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BRIEF REPORT

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Acute effects of non-invasive ventilatory support on functional mitral regurgitation in patients with exacerbation of congestive heart failure

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Abstract *Objective:* The purpose of this study was to evaluate the acute effects of continuous positive airway pressure (CPAP) and bi-level airway pressure (BiPAP) on functional mitral regurgitation (MR) in patients with acute exacerbation of severe chronic congestive heart failure (CHF). *Design:* A cross-over study. *Setting:* A cardiopulmonary intensive care unit. *Patients and interventions:* Ten male patients affected by an acute exacerbation of congestive heart failure and hemodynamically significant MR were submitted to an echocardiograph color Doppler ultrasound evaluation during CPAP and BiPAP non-invasive ventilation. We analyzed left ventricle ejection fraction, area of MR and deceleration time (Dec-t). *Outcome measures:* The primary end point was to evaluate whether CPAP and BiPAP were effective in reducing functional MR. *Results:* After 30 min, the area of MR decreased from 10.0±2.7 to 8.0±2.9 cm^2 with CPAP and from 9.9±2.6 to 8.6±2.6 cm^2 with BiPAP ($p<0.01$); Dec-t increased from 120.9±12.7 to 136.0±8.7 ms after CPAP and from 120.5±11.4 to 134.2±13.6 ms after BiPAP ($p<0.01$). *Conclusion:* In patients with exacerbation of severe CHF and functional MR, both modalities of non-invasive ventilation (CPAP and BiPAP) significantly improved ejection fraction and were equally effective in reducing MR.

Keywords Acute exacerbation of congestive heart failure · Functional mitral regurgitation · Echocardiography · Non-invasive ventilation · Continuous positive airway pressure · Bi-level positive airway pressure

Introduction

Secondary mitral regurgitation (MR), arising from mitral annular dilation and papillary muscle dysfunction, is a common finding in patients with chronic heart failure (CHF). It contributes to the elevation of left ventricular end-diastolic pressure as well as left and right atrial pressures and causes progressive distention of the left ventricle [1]. The presence of significant functional MR predicts the benefit of intensive pharmacological treatment [2, 3]. Continuous positive airway pressure (CPAP) delivered by face mask in patients with acute cardiogenic pulmonary edema (ACPE) resulted in early physiologic improvement and reduced the need for intubation and mechanical ventilation [4].

In patients with CHF, CPAP has been shown to reduce the MR fraction and improve the left ventricle ejection fraction (LVEF), especially in cases of Cheyne-Stokes respiration with central sleep apnea [5]. Several studies have suggested that bi-level positive airway pressure (BiPAP) is a highly effective technique in patients with ACPE from other causes than myocardial infarction [6, 7, 8]. To our knowledge, no data are available about the effects of non-invasive positive pressure ventilation (NIPPV) on functional MR in an acute setting.

The aim of our study was to evaluate the effect of CPAP and BiPAP on the reduction of functional MR during an episode of acute exacerbation in patients with advanced CHF.

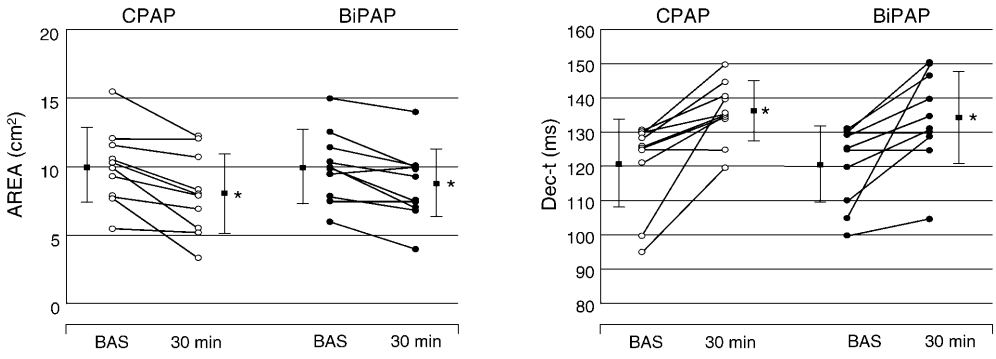

Fig. 1 Individual data for area of mitral regurgitation (*AREA*; cm^2) and deceleration time (*Dec-t*; ms) at baseline (*BAS*) and after 30 min with continuous positive airway pressure (*CPAP*) and bi-level positive airway pressure (BiPAP) *$p<0.01$ versus baseline

Table 1 Clinical data and characteristics of the ten patients (*BMI* body mass index, *NYHA* New York Heart Association functional class, *ACE* angiotensin-converting enzyme)

Age (years)	65.1±5.8
BMI (kg/m^2)	26.0±1.4
NYHA III/IV	7/3
Diuretics (% of patients)	100
ACE-inhibitors (%)	80
Beta-blockers (%)	70
Nitrates (%)	50
Anticoagulant (%)	50
Digoxin (%)	20
Calcium-blockers (%)	20
Anti-arrhythmics (%)	20
Aspirin (%)	20

