Oxygenation failure after cardiac surgery: early re-intubation versus treatment by nasal continuous positive airway pressure (NCPAP) or non-invasive positive pressure ventilation (NPPV)

Ipossia dopo chirurgia cardiaca: re-intubazione precoce verso trattamento a pressione positiva nasale continua (NCPAP) o ventilazione a pressione positiva non invasiva (NPPV)

Muhammed Kurt, Udo Boeken, Jens Litmathe, Peter Feindt, Emmeran Gams

ABSTRACT: Oxygenation failure after cardiac surgery: early re-intubation versus treatment by nasal continuous positive airway pressure (NCPAP) or non-invasive positive pressure ventilation (NPPV). M. Kurt, U. Boeken, J. Litmathe, P. Feindt, E. Gams.

Background: Due to an increasing incidence of respiratory failure after cardiac surgery we wanted to study whether nasal continuous positive airway pressure (NCPAP) may improve pulmonary oxygen transfer and may avoid reintubation after coronary operations. Additionally, we compared this protocol to non-invasive positive pressure ventilation (NPPV).

Methods: For a period of 2 years we analyzed all patients that were extubated within 12 hours after coronary surgery, and in whom oxygen transfer (PaO2/FIO2) deteriorated without hypercapnia so that all these patients met predefined criteria for reintubation: group A=immediate reintubation (n=88), group B=NCPAP-treatment (n=173), group C=NPPV(n=18).

Results: 25.4% of group B- and 22.2% of group C-patients were also intubated after a period of NCPAP or NPPV. All other patients of groups B and C could be weaned from these devices (B = 34.3 ± 5.9 hours; C = 26.4 ± 4.4 h; p<0.05) and were well oxygenated by face mask at ambient pressure (Ratio PaO2/FIO2; B, 138 ± 13; C, 140 ± 13). In group A we found a higher mortality (7.95%) compared to group B (4.04%) and group C (5.55%). NCPAP-patients suffered more frequently from an impaired sternal wound healing (A = 4.5%, B = 8.6%; p<0.05).

Conclusions: We conclude that reintubation after cardiac operations should be avoided since NCPAP and NPPV are safe and effective to improve arterial oxygenation in most patients with non hypercapnic respiratory failure.

Keywords: cardiac surgery, respiratory failure, reintubation, non-invasive positive pressure ventilation (NPPV), nasal continuous positive airway pressure (NCPAP).

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ed from this study, even in cases of concomitant coronary artery bypass grafting.

Altogether 279 of all patients undergoing an isolated coronary artery bypass grafting operation met after primary extubation the criteria for reintubation. Patients suffering from a lack of consciousness and/or hypercapnia underwent immediate reintubation, all other received non-invasive ventilation support. The entire cohort was divided into three study-groups: Group A = immediate reintubation (n=88), group B = NCPAP-treatment (n=173) and group C = NPPV (n=18). All relevant clinical data as well as important hemodynamic measures, such as heart rate (HR), mean arterial pressure (MAP) and central venous pressure (CVP) and furthermore the ratio of PaO2 and FiO2 were listed.

The perioperative characteristics for all three groups are shown in table 1.

**Operative details and proceeding at the ICU**

All operations were performed using a median sternotomy, with help of cardiopulmonary bypass (CPB) in mild hypothermia and cardioplegic arrest using either Bretschneider’s solution or the Calafiore-technique. In all cases a coronary artery bypass grafting (CABG) was carried out.

After transfer to the intensive unit care (ICU), the patients were weaned from the respirator following a standard regime. They were extubated when vigilance and oxygenation (pO2 > 60 mmHg at FiO2 0.3) were satisfactory. In detail standard criteria for extubation were defined as respiratory rate of 10 to 28 breaths/min, tidal volume higher than 5 ml/kg body weight, vital capacity greater than 10 ml/kg body weight and the ability to maintain adequate oxygenation with supplemental oxygen below 40% FiO2.

The follow-up included at maximum the in-hospital-stay.

### Statistical analysis

Descriptive measures are given as mean values with the standard error of the mean (SEM). Comparisons between groups were performed using the X² test or with Student’s t-test as appropriate. A p-value ≤ 0.05 was considered to be statistically significant.

