Nasal-Continuous Positive Airway Pressure Reduces Pulmonary Morbidity and Length of Hospital Stay Following Thoracoabdominal Aortic Surgery*

Detlef Kindgen-Milles, MD, PhD; Eckhard Müller, MD, PhD; Rolf Buhl, MD; Hinrich Böhner, MD; Dennis Ritter; Wilhelm Sandmann, MD, PhD; and Jörg Tarnow, MD, PhD

Study objectives: Patients who undergo surgical repair of thoracoabdominal aortic aneurysms have a high risk for the development of respiratory complications, which cause significant postoperative morbidity and prolong hospitalization, compared to patients who undergo other types of surgery. We studied whether prophylactic noninvasive application of nasal continuous positive airway pressure (nCPAP) administered via a facemask immediately after extubation may reduce pulmonary morbidity and shorten the length of hospitalization.

Design: Prospective randomized clinical trial.

Setting: Surgical ICU of a university hospital.

Patients: Fifty-six patients following elective prosthetic replacement of the thoracoabdominal aorta, of whom 6 patients were excluded because they had received prolonged mechanical ventilation.

Interventions: Following extubation in the ICU, nCPAP was applied for 12 to 24 h at an airway pressure of 10 cm H2O to patients in the study group (n = 25). Subjects in the control group (n = 25) received standard treatment including intermittent nCPAP (10 cm H2O for 10 min) every 4 h.

Measurements and results: In the study group, nCPAP was applied for a mean (± SD) duration of 23 ± 3 h at an airway pressure of 10 ± 1 cm H2O, which improved pulmonary oxygen transfer without altering hemodynamics (ie, heart rate, mean arterial BP, and central venous pressure). The application of nCPAP was associated with fewer pulmonary complications (PaO2/fraction of inspired oxygen [FIO2] <100, atelectasis, pneumonia, reintubation rate) compared to the control group (7 of 25 patients vs 24 of 25 subjects, respectively; p = 0.019). The mean duration of intensive care treatment tended to be shorter in the study group compared to the control group (8 ± 1 vs 12 ± 2 days, respectively; difference not significant), while the mean length of hospital stay was shorter with nCPAP therapy (22 ± 2 vs 34 ± 5 days, respectively; p = 0.048).

Conclusions: The prophylactic application of nCPAP at airway pressures of 10 cm H2O significantly reduced pulmonary morbidity and length of hospital stay following the surgical repair of thoracoabdominal aortic aneurysms. Thus, it can be recommended as a standard treatment procedure for this patient group.

Key words: continuous positive airway pressure; noninvasive ventilation; pulmonary complications; thoracoabdominal aortic aneurysm

Abbreviations: FIO2 = fraction of inspired oxygen; FRC = functional residual capacity; nCPAP = nasal continuous positive airway pressure; PEEP = positive end-expiratory pressure

The poor prognosis associated with conservative treatment of thoracoabdominal aortic aneurysms has been reasonably well established as the rupture of the aneurysm is the most common cause of death in these patients.1 In contrast, survival after high-risk thoracoabdominal aortic surgery has increased over the past few decades due to advances in the perioperative care of these patients. Therefore, surgery to repair such aneurysms is advocated nowadays.1–4

*From the Departments of Anesthesiology (Drs. Kindgen-Milles, Müller, Buhl, Ritter, and Tarnow) and Vascular Surgery and Kidney Transplantation (Drs. Böhner and Sandmann), University Hospital, Düsseldorf, Germany. Manuscript received August 3, 2004; revision accepted February 7, 2005.

Reproduction of this article is prohibited without written permission from the American College of Chest Physicians (www.chestjournal.org/misc/reprints.shtml).

Correspondence to: Detlef Kindgen-Milles, MD, PhD, Klinik für Anästhesiologie, Universitätsklinikum Düsseldorf, Moorenstr 5, D-40225 Düsseldorf, Germany; e-mail: Kindgen-Milles@med.uni-duesseldorf.de
Nevertheless, in a large number of patients, subsequent pulmonary complications and even respiratory failure occur. It is clear that since both the abdomen and thorax are operated on during thoracoabdominal aortic surgery, these patients are particularly prone to developing respiratory problems. These are the cause of significant postoperative morbidity, contribute to increased mortality, and cause additional costs since length of intensive care surveillance and hospital treatment is prolonged.

