João Batista Raposo Mazullo Filho[1], Vânia Jandira Gomes Bonfim[2], Esperidião Elias Aquim[3]

Noninvasive mechanical ventilation in immediate postoperative cardiac surgery patients

Ventilação mecânica não invasiva no pós-operatório imediato de cirurgia cardíaca

1. Physiotherapist, Professor of the Faculdade Santo Agostinho – FSA - Teresina (PI), Brazil.
2. Physiotherapist, Professor of the Universidade de Angola – Luanda, Angola.
3. PhD, Physiotherapist, Professor of the Universidade Tuiuti do Paraná – Curitiba (PR), Brazil.

Received from the Universidade Tuiuti do Paraná - UTP - Curitiba (PR), Brazil.

Submitted on June 2, 2008
Accepted on July 26, 2010

Author for correspondence:
João Batista Raposo Mazullo Filho
Rua Arlindo Nogueira, 2530 - Bl-A - Apt. 201
Cond. Santa Bárbara - Bairro Macaúba
Zip Code: 64016-080 – Teresina (PI), Brazil.
E-mail: mazullo@saomarcos.org.br

ABSTRACT

Background: Noninvasive ventilation is routine in acute respiratory failure patients; nevertheless, the literature is controversial for its use in cardiac surgery postoperative period.

Objective: To evaluate the effectiveness of preventive noninvasive ventilation in the immediate postoperative period of cardiac surgery, monitoring its impact until the sixth day of hospitalization.

Methods: This was a controlled study, where patients in immediate postoperative period of cardiac surgery were randomized into two groups: control (G1) and investigational (G2) which received noninvasive ventilation set on pressure support mode and positive end expiratory pressure, for 2 hours following extubation. Were evaluated ventilatory, hemodynamical and oxygenation variables both immediately after extubation and after noninvasive ventilation in G2.

Results: Thirty-two patients completed the study, 18 in G1 and 14 in G2. The mean age was 61±16.23 years for G1 and for G2 61.5 ± 9.4 years. Of the initial twenty-seven patients in G1, nine patients (33.3%) were excluded due to invasive ventilation requirements, and three patients (11.11%) had to go back to invasive mechanical ventilation. None of the 14 G2 patients was reintubated. Patients undergoing early ventilatory support showed better results in the assessments throughout the hospitalization time.

Conclusion: Noninvasive post-cardiac surgery ventilation was proven effective, as demonstrated by increased vital capacity, decreased respiratory rate, prevention of post-extubation acute respiratory failure and reduced reintubation rates.

Keywords: Respiration, artificial; Cardiac surgery; Postoperative period

INTRODUCTION

Noninvasive mechanical ventilation (NIMV) is routine in patients with acute respiratory failure (ARF) following tracheal extubation.[1]

NIMV benefits are well established for ARF secondary to other causes, including in the post-operative period of thoracic surgeries and also as a supportive tool for conventional mechanical ventilation weaning.[1,2]

The British Thoracic Society guidelines state that the use of noninvasive ventilation in thoracic post-operative chest complications reduces the reintubation risk, time of intensive care unit (ICU) stay, and consequently, mortality, with evidence level B.[3]

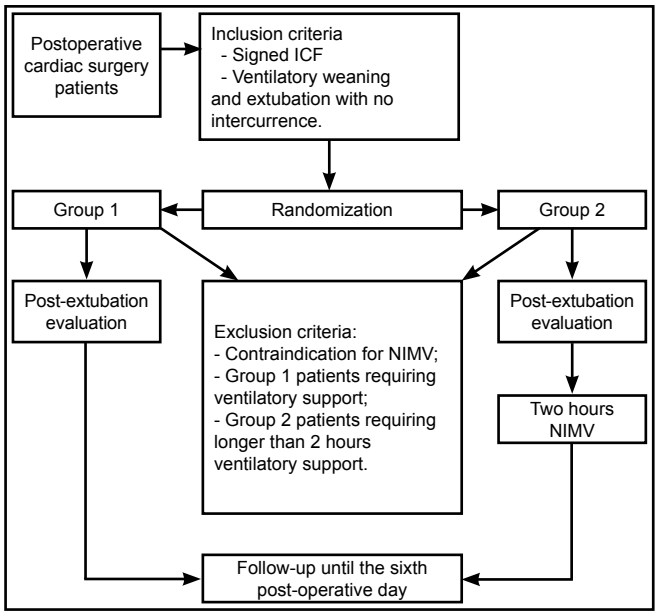
Heart surgery intraoperative issues lead to pulmonary volumes re-