### Results

The clinical status was comparable in all three groups, just the elapsed time since primary extubation was significantly shorter in patients undergoing NCPAP-therapy (group B, table 2).

| Table 1. - Perioperative patients’ characteristics in groups A, B and C |
|-----------------------------|---------------------|---------------------|---------------------|---------------------|
|                            | group A (n=88)       | group B (n=173)      | group C (n=18)       | p(A/B)              |
| age (years)                 | 64.1 ± 12.3         | 64.5 ± 11.3         | 65.1 ± 12.1         | >0.05               |
| gender (% male)             | 78                  | 75                  | 76                  | >0.05               |
| body mass index             | 25.4 ± 3.5          | 25.0 ± 3.3          | 26.2 ± 3.8          | >0.05               |
| preop. EF (%)               | 62 ± 8.5            | 61 ± 8.2            | 63 ± 7.8            | >0.05               |
| emergency op. (%)           | 3.4                 | 2.9                 | 5.5                 | >0.05               |
| duration of op. (min)       | 211 ± 23            | 218 ± 25            | 209 ± 21            | >0.05               |
| duration of ischemia (min)  | 48 ± 6              | 47 ± 7              | 49 ± 9              | >0.05               |
| number of grafts (n)        | 3.7 ± 0.5           | 3.5 ± 0.4           | 3.4 ± 0.4           | >0.05               |
| LIMA-utilization (%)        | 91                  | 88                  | 89                  | >0.05               |
| LCOS (%)                    | 5.6                 | 5.7                 | 5.5                 | >0.05               |

| Table 2. - Clinical status before re-ITN (A), NCPAP (B) and NPPV (C) |
|-----------------------------|---------------------|---------------------|---------------------|---------------------|
|                            | group A (n=88)       | group B (n=173)      | group C (n=18)       | p(A/B)              |
| conscious (%)               | 91                  | 100                 | 100                 | <0.05               |
| P_aCO2 (mmHg)               | 49.8 ± 7.5          | 45.5 ± 6.4          | 45.8 ± 6.2          | <0.05               |
| catecholamines (%)          | 16.8                | 17.1                | 16.5                | >0.05               |
| temperature > 38°C (%)      | 11.4                | 11.0                | 11.1                | >0.05               |
| neurologic problems (%)     | 3.4                 | 2.9                 | 5.5                 | >0.05               |
| bleeding problems (%)       | 3.4                 | 3.5                 | 5.5                 | >0.05               |
| prim. ventil. time (h)      | 6.8 ± 0.9           | 6.5 ± 0.8           | 7.0 ± 1.0           | >0.05               |
| time since prim. extub. (h) | 6.6 ± 1.4           | 5.1 ± 0.8           | 6.4 ± 1.0           | <0.05               |
25.4% of group B- and 22.2% of group C-patients were also intubated after a period of CPAP or NPPV. All other patients of groups B and C could be weaned from these devices (B: 34.3±5.9 hours; C: 26.4±4.4 h; p<0.05) and were well oxygenated by face mask at adequate pressure (PaO₂/FiO₂: B:138±13, C:140±13 after finishing). The ratio was significantly increased in group A during the first 24 hours of observation, figure 1).

In group A a higher mortality (7.95%) compared group B (4.04%) and group C (5.55%) was observed. Stay on ICU and in-hospital-stay was significantly prolonged in group A. The incidence of pulmonary infections (A: 22.7%, B:10.4%, C: 11.1%, p<0.05) and the need for catecholamines were significantly increased in group A, whereas NCPAP-patients significantly more often suffered from an impaired sternal wound healing (A: 4.5%, B: 8.6%, p<0.05, figures 2 and 3).

Central venous pressure (CVP) and mean arterial blood pressure (MAP) had a different behaviour: CVP was significantly higher in group B compared to group A 4, 8 and 24 hours after start of observation, whereas MAP was significantly higher in group A 8 and 24 hours after onset of observation (figures 4 and 5). Finally, heart rate (HR) was significantly higher in group A 8, 12 and 24 hours after onset of observation (figure 6).