Patients and methods

Between January 1999 and March 2000, 42 patients (35 had ischemic heart disease and 7 had idiopathic dilated cardiomyopathy) were admitted to our cardio-pulmonary intensive care unit with acute heart failure. All patients suffered from advanced CHF, class III or IV of the New York Heart Association (NYHA) classification and LVEF less than 35%. The criteria for entry into the trial included clinical signs of severe heart failure with dyspnea, orthopnea and third heart sound, with radiological evidence of pulmonary venous congestion and cardiomegaly. Patients were excluded from the study if they were febrile, had evidence of sepsis, pneumonia or altered mental status, or were at risk for aspiration. Ten of these patients (Table 1) had hemodynamically significant functional MR and they were selected for a randomized cross-over study of non-invasive ventilation with CPAP and BiPAP in addition to standard medical therapy. NIPPV was delivered using a BiPAP machine with a full face mask (Respironics, Murrysville, Pa., USA) for all patients. The BiPAP system was delivered in spontaneous/time mode with a plateau valve (Respironics) for expiration. The setting of ventilator was set at 15 cmH_2O of inspiratory positive airway pressure (IPAP) and 5 cmH_2O of expiratory positive airway pressure (EPAP) during BiPAP (inspiratory support of 10 cmH_2O) and at 10 cmH_2O of CPAP.

During the study period, standard medical therapy was not changed [9]. The study was initiated at least 6 h after the last dose of a diuretic drug and 1 h after discontinuation of vasodilator and inotropic drugs. The study protocol was approved by the local ethics committee. All patients gave written informed consent before entry into the study.

Study protocol

After 1 h of rest, patients were randomly allocated to CPAP and BiPAP in cross-over order. Images were recorded before and during the last 5 min of ventilation with CPAP and BiPAP. We analyzed LVEF, area of MR (AREA) and deceleration time (Dec-t). At the end of ventilation, patients rested for at least 2 h in a sitting position before the protocol was repeated with the other modality of non-invasive ventilation. Arterial oxygen saturation (SpO_2) was continuously monitored with a pulse oximeter (MiniOx V, MSA; Md., USA). SpO_2, heart rate, respiratory frequency and arterial blood pressure were measured before and at the end of both modalities of ventilation. The total time spent ventilating a patient for each trial of CPAP/BiPAP was 30 min.

Echocardiography

Complete M-mode and two-dimensional echocardiograms and Doppler ultrasound examination were performed by using a commercial imaging system (ATL Ultramark 9 HDI). Ejection fraction was derived from the standard equation (Simpson rule). MR was defined as hemodynamically significant when the jet area was at least 4 cm^2. All tracings were recorded by one investigator, and each value represented the average of three tracings. Since inter- and intra-observer reproducibility has been shown to be excellent in quantifying MR with this method (r=0.93), a 10% change was considered significant for the valvular regurgitation data [10]. Doppler traces were analyzed using a microcomputer-based digitizing system (Nova Microsonic Image Vue 1.5) and the following variables were measured: peak flow velocity in early diastole (E) and during atrial contraction (A), and deceleration time of early diastolic flow (Dec-t).

Statistical analysis

Two-tailed unpaired *t*-test were used to compare baseline data for patients before CPAP/BiPAP. Two-tailed paired *t*-tests were used to compare within group (CPAP or BiPAP) data at baseline and after 30 min of ventilation. A p value less than 0.05 was considered statistically significant. The results are expressed as mean values ± SD.

Results

The baseline clinical data of the patients are shown in Table 1. After 30 min of CPAP/BiPAP treatment, LVEF increased from 18.8±2.4 to 23.6±1.6% after CPAP and

from 18.7±2.6 to 22.8±1.4% after BiPAP ($p<0.01$), left ventricular end-diastolic volume (LVEDV) decreased from 291.4±8.9 to 265.0±9.7 ml after CPAP ($p<0.01$) and from 288.0±12.1 to 267.5±10.2 ml after BiPAP ($p<0.01$). AREA of MR and Dec-t are shown in Fig. 1. Arterial blood pressure, respiratory frequency, heart rate and SpO_2 did not change significantly during the two treatments. No patient showed a significant change of baseline data before starting with the two different modalities of ventilation. No adverse effects related to ventilation by mask were observed with regard to skin injury or gastro-abdominal distention.

Discussion

Our data demonstrate that the two modalities of NIPPV (CPAP and BiPAP) in selected patients with acute exacerbation of CHF due to a severe left ventricular systolic dysfunction are equally effective in causing a significant reduction in functional MR. The goal of treatment with CPAP in patients with acute heart failure is to improve oxygenation, decrease respiratory work and improve left ventricular function. Some patients increased stroke volume index (SVI) with CPAP, whereas others showed an unchanged or slightly decreased SVI [11]. A previous study [12] evaluated the ventilatory and hemodynamic effects of CPAP by mask in nine patients with acute left heart failure and found that the main effect of CPAP in these patients was to relieve respiratory muscle effort with modest improvement in cardiac performance. For this reason we used BiPAP in comparison with CPAP because it is more efficient than CPAP into reducing respiratory muscle effort [13]. In addition, our study has shown that CPAP and BiPAP increase LVEF, but this effect does not necessarily correlate with a reduction in MR fraction, because LVEF reflects both forward and regurgitant flow [14]. However, the presence of a significant MR in our patients might identify a subgroup of patients in whom NIPPV produces equally beneficial effects in heart function and in the relief of respiratory muscle effort.

In conclusion, in patients with acute exacerbation of severe CHF and hemodynamically significant functional MR, the treatment by CPAP and BiPAP, associated with a standard medical therapy, provided similar favorable effects in a reduction of the MR fraction.

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