Heart, Lung and Vessels. 2013; 5(3): 137-141

Non-invasive ventilation in cardiac surgery: a concise review

L. Cabrini, V.P. Plumari, L. Nobile, L. Olper, L. Pasin, S. Bocchino, G. Landoni, L. Beretta, A. Zangrillo

Department of Anesthesia and Intensive Care, San Raffaele Scientific Institute, Milan, Italy

Heart, Lung and Vessels. 2013; 5(3): 137-141

ABSTRACT

Mild to severe respiratory dysfunction is still a common issue after cardiac surgery. Postoperative respiratory complications are associated with prolonged hospitalization and worse survival. In this high-risk surgery, non-invasive ventilation could have relevant positive effects. The present narrative concise review aims to summarize available data on the role of non-invasive ventilation before and after cardiac surgery. Non-invasive ventilation exerts its main effects on the pulmonary and on the cardiovascular systems. Non-invasive ventilation can be applied to prevent acute respiratory failure; it can also be prescribed as a curative tool to treat an established postoperative acute respiratory failure. Non-invasive ventilation could also be applied to wean patients from mechanical ventilation. When applied as a preventive tool, the main scope is the prevention of pneumonia by resolving or preventing atelectasis. So far, limited (but encouraging) data are available: its routine use in all patients to prevent postoperative acute respiratory failure cannot be recommended. Non-invasive ventilation to treat postoperative acute respiratory failure has been evaluated more extensively. A failure rate from 10 to 55 % was reported. Safety appears preserved, with no relevant hemodynamic complication reported. Non-invasive ventilation has also been applied during percutaneous aortic valve implant in patients unable to lie supine due to severe respiratory limitation and orthopnea. In conclusion, non-invasive ventilation has the potential to be very useful before and after cardiac surgery. So far, results are promising but available data are limited. Training and experience are essential to obtain positive results and to avoid complications.

Keywords: *non invasive ventilation, cardiac surgery, acute respiratory failure, perioperative medicine, cardiac anesthesia.*

INTRODUCTION

Mild to severe respiratory dysfunction is still a common issue after cardiac surgery, often associated with a postoperative respiratory restrictive syndrome (1-7). Anesthesia, cardiopulmonary by-pass, thoracotomy, diaphragm dysfunction, sternotomy, postoperative pain, fluid overload, massive transfusion, and patient's pre-existing comorbidities, contribute to the postoperative risk of respiratory complications (1-7). Postoperative respiratory complications are associated with prolonged hospitalization and poor survival (1-7). Non-invasive ventilation (NIV), including both continuous positive airway pressure (CPAP) and non-invasive positive airway pressure (NPPV) modalities, has been evaluated in cardiac surgery to prevent or to treat postoperative acute respiratory failure (ARF) with non-conclusive results (8). In this high-risk surgery, NIV could have relevant positive effects (9), but negative consequences are also possible. Moreover, patients scheduled for cardiac surgery are often frail and some require procedures (like transesophageal

Corresponding author:
Cabrini Luca, MD
General Intensive Care
Department of Anesthesia and Intensive Care
San Raffaele Scientific Institute
Via Olgettina, 60 - 20132 Milan, Italy

echocardiography - TEE) that could be dangerous in these patients. Recently, NIV showed to be potentially useful during procedures performed in cardiac surgery patients at high risk for respiratory failure, like orthopnoic patients (10-12). The present narrative concise review aims to summarize available data on the role of NIV before and after cardiac surgery.

NIV physiological effects

NIV exerts its main effects on the pulmonary and on the cardiovascular systems (13). Through the application of a positive end-expiratory pressure (PEEP), with or without a pressure support during inspiration, NIV restores lung volumes by opening atelectatic areas (a common postoperative finding), increases alveolar ventilation and reduces the work of breathing (10-12). By reopening atelectasis, NIV can prevent postoperative pneumonia (14-20).

NIV can also offer beneficial effects on the cardiovascular function, lowering left ventricle afterload and improving cardiac output (13); however, data about improvement of cardiovascular function are scarce and a mild reduction of the cardiac function due to NIV has been reported (21, 22). A strict monitoring is required in patients with labile cardiac function.

Aims and timing

NIV can be applied preoperatively or postoperatively to prevent ARF; it can also be prescribed as a curative tool to treat an established postoperative ARF (23, 24). There is a growing amount of data on NIV efficacy and safety in cardiac surgery patients (8). NIV could also be applied to wean patients from mechanical ventilation (25, 26). When applied as a preventive tool, the main aim of NIV is the prevention of pneumonia by resolving or preventing atelectasis, a common finding in postoperative radiological examinations (23, 27, 28). The first studies failed to demonstrate clinically relevant positive effects (14, 18, 20, 29). Two recent large studies found more encouraging results. In the first study (19), NPPV applied for one hour every six hours for one day reduced the incidence of atelectasis and improved lung volumes; however, the length of intensive care unit (ICU) and hospital stay was not reduced. In the largest study so far performed in cardiac surgery (500 patients) (30), nasal CPAP applied on the first postoperative day for at least six hours allowed a significant reduction in the number of pulmonary complications (including pneumonia and re-intubation rate) and in the readmission rate to