duction, reducing the respiratory system complacency, and may progress to ARF although using oxygen supplementation.[4,5]

NIMV has been shown a feasible alternative, as it improves alveolar ventilation and gas exchange, reduces the ventilatory load, increases the pulmonary volumes, reduces the mechanical ventilation time, therefore preventing reintubation and consequently shortening the ICU stay time.[6-9]

Is also has hemodynamical benefits, such as reducing preload from venous return reduction, reducing left ventricle postload from transmural pressure reduction, therefore increasing the cardiac output, which in turn leads to improved heart pump performance.[10]

This study was aimed to measure the effectiveness of preventive NIMV use during the immediate postoperative period in cardiac surgery patients, evaluating its impact up to the sixth hospitalization day.



NIMV – Noninvasive mechanic ventilation; ICF – informed consent form.

Chart 1 – Study patients' algorithm

METHODS

This was a controlled randomized study conducted from January 2006 to December 2007 in the ICU of the Hospital São Marcos em Terezina – PI, Brazil. After signing an informed consent form (ICF), patients in immediate postoperative period of heart surgery, undergoing mechanical ventilation weaning and extubated without intercurrences according to the ICU protocol, were included. Were excluded patients with contraindications for NIMV or those with an indication for NIMV, as the study was aimed to preventive use evaluation (Chart 1).

After extubated, the patients were randomized into two groups: G1, control and G2, investigational. Immediately after extubation, the baseline variables were collected, namely: heart rate (HR), blood pressure (BP), peripheral oxygen saturation (SpO_2), arterial blood gas contents (pH, PaO_2, PCO_2, HCO_3), respiratory rate (RR), vital capacity (VC) and minute volume (MV).

For G2, the NIMV protocol was applied for two hours, using microprocessed mechanical ventilators Savina® Drager®, in the ventilatory mode, support pressure ventilation (PSV) with 5 cmH2O positive end-respiratory pressure (PEEP) and 40% inspired oxygen fraction (FiO_2),[11,12] with PSV levels adjusted for a tidal volume of 5 to 8 mL/kg. The patient-ventilator interface was made by means of a Gibeck® facial mask,[13] adapted with a silicon head holder. As the trial purpose was to evaluate the preventive NIMV role, patients needing longer NIMV were excluded. The G1 (control group) had no ventilatory support. However, patients who required NIMV were excluded from the trial.

On group 2, the same evaluations were repeated after NIMV. Additionally, both groups underwent daily morning evaluation, from the first to the sixth subsequent day.

The data are expressed as mean and standard deviation. For comparison of the means within a group, i.e., group 2 before and after NIMV, the pairwise samples Student's t test was used. For between groups' comparison, both regarding demographic characteristics and the respiratory variables, the Student's t test was used. In both cases, a significance level $p < 0.05$ was considered.

RESULTS

Forty four patients were initially included, divided into two groups. Of the 27 G1 patients, nine (33.3%) required any type of ventilatory support, and were excluded from study participation.

Table 1 – Study completers population (N = 32)

	Control - G1 (N = 18)	Investigational - G2 (N = 14)	p value
Age (years)	61.0 ± 16.2	61.5 ± 9.4	0.29
Height (m)	1.62 ± 8.10	1.60 ± 8.70	0.75
Weight (kg)	59.0 ± 8.6	65.5 ± 12.7	0.02
Gender			
Male	11 (61.1)	8(57.1)	0.46
Female	7(38.9)	6(42.9)	0.49

Results expressed as number (%) and mean ± standard deviation. Student's *t* test with p<0.05 significance level.