It is obvious, therefore, that one major aspect of postoperative intensive care treatment must be to optimize respiratory support. Respiratory support is of particular importance following extubation because during invasive ventilation, functional residual capacity (FRC) is maintained by the application of positive end-expiratory airway pressure (PEEP). After extubation and with spontaneous breathing at ambient pressure, derecruitment of lung areas occurs, and FRC and pulmonary oxygen transfer decrease rapidly. To maintain normal arterial blood oxygenation, therefore, supplemental oxygen application, usually by the use of a nonocclusive facemask or nasal prongs, is required. Although the application of oxygen may normalize arterial oxygen saturation, it is a purely symptomatic approach that does not treat the underlying pathophysiologic disturbance (i.e., the reduction of FRC). In contrast, the noninvasive application of continuous positive airway pressure is an effective means to increase FRC and vital capacity following major surgery. It may reopen atelectasis, improve blood oxygenation, and decrease respiratory workload. Thus, this technique seems ideally suited to preventing pulmonary complications in patients who are at high risk.

We conducted a prospective randomized study to evaluate the effects of prophylactic application of nasal continuous positive airway pressure (nCPAP) on blood oxygenation, pulmonary morbidity, and length of hospital stay in patients following prosthetic replacement of the thoracoabdominal aorta. It will be shown that the prophylactic application of nCPAP improves blood oxygenation and reduces the incidence of pulmonary complications as well as the length of hospital stay.

Materials and Methods

The study was approved by the committee of medical ethics of the Heinrich-Heine-University of Düsseldorf and was conducted in accordance with the principles outlined in the Declaration of Helsinki. Patients who are scheduled for elective surgical repair of thoracoabdominal aortic aneurysms of types I to III, according to the Crawford classification, were eligible for the study. All consecutive patients who had undergone surgery during 1 year were informed about the study and, in brief, were instructed on the use of nCPAP on the day before surgery. After written informed consent was obtained, patients were enrolled into the study. Patients were excluded for one of the following reasons: no consent was obtained; age < 18 years; pulmonary emphysema with bullae; glucocorticoid treatment; and mechanical ventilation for > 48 h.

After arrival in the ICU, patients were randomized by means of a computer-generated randomization list to receive either nCPAP at an airway pressure of 10 cm H2O for at least 12 h and up to 24 h (i.e., the study group) or to receive standard treatment, consisting of oxygen therapy applied at ambient pressure via a nonocclusive facemask and intermittent mask CPAP therapy at a pressure of 10 cm H2O every 4 h for 10 min (i.e., the control group).

Initially, all patients received mechanical ventilation (at a pressure-controlled, peak airway pressure of 35 cm H2O, targeting a tidal volume of 8 mL/kg, an initial PEEP of 10 cm H2O, with a fraction of inspired oxygen (FiO2) level designed to keep arterial oxygen saturation at > 95%). Weaning was started if patients were normothermic and hemodynamically stable, and if operative revision was not required. Weaning was facilitated by reducing respiratory rate and changing to pressure support ventilation if spontaneous breathing had returned. Patients were extubated if they were fully conscious, responsive to commands, had sufficient protective airway reflexes, and met the following criteria: PaO2 of > 70 mm Hg at an FiO2 of 0.35 and a PEEP of 7 cm H2O; and PaCO2 of < 46 mm Hg at a pressure support of < 8 cm H2O. Prior to the extubation, chest physiotherapy was performed by certified registered physiotherapists, and a standardized recruitment maneuver (i.e., application of an airway pressure of 40 cm H2O for 15 s) was performed.

The standard treatment for all patients included regular chest physiotherapy (i.e., manual vibration therapy by certified physiotherapists) once daily, positioning with an elevated upper body, and early mobilization if possible. Drug treatment included IV aminophylline, 45 mg/d, and IV acetylcysteine, 900 mg/d (routine mucolytic therapy for all surgical patients in the ICU), a stress ulcer prophylaxis with ranitidine, 150 mg/d, and perioperative antibiotic prophylaxis with ampicillin/sulbactam, 3 g/d for the first 3 postoperative days. Analgesia was performed by application of morphine hydrochloride via a thoracic epidural catheter and supplemental systemic metamizole.

In the control group, supplemental oxygen therapy was applied using a nonocclusive facemask with a flow of 25 L/min (heated and humidified). Oxygen concentration was chosen (previously calibrated oxygen blender) to keep arterial oxygen saturation at > 95%. In addition, intermittent nCPAP (with full facemask) was applied every 4 h for 10 min at an airway pressure of 10 cm H2O.

