et al. [19] 2007	40 patients after CABG. RPPI group: (n=20; 40% female); Incentive spirometry group: (n=20; 20% dfemale)	RPPI (RM); Incentive spirometry	To analyze the physiotherapeutic effect of IPPB and incentive spirometry on patients submitted to CABG.	Age, weight, height, body mass index, surgical time, CABG time, number and location of drains, SpO2; TV, MIP and MEP.	IPPB was more efficient in reversing hypoxemia earlier compared to the incentive spirometry. To improve the strength of respiratory muscles, the incentive spirometry was more effective.
Coimbra et al. [20] 2007	57 patients: 22 submitted to CABG, 13 valvar replacement, 5 aneurism correction or aortic dissection, 3 CPT and 15 combined surgeries. Group A: PS + PEEP through NIV (n=19); Group B: CPAP (n=19); Group C: BiPAP (n=19)	CPAP; PS + PEEP; BiPAP	To verify ventilatory responses, oxygenation and hemodynamics in patients with RF after cardiac surgery, seeking success variables and compare the different modalities of NIV.	Respiratory parameters (RR); Oxygenation parameters(pH, PaO2, PCO2 and SpO2); Hemodyinamic parameters (HR and MAP)	There was improvement in oxygenation, RR, and HR during the application of NIV. In older patients with higher baseline RR and HR, NIV was not sufficient to reverse RF. Arrangements with two pressure levels showed better results.
Müller et al. 2006 [21]	40 patients submitted to CABG, 33 male and 7 female. CPAP group (n=20); IPPB group (n=20)	CPAP; IPPB (MR)	To compare the result from the application of CPAP and the application of IPPB in patients after cardiac surgery.	Blood gas parameters (pH, PaO2, PCO2 and SpO2); Respiratory parameters (TV, MV and RR); Physical examination (dyspnea and assessory muscle activity); Thorax x-ray (medical diagnosis)	Both resources maintained values of PO2, PCO2 and SpO2 within normal limits. For the pulmonary reexpansion with less imposed workload, the MR was more effective and presented lower levels of dyspnea, accessory muscle activity and FR.

N = number of subjects; CABG = coronary artery bypass grafting; HR = heart rate; MAP = mean arterial pressure; RR = respiratory rate; SpO_2 = oxygen saturation; TV = tidal volume; MV = minute volume; MIP = maximal inspiratory pressure, MEP = maximal expiratory pressure; CPT = chronic pulmonary thromboendarterectomy; pH = hydrogen potential; O_2 = oxygen; PaO_2 = arterial partial pressure of O_2, PCO_2 = arterial partial pressure of carbon dioxide; RF = respiratory failure; NIV = noninvasive ventilation; BIPAP = pressure bi-level positive airway; PSV + PEEP = pressure ventilatory support more positive end expiratory pressure; CPAP = continuous positive airway; IPPB = intermittent positive pressure breathing; RM = Müller resuscitation

with other interventions. Oxygenation was better in groups using CPAP compared to the control group and pulmonary function of NIV groups on the 2nd postoperative day was better than the other groups. The authors reported that CPAP has been used intermittently to avoid gastric distension, restricted oral intake, nausea and vomiting, and that NIV improved radiological scores of atelectasis [16].

A randomized clinical trial assessed the safety and compliance of preventive application of BiPAP ® in spontaneous mode with IPAP 8-12 cmH_2O and EPAP at 6 cm H_2O, twice daily for 30 minutes associated with conventional respiratory therapy (CRT) in patients in the immediate postoperative [17]. The authors found that the application of BiPAP ® was beneficial to restore lung function, especially vital capacity (VC), safely, and well accepted by patients, due to higher comfort with the sensation of pain during the execution of CRT and the use of BiPAP ® leads to an increase in the incursion chest with consequent improvement in the efficacy of cough, increased secretion clearance and airway patency, by improving the peak flow [17].

The preventive efficacy of NIV in the pressure support ventilation combined with positive end expiratory pressure (PEEP + PSV) for two hours, was assessed in the immediate

POCS in a randomized controlled trial, which showed significant results in hemodynamic and ventilatory variables assessed after NIV compared to post-extubation [6]. The hemodynamic benefits were attributed to the increase in VC, accompanied with increase in lung volume and decreased respiratory work, and maintenance of HR within the normal range [6].

Most studies assessed positive evidence of the NIV application in POCS such as: improvement in arterial oxygenation [14-16], cough improvement [15,16], reestablishment of lung function with increased VC [6 , 17], reduced incidence of pulmonary complications [15], benefic effects on readmission rates in intensive care units [15], and also increased clearance of secretions and airway permeability [6.15].

Comparison of different modalities of NIV in the POCS

We found only three studies that indicated any superiority of one NIV modality over another. Assessing hemodynamic and ventilatory parameters induced by the application of IPPB and incentive spirometry (IS) in patients undergoing CABG, Romanini et al. [19] showed that IPPB was more efficient in reversing hypoxemia earlier, and it was also more effective to improve the strength of the respiratory muscles. According to the authors the IPPB is a passive process of lung expansion that does not require active work of breathing, which in the initial stage of recovery from surgery may lead to increased pain, restrict respiratory expansion and change the ventilation-perfusion (V/Q), factors that may lead to the hypoxemia development [19].

Another comparison of different modalities of NIV in POCS was performed in patients with hypoxemic respiratory failure (RF), who were randomized in the CPAP, PSV + PEEP or BiPAP® modalities. Oxygenation variables and respiratory rate showed improvement only in the groups with two modalities pressure levels. However, regarding the occurrence of success and failure characterized as return or no return to mechanical ventilation, there was no significant difference between the modalities. The authors attributed this mechanism to the different causes that lead to RR, that in POCS, and it presents as main causes processes collapse and pulmonary infiltrates [20].

The effects of IPPB (Müller Resuscitator [MRI]) were compared with CPAP in patients in the PO period of CABG and it was verified that, when seeking the pulmonary reexpansion with lower imposed workload, the MRI was more effective due to its faster action, with lower levels of dyspnea, respiratory rate and accessory muscle activity [21]. Leaks or air leaks are common situations in the application of CPAP, but also the possibility of aerophagia; such a situation, in MRI is suppressed by the safety valve that prevents a higher pressure, providing a synchronism between the operator and the patient, respecting the patient's respiratory cycle and offering a perfect fit of the mask, causing higher VC gain and pulmonary expansion [21].

In summary, comparative studies have shown some results that point to signs of better effects with the application of a NIV modality over the other. However, the extrapolation of these data for all patients undergoing CS does not present strong scientific evidence.

CONCLUDING REMARKS

The NIV modalities conventionally described in the literature, as CPAP, BiPAP® and IPPB were used in postoperative surgery, added to a current modality, PSV + PEEP, with satisfactory results. Studies that compare different NIV modalities are scarce, although some studies have been demonstrated to be better in the case of IPPB to reverse hypoxemia and in the case of BiPAP ® to improve oxygenation, respiratory rate and heart rate in these patients.

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