Discussion

The patient population in cardiac surgery has significantly changed during the last two decades: Since interventional cardiology especially in coronary artery disease has tremendously improved, both cardiac pathology and concomitant clinical status of patients scheduled for CABG have impressively impaired [5]. Thus, the individual treatment for each patient has the main goal to avoid adverse events in order to optimize the immediate postoperative outcome. Early extubation is a
tool that enables to shorten stays at ICU with all corresponding economic advantages and may prevent from pneumonia; however, it should not be burdened with a higher rate of respiratory failure afterwards. The aim of the current study was to compare different types of invasive and non-invasive therapy in cases of respiratory failure following coronary surgery.

Nasal CPAP is a device for patients breathing spontaneously, it is easy to implement and the technical requirements are simple. It has been proven effective in acute respiratory distress due to cardiogenic pulmonary edema [6], acute exacerbation of chronic obstructive pulmonary disease (COPD) [7] and chest wall diseases including neurogenic diseases [8]. Also positive effects in atelectasis and postoperative hypoxemia have been described [9]. Considering the efficacy, it is also important to apply effective airway pressures. Studies in patients who had undergone major cardio-thoracic surgery have already shown that only airway pressures beyond 10 cm H2 O within the facemask were effective in keeping the intrathoracic airway pressures positive within the entire respiratory cycle, which is mandatory for improving pulmonary function and for avoiding the derecruitment of lung areas [10].

A few more studies have focused on the role of non-invasive ventilation as breathing support in general and especially in cardio-thoracic patient cohorts. In these investigations the authors were not able to prove the beneficial effects of this device, such as reduction of pulmonary infections or duration of stay at ICU or in hospital [11, 12]. Furthermore Böhn er and colleagues claim even for a prophylactic use of non invasive breathing supports in early periods of oxygenation failure following primarily early extubation [13]. These findings are congruent to our current series: we found significantly shorter durations of stay at ICU and in hospital as well as a lower incidence of mortality and major complications. The
OXYGENATION FAILURE FOLLOWING CORONARY SURGERY

only exception represent sternal wound complications which were significantly higher in group B. Hemodynamic changes, however, were more pronounced in patients receiving non-invasive respiratory support. It is remarkable that only 22% and 25% of group C and B, respectively, were once more reintubated after a period of non invasive ventilation.

Taken together NCPAP and NPPV are technically simple, inexpensive and well tolerated methods to restore or even improve pulmonary function following coronary surgery. Thus, the prophylactic and therapeutic use is recommended in these type of surgery and should be preferred to early reintubation thus avoiding a subsequent prolonged course of mechanical ventilation. Such non-invasive tools do not, however, represent a permanent therapeutic option in cases of impaired consciousness or hypercapnic state. Additionally, it is of great importance to take special care of possible sternal wound complications, especially in high risk populations [14, 15].

Riassunto

Background: L’incidenza di insufficienza respiratoria dopo cardiochirurgia è in aumento. Scopo del presente lavoro è valutare se la pressione continua nasale positiva (NCPAP) migliorava il trasferimento di ossigeno polmonare e può evitare la reintubazione dopo cardiochirurgia, rispetto alla ventilazione non invasiva a pressione positiva (NPPV).

Metodi: Per un periodo di 2 anni sono stati analizzati tutti i pazienti intubati nelle prime 12 ore dopo cardiochirurgia, nei quali il trasporto di ossigeno (PaO2/FIO2) deteriorava senza ipercapnia, così da rientrare nei criteri di reintubazione: gruppo A = reintubazione immediata (n=88), gruppo B = NCPAP (n=173), gruppo C = NPPV (n=18).

Risultati: Dopo un periodo di NCPAP o NPPV, 25.4% dei pazienti del gruppo B e 22.2% del gruppo C sono stati re-intubati. Tutti gli altri pazienti dei gruppi B e C sono stati svezzati da questi dispositivi nella maggior parte dei pazienti che presentano una maggiore mortalità (7.95%) rispetto al gruppo A (4.5%, B = 8.6%; p<0.05).

Conclusioni: la reintubazione dopo cardiochirurgia dovrebbe essere evitata poiché la NCPAP e la NVVP sono sicure ed efficaci nel migliorare l’ossigenazione nella maggior parte dei pazienti che presentano un’insufficienza respiratoria non ipercapnica.

Parole chiave: cardiochirurgia, insufficienza respiratoria, reintubazione, ventilazione non invasiva a pressione positiva (NPPV), pressione continua nasale positiva nelle vie aeree (NCPAP).

Conflict of interest statement

All authors disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work.

References