In the study group, immediately after extubation, nCPAP was applied as has been described previously. In brief, the same air/oxygen source (FDF3/AC; B+P Beatmungsprodukte; Neunkirchen, Germany) used for oxygen application in the control group was facilitated to provide a constant flow of 65 L/min (heated and humidified), passing through a compliant rubber bag (volume, 10 L; reservoir) via a T-piece to the nasal mask (Respironics; Murrysville, PA). End-expiratory pressure was measured in the nasal mask, was displayed continuously on an electronic monitor, and was kept constant at 10 cm H2O by means of a standard PEEP valve. According to the protocol, prophylactic nCPAP therapy was applied between 12 and 24 h following extubation. This interval was chosen due to the experience gained in a study on the therapeutic application of nCPAP in postoperative patients with severe oxygenation failure. In that study, a treatment duration of 12 to 24 h was effective in achieving a sustained improvement of pulmonary oxygen transfer in all patients. The criteria to terminate nCPAP therapy before 24 h were withdrawal of consent or transfer of patients to the intermediate care unit where nCPAP therapy was not available at
that time. All patients were monitored using an indwelling arterial cannula, a central venous catheter, continuous pulse oximetry, and continuous ECG recording.

From the arterial cannula, arterial blood gas samples were drawn and immediately analyzed (ABL750; Radiometer; Copenhagen, Denmark). PaO₂/Fio₂ ratios were calculated for each patient during the first 24 h and after the cessation of nCPAP, using the arterial PO₂ and the Fio₂ that had been chosen at the oxygen blender. In every patient, an arterial blood gas analysis was performed every 4 h while in the ICU, and PaO₂/Fio₂ ratios were calculated accordingly. Severe impairment of pulmonary oxygen transfer was defined as a PaO₂/Fio₂ ratio of < 100.

Chest x-rays were analyzed by a radiologist to detect atelectasis. Pneumonia was defined according to the Centers for Disease Control and Prevention criteria.12

The decision to transfer patients to a general ward was made by intensive care physicians and the attending surgeons, respectively, who were not informed about the group allocation of the patient. This was achieved by removing all nCPAP-associated devices from the patient’s box before the daily morning rounds. The decision to reintubate was made by the attending intensive care physicians in accordance with the general operating procedures of the ICU.

We recorded demographic data, the duration of the operation, transfusion requirements, and perioperative catecholamine therapy. In the ICU, hemodynamics (ie, heart rate, arterial BP, and central venous pressure), the application of oxygen (ie, Fio₂), and airway pressures during nCPAP therapy were recorded continuously.

The number of patients with PaO₂/Fio₂ ratios of < 100, atelectasis, and pneumonia, and those requiring reintubation were documented, as well as the duration of intensive care treatment and hospital length of stay.

The statistical analysis was performed on an intention-to-treat basis. All data are shown as the mean ± SD. For normally distributed data, an analysis of variance for repeated measurements was performed followed by post hoc testing with the Schéffé test in case of significant differences between the study group and the control group. To compare nominal variables, the χ² test was used. The Bonferroni correction for multiple comparisons was applied. A p value of < 0.05 was considered to be significant.

## RESULTS

We recruited 56 consecutive patients following elective prosthetic replacement of the thoracoabdominal aorta. Six patients were excluded because they could not be extubated within < 48 h. Of these, five patients developed paraplegia, and four of them died, while the other two patients survived after prolonged intensive care therapy.

Accordingly, 50 patients were randomized (control group, 25 patients; study group, 25 patients). The subcategories of thoracoabdominal aortic aneurysms (using the Crawford classification) were evenly distributed within the control and study groups (type I, 5 vs 3 patients, respectively; type II, 9 vs 9 patients, respectively; type III, 11 vs 13 patients, respectively; difference not significant). Demographic data and data on the surgical procedures are shown in Table 1. It is worth mentioning that in both the study and control groups 7 of the 25 patients were active smokers. The incidences of a preoperative diagnosis of COPD were not different (control group, 12 of 25 subjects; study group, 13 of 25 patients; difference not significant) between both groups. One patient in the study group had undergone a tracheotomy for prolonged mechanical ventilation after pneumonia several years before. There were no other statistically significant differences between the control group and the study group. However, in all patients intraoperative catecholamine therapy was necessary, and the mean blood loss exceeded 4 L.