Table 2 – Variables comparison before and after non-invasive mechanical ventilation in group 2 patients

Variables	Post-extubation	Post-NIMV	p value
RR (ipm)	28.0 ± 8.4	18.0 ± 5.6	0.01
SpO_2 (%)	91.0 ± 3.7	97.0 ± 2.2	0.001
VC (ml)	300.0 ± 146.4	550.0 ± 204.7	0.001
MV (ml)	7650 ± 3952	6840 ± 2200	0.72
HR (bpm)	96.0 ± 17.4	90.0 ± 14.2	0.005

NIMV – non-invasive mechanical ventilation; RR – respiratory rate; SpO_2 – peripheral oxygen saturation; VC – vital capacity; MV – minute volume; HR – heart rate; ipm – inspirations per minute; bpm – beats per minute. Results expressed as mean ± standard deviation. Pairwise Student's *t* test.

Of these, three patients (11.11%) had to go back to mechanical ventilation. Of the 17 G2 patients, three (17.6%) were excluded for longer than two hours NIMV requirement; none of the G2 patients required reintubation.

Thirty two patients completed the trial. Of these, eighteen were in G1 and fourteen in G2. Regarding the surgical procedure characterization, twenty three patients underwent myocardial revascularization surgery, three underwent valve replacement, three underwent combined surgery, two had interatrial defect correction, and one underwent aneurism surgery. The demographic data are shown in table 1.

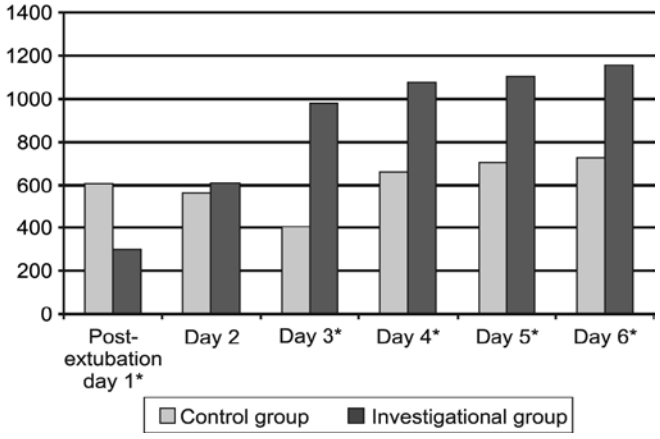
In the post-NIMV evaluation, the investigational group patients showed statistically significant better results regarding the variables RR, SpO_2, VC, and HR (see Table 2). The comparison of the variables from the baseline until the sixth day showed satisfactory outcome for G2, where RR, VC and HR should be emphasized (Table 3).

These results show that patients undergoing early NIMV had better outcomes over the hospitalization time, mainly due to increased VC (Figure 1), reduced ventilatory and cardiac load, as proven by RR (Figure 2) and HR (Figure 3) drops.

Table 3 – Inter-groups variables comparison during the intensive care unity stay

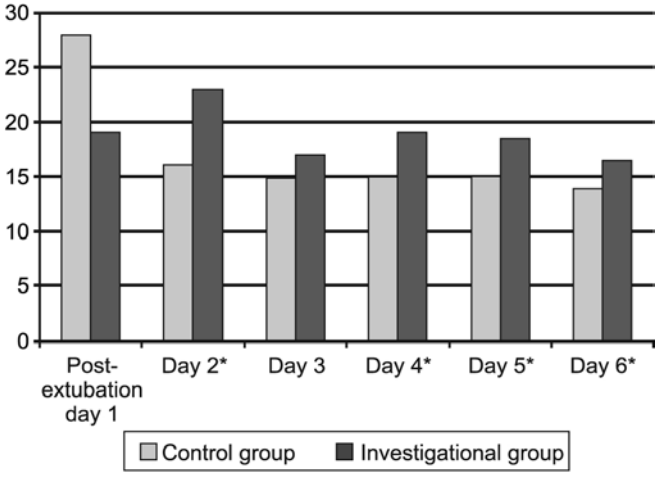
Variable		RR (ipm)	SpO_2 (%)	VC (ml)	MV (ml)	HR (bpm)
Day 1	Group 1	19 ± 7.05	95 ± 1.08	600 ± 548.80	6250 ± 1887.89	89 ± 23.52
	Group 2	28 ± 8.39	91 ± 3.71	300 ± 146.38	7650 ± 3952.75	96 ± 17.40
	p value	0.09	0.01	0.01	0.40	0.88
Day 2	Group 1	23 ± 5.40	97 ± 8.51	560 ± 576.30	7500 ± 2232.81	94 ± 16.51
	Group 2	16 ± 5.22	95 ± 2.27	600 ± 207.30	6240 ± 3364.38	86 ± 17.73
	p value	0.01	0.24	0.49	0.88	0.03
Day 3	Group 1	17 ± 4.81	95 ± 4.36	600 ± 509.61	5800 ± 2337.43	93 ± 15.07
	Group 2	15 ± 4.10	94 ± 4.06	975 ± 223.61	5740 ± 2558.54	75 ± 17.67
	p value	0.32	0.64	0.02	0.59	0.02
Day 4	Group 1	19 ± 4.60	95 ± 4.50	660 ± 641.59	7150 ± 2710.16	92 ± 15.94
	Group 2	15 ± 1.64	95 ± 2.22	1075 ± 207.14	6300 ± 1889.58	85 ± 16.23
	p value	0.004	0.21	0.02	0.15	0.01
Day 5	Group 1	18 ± 3.32	97 ± 4.26	700 ± 632.75	8300 ± 1888.32	88 ± 11.39
	Group 2	15 ± 0.66	96 ± 1.99	1100 ± 289.56	6200 ± 1747.18	87 ± 16.21
	p value	0.004	0.16	0.02	0.19	0.09
Day 6	Group 1	16 ± 3.63	97 ± 3.11	720 ± 585.98	8300 ± 1821.31	88 ± 12.59
	Group 2	14 ± 2.03	95 ± 4.09	1150 ± 220.13	6150 ± 1710.80	80 ± 10.95
	p value	0.02	0.25	0.01	0.02	0.01

RR – respiratory rate; SpO_2 – peripheral oxygen saturation; VC – vital capacity; MV – minute volume; HR – heart rate; ipm – inspirations per minute; bpm – beats per minute. Results expressed as mean ± standard deviation. Student's *t* test.



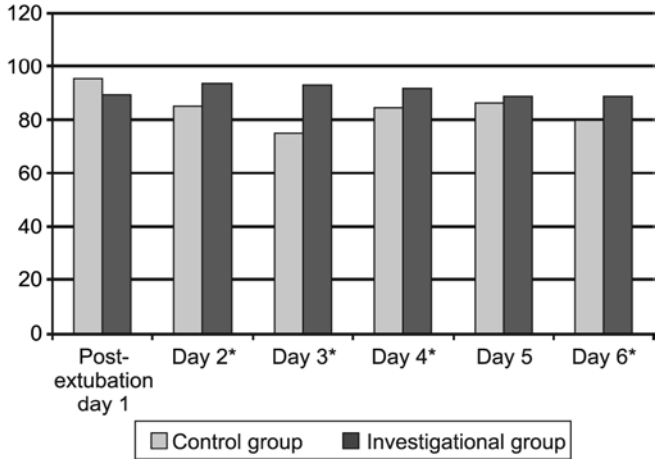
*p< 0.05 for vital capacity progression.

Figure 1 – Vital capacity analysis: investigational versus control groups



*p< 0.05 for respiratory rate progression.

Figure 2 – Respiratory rate analysis: investigational versus control groups.



*p< 0.05 for heart rate progression.

Figure 3 – Heart rate analysis: investigational versus control groups.