The mean duration of mechanical ventilation in the ICU was not different between the control group (26.9 ± 3.4 h) and the study group (26.6 ± 3.5 h). In the study group, nCPAP therapy was always initiated within 30 min following extubation. nCPAP therapy was maintained for a mean duration of 22.8 ± 2.8 h, and mean airway pressures were always kept at 10 ± 1 cm H₂O.

In Figure 1, heart rate, mean arterial BP, and central venous pressure are shown for the first 28 h following extubation (ie, before, during, and after the cessation of nCPAP therapy). There were no differences between the control group and the study group.

In Figure 2, PaO₂/Fio₂ ratios following extubation are shown. In both groups, baseline pulmonary oxygen transfer was impaired, as indicated by a PaO₂/Fio₂ ratio below 250. In the study group, pulmonary oxygen transfer improved significantly compared to the control group. After the cessation of nCPAP therapy, PaO₂/Fio₂ ratios in both groups returned to baseline values.

Although the improvement of pulmonary oxygen transfer with nCPAP therapy was only transient, pulmonary complications were significantly reduced in the study group (Table 2). It is worthwhile to note

### Table 1—Demographic Data and Data on the Surgical Procedures in the Study and Control Groups*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>nCPAP Group</th>
<th>Control Group</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>14</td>
<td>NS</td>
</tr>
<tr>
<td>Female</td>
<td>10</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>66 ± 3</td>
<td>67 ± 4</td>
<td>NS</td>
</tr>
<tr>
<td>Height, cm</td>
<td>171 ± 6</td>
<td>169 ± 5</td>
<td>NS</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>75 ± 4</td>
<td>72 ± 3</td>
<td>NS</td>
</tr>
<tr>
<td>Duration of operation, min</td>
<td>275 ± 10</td>
<td>265 ± 11</td>
<td>NS</td>
</tr>
<tr>
<td>Blood loss, mL</td>
<td>4,334 ± 60</td>
<td>4,024 ± 51</td>
<td>NS</td>
</tr>
<tr>
<td>Blood transfusion, U</td>
<td>16 ± 5</td>
<td>12 ± 3</td>
<td>NS</td>
</tr>
<tr>
<td>Retransfusion, mL</td>
<td>2,842 ± 42</td>
<td>2,041 ± 35</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Retransfusion = amount of blood retransfused using a cell saver; NS = not significant.
that also the incidence of cardiac complications (ie, myocardial infarction and arrhythmias) tended to be lower in the study group, although the difference was not statistically significant. Concerning other relevant adverse effects of surgery, like acute renal failure or postoperative delirium, no differences between the study group and the control group were observed.

The main result is shown in Figure 3. The duration of intensive care treatment tended to be shorter in the study group, and the total length of hospital stay was significantly reduced by one third in those patients receiving prophylactic nCPAP therapy. The adverse effects of nCPAP therapy were restricted to mild and transient ulcerations of the nasal bridge in two patients. Other side effects (eg, claustrophobia, nausea, vomiting, or aspiration) were not observed. One patient refused nCPAP therapy after 4 h because of discomfort.

In the control group, one patient died from acute myocardial infarction 2 weeks after transfer to the general ward. There were no deaths in the study group.

**DISCUSSION**

The natural history of patients with thoracoabdominal aortic aneurysms that have not been surgically treated is characterized by a poor outcome. In four large studies, it was shown that rupture rates are within the range of 42 to 73% within the...
first years following diagnosis. The 5-year survival rates in these cohorts were 13 to 39% with rupture of the aneurysm being the most common cause of death.3,13–15 Some studies3 have shown that the extent of the aneurysm, as reflected by the maximal aortic diameter, as well as the growth rate are predictive for the risk of rupture. Thus, in patients who have large aneurysms at the initial evaluation and in those with fast-growing aneurysms, elective surgical repair is advisable to prevent rupture and to improve survival.2

With current surgical techniques and due to the advances in perioperative care, elective repair of thoracoabdominal aortic aneurysms can now be accomplished with mortality rates of 7 to 12%,1 which, given the natural course of this disease and the extraordinary high mortality rate in emergency operations, clearly favors elective surgical therapy. However, patients who undergo combined thoracoabdominal surgery have a high risk of developing postoperative pulmonary sequelae. The division of the diaphragm and costal margin during the operation, high blood losses and transfusion requirements, and hemodynamic instability make these patients particularly prone to developing respiratory insufficiency. Accordingly, postoperative respiratory problems are a major cause of morbidity following this type of surgery. In a large study on 1,414 patients following the repair of thoracoabdominal aortic aneurysms, respiratory problems occurred in 60% of all patients. The most important respiratory complications were severe atelectasis (37%), pleural effusions (21%), and pneumonia (8%), leading to prolonged ventilatory support and to tracheostomy, finally, in 8% of all patients.5

Severe atelectasis reduces FRC and may cause hypoxemia. Furthermore, the ability to cough effec-

---

### Table 2—Pulmonary, Cardiac, and Other Relevant Complications in the Study and Control Groups*

<table>
<thead>
<tr>
<th>Complications</th>
<th>nCPAP Group</th>
<th>Control Group</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary complications</td>
<td>7</td>
<td>24</td>
<td>0.019</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Atelectasis</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>PaO_2/FIO_2 &lt; 100</td>
<td>4</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Reintubation</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Cardiac complications</td>
<td>4</td>
<td>8</td>
<td>NS</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cardiac arrhythmia</td>
<td>4</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>1</td>
<td>3</td>
<td>NS</td>
</tr>
<tr>
<td>Postoperative delirium</td>
<td>5</td>
<td>4</td>
<td>NS</td>
</tr>
</tbody>
</table>

*See Table 1 for abbreviation not used in the text.
tively is impaired so that mucous retention may promote pneumonia. In addition, these impairments of respiratory function increase the work of breathing and thus oxygen uptake. This way, a vicious cycle is initiated that finally results in a severe oxygenation deficit, respiratory insufficiency, the need for reintubation, and nosocomial infection. Postoperative respiratory insufficiency due to pneumonia nearly triples mortality. If reintubation becomes necessary, mortality nearly quadruples and length of stay in the ICU and in the hospital is prolonged by about 15 days, which also increases the overall treatment costs.

Thus, the prevention of such complications is of major importance in improving the clinical outcomes of these high-risk patients, and also in economizing the use of ICU and hospital resources. In this context, the noninvasive application of nCPAP therapy via a facemask has been described as an effective method for improving postoperative pulmonary dysfunction and pulmonary oxygen transfer, for resolving atelectasis, and even for avoiding reintubation in patients with severe postoperative respiratory failure. By increasing intrathoracic pressure, nCPAP therapy can restore a decreased FRC, and avoid atelectasis and hypoxemia. In addition, by increasing intrathoracic pressure, nCPAP therapy may shift the pressure-volume curve of the lung to the right, so that besides improving pulmonary oxygen transfer, nCPAP therapy also reduces the work of breathing and thus the respiratory workload.

Given these positive effects of nCPAP therapy on respiratory function, we hypothesized that the prophylactic application of nCPAP following elective extubation in high-risk surgical patients may reduce pulmonary morbidity, thereby improving the clinical course and shortening the length of hospitalization. Considering prophylactic application, it is important that nCPAP therapy is a well-tolerated, simple, and inexpensive technique. It does not require a ventilator since elevated airway pressures are created by means of a high-flow gas source and a simple PEEP valve. Patient acceptance of nCPAP is better compared to full facemask CPAP because normal communication, oral uptake of fluids, and effective clearance of respiratory secretions by cough is feasible, thus allowing continuous treatment for several hours, which is mandatory for successful therapy. In this context, it should be mentioned that in patients immediately after a surgical procedure, including opening of the abdominal cavity, the risk of stomach distension, nausea, and, thus, a potential for emesis and aspiration must be discussed. We did not observe any of these events in our patients, nevertheless we restricted the oral uptake of clear fluids to 500 mL in the first 24 h.

**Figure 3.** Length of stay in the ICU and in the hospital in the control group and the study group. The LOS in the hospital was significantly reduced by 12 days in the study group compared to that in control group. LOS ICU = length of stay in the ICU; LOS Hosp = length of stay in the hospital. * = p < 0.05 for comparison of the control group vs the study group.
Taken together, nCPAP therapy seems ideally suited to avoiding postoperative pulmonary complications following surgery of the thoracoabdominal aorta. Accordingly, it was shown that nCPAP improved pulmonary oxygen transfer in our patients receiving nCPAP therapy compared to patients who were treated with supplemental oxygen and intermittent mask CPAP. However, the latter observation rests on the premise that the FIO2 value chosen at the oxygen blender reflects the airway FIO2, which is a prerequisite for the exact calculation of the PaO2/FIO2 ratios. One may speculate on whether there was a difference in airway FIO2 between the two groups, with a higher airway FIO2 in the nCPAP group due to the tight-fitting CPAP mask and different gas flows. In a previous study, we showed that this was not the case. We analyzed intratracheal gas samples from spontaneously breathing patients who had received either nCPAP or oxygen therapy by a nonocclusive facemask at ambient airway pressure. It was shown that with gas flows of ≥25 L/min, the FIO2 chosen at the oxygen blender was almost the same as that in the trachea. Most important, there was no difference in airway FIO2 between patients in the CPAP group and those patients receiving oxygen via a nonocclusive facemask at ambient airway pressure. Thus, the calculated PaO2/FIO2 ratios in this study are reliable and, in particular, were improved by nCPAP therapy in the study group.

Although these positive effects on pulmonary gas exchange were restricted to the treatment period, nevertheless, the incidence of pulmonary complications (ie, atelectasis, impaired pulmonary oxygen transfer, and pneumonia) were lower in the study group. As a consequence, fewer patients in the study group required reintubation and mechanical ventilation. The decreased pulmonary morbidity also reduced the length of hospitalization by one third (ie, 12 days) and thus reduced treatment costs.

This study is the first to investigate prophylactic noninvasive ventilatory support by means of nCPAP following thoracoabdominal vascular surgery. Previously, in another randomized clinical trial, nCPAP therapy was shown to be effective in avoiding hypoxemia in patients undergoing abdominal aortic and peripheral vascular surgery. However, these patients had a lower risk of pulmonary complications due to the type of surgery. Thus, the incidence of respiratory failure requiring reintubation was low, so that effects on reintubation rate and length of hospitalization were not observed. In our high-risk group, we decided to use nCPAP therapy very early (ie, immediately following extubation in the ICU) because the decrease in FRC and thus the deterioration of pulmonary function occurs rapidly after the loss of PEEP (ie, within minutes after extubation). This was observed also in our control group since PaO2/FIO2 ratios decreased continuously following extubation. The latter could not be avoided by routine chest physiotherapy and the intermittent application of nCPAP therapy using a facemask every 4 h. This observation was made in accordance with data from studies using prophylactic application of intermittent facemask nCPAP in patients after extended abdominal surgery. The improvement of pulmonary gas exchange and the increase of FRC was short-lived, and was restricted to the period of elevated airway pressures, with a rapid deterioration after the cessation of nCPAP therapy. Thus, it is important to initiate prophylactic nCPAP therapy early but also to make sure that therapy is indeed performed continuously. This is emphasized also by data from patients with severe respiratory failure in whom oxygenation improved significantly with nCPAP therapy, as long as it was applied without interruptions.

Considering the efficacy of nCPAP therapy, it is also important to apply effective airway pressures. Studies in patients who had undergone major thoracic surgery showed that only airway pressures of about 10 cm H2O within the nCPAP facemask were effective in keeping intrathoracic airway pressures positive during the whole respiratory cycle, which is mandatory for improving pulmonary function and for avoiding the derecruitment of lung areas. Airway pressures within this range were well-tolerated, and significant side effects on hemodynamics, intolerance by patients, or other complications were not observed in our study.

Finally, it is worth mentioning that there were also fewer adverse cardiac effects in the nCPAP group, although the difference failed to reach statistical significance. In previous studies, nCPAP therapy had been shown to reduce preload and afterload of the left ventricle by reducing left ventricular transmural pressures. In patients with impaired left ventricular performance, nCPAP therapy thus reduced the left ventricular workload and improved cardiac output. Since a considerable number of patients with vascular diseases experience reductions in cardiac function, one may speculate whether nCPAP therapy exerts beneficial effects on hemodynamics in this group.

Taken together, nCPAP therapy is a technically simple, inexpensive, and well-tolerated method for improving pulmonary function in postoperative patients following thoracoabdominal vascular surgery. It reduced the incidence of major postoperative pulmonary complications and shortened the length of hospitalization. Thus, the prophylactic application of nCPAP therapy can be recommended as a standard treatment following this type of surgery.
References