DISCUSSION

Immediate postoperative cardiac surgery patients extubated and immediately placed on NIMV showed no signs of ARF and, consequently, none of them returned to invasive mechanical ventilation. Also, they showed better outcomes throughout the six days follow-up, with reduced postoperative complications and possibly reducing their total hospitalization time.

In the post-extubation evaluation, of the patients with lower than 15 mL/kg VC and randomized to G1, nine (33.3%) were excluded from the trial due to ARF within 24 hours after extubation, although with high flow oxygen therapy, and required ventilatory support. Of these, three (11.11%) were reintubated.

Three G2 patients (17.6%) required longer than 2 hours NIMV, as still had ARF signs, although showing good responses to NIMV. Pasquina et al., in their study on prophylactic noninvasive ventilation, found similar to our intervention group results regarding the NIMV group with PSF+PEEP, with no patient reintubated. However, in their study, one patient in the group with NIMV and CPAP had to be reintubated for ARF.[14]

Regarding the investigational group, the steady VC increase throughout the trial has shown that, from a ventilatory point of view, these patients were no longer at ARF risk. Comparing these results with Matte et al. findings, where the groups with NIMV had incremented VC, from the second postoperative day on the vital capacity was shown to be an important parameter to decide whether or not a patient is at reintubation risk.[15]

Still about the Matte et al. paper, our study's intervention group has shown similar results to their NIMV patients. Although the comparison of NIMV versus CPAP outcomes had no statistical significance, the results were somehow above those of non-NIMV patients.[15]

In the NIMV intervention group analysis, the drop of RR, increase of SpO_2, drop of HR and increase of VC showed statistical significance due to the beneficial post-extubation effects immediate impact, as described in the literature,[1-3, 6-9,16] being none of the preventive NIMV patients reintubated. Confirming the findings by Lopes et al., when postoperative patients underwent post-extubation noninvasive ventilation, their oxygenation improved

and their reintubation rate was reduced.[17]

The SpO_2 comparison shows that the eighteen G1 patients who remained for the entire six days evaluation always had better saturations than the G2 patients, therefore evidencing that they where less severely ill than those with similar SpO_2 values to the investigational group and excluded for ventilatory support requirement.

Patients undergoing early NIMV had better hospitalization outcomes, mainly due to increased VC throughout the six evaluation days, proving their increased pulmonary volumes.[15] Therefore, the ventilatory load was reduced, as proven by the RR drop.

We could evidence in this trial the hemodynamical benefits mentioned by some authors.[10,18] HR was within the normal range in both groups, however G2 had better mean six-day evaluation, with a lower cardiac output due to less energy expenditure from lower ventilatory load.

CONCLUSION

Preventive NIMV in immediate postoperative heart surgery patients was shown effective by increasing VC, reducing the ventilatory load, preventing post-extubation ARF, and reducing reintubation rates. Additional studies are encouraged to demonstrate vital capacity measurement as indicative variable for ventilatory support.

RESUMO

Introdução: A ventilação mecânica não invasiva é utilizada rotineiramente em pacientes que evoluem com insuficiência respiratória aguda. Entretanto, estudos mostram evidências controversas para sua indicação em pós-operatório de cirurgia cardíaca.

Objetivo: Verificar a eficácia da ventilação mecânica não invasiva preventiva no pós-operatório imediato de cirurgia cardíaca, acompanhando seu impacto até o sexto dia de internação.

Métodos: Tratou-se de um estudo controlado onde os pacientes em pós-operatório imediato de cirurgia cardíaca foram randomizados em dois grupos: controle (G1) e experimental (G2) que recebeu ventilação mecânica não invasiva no modo pressão de suporte com pressão expiratória final positiva, após extubação durante 2 horas. Foram avaliadas: variáveis ventilatórias, de oxigenação e hemodinâmicas imediatamente após extubação e após ventilação mecânica não invasiva no grupo G2.

Resultados: Trinta e dois pacientes finalizaram o estudo, sendo 18 no G1 e 14 no G2. A média da idade do G1 foi 61 anos ± 16,23 e do G2 61,5 anos ± 9,4. Dos vinte e sete pacientes iniciais do G1, nove (33,3%) foram excluídos por necessitarem utilizar ventilação mecânica não invasiva, sendo que três pacientes (11,11%) retornaram à ventilação mecânica invasiva. Nenhum dos 14 pacientes do G2 foi reentubado. Os pacientes que foram submetidos precocemente a suporte ventilatório apresentaram melhores resultados nas avaliações ao longo do tempo de internação.

Conclusão: A ventilação mecânica não invasiva se mostrou eficaz em pós-operatório de cirurgia cardíaca do grupo estudado, pois incrementou capacidade vital, diminuiu freqüência respiratória, preveniu a insuficiência respiratória aguda pós extubação e reduziu os índices de reintubação.

Descritores: Respiração artificial; Cirurgia cardíaca; Período pós-operatório

REFERENCES

1. Hill NS. Noninvasive ventilation. Does it work, for whom, and how? Am Rev Respir Dis**.** 1993;147(4):1050-5.
2. Sassoon CS, Mahutte CK. Noninvasive positive-pressure ventilation in acute respiratory failure: review of reported experience with special attention to use during weaning. Respir Care. 1995;40(3):282-8.
3. British Thoracic Society Standards of Care Committee. Non-invasive ventilation in acute respiratory failure. Thorax. 2002;57(3):192-211
4. Ambrozin ARP, Cataneo AJM. Aspectos da função pulmonar após revascularização do miocárdio relacionados com risco pré-operatório. Rev Bras Cir Cardiovasc. 2005;20(4):408-15.
5. Baudouin SV. Lung injury after thoracotomy. Br J Anesth. 2003;91(1):132-42.
6. Kramer N, Meyer TJ, Meharg J, Cece RD, Hill NS. Randomized, prospective trial of noninvasive positive pressure ventilation in acute respiratory failure. Am J Respir Crit Care Med. 1995;151(6):1799-806.
7. Meyer TJ, Hill NS. Noninvasive positive pressure ventilation to treat respiratory failure. Ann Intern Med. 1994;120(9):760-70.
8. Brochard L. Noninvasive ventilation in acute respiratory failure. Respir Care. 1996;41(5):457-64.
9. Mehta S, Hill NS. Noninvasive ventilation. Am J Respir Crit Care Med. 2001;163(2):540-77. Review.
10. Maurat MM. Avaliação dos benefícios da ventilação não invasiva nos pacientes em pós-operatório de cirurgia cardíaca. Rev SOCERJ. 2003;16(3):142
11. Schettino GPP, Reis MAS, Galas F, Park M, Franca SA, Okamoto VN, Carvalho CRR. Ventilação mecânica não-invasiva com pressão positiva. Rev Bras Ter Intensiva. 2007;19(2):245-57.

12. Müller AP, Olandoski M, Macedo R, Constantini C, Guarita-souza LV. Estudo comparativo entre a pressão positiva intermitente (Reanimador de Müller) e contínua no pós-operatório de cirurgia de revascularização do miocárdio. Arq Bras Cardiol. 2006;86(3):232-9.
13. Pennock BE, Crawshaw L, Kaplan PD. Noninvasive nasal mask ventilation for acute respiratory failure: Institution of a new therapeutic technology for routine use. Chest. 1994;105(2):441-4.
14. 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; table of contents.
15. 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.
16. Nava S, Ceriana P. Causes of failure of noninvasive mechanical ventilation. Respir Care. 2004;49(3):295-303.
17. Lopes CR, Brandão CMA, Nozawa E, Auler Júnior JOC. Benefícios da ventilação não-invasiva após extubação no pós-operatório de cirurgia cardíaca. Rev Bras Cir Cardiovasc. 2008;23(3):344-50.
18. Gust R, Gottschalk A, Schmidt H, Böttiger BW, Böhrer H, Martin E. Effects of continuous (CPAP) and bi-level positive airway pressure (BiPAP) on extravascular lung water after extubation of the trachea in patients following coronary artery bypass grafting. Intensive Care Med. 1996;22(12):1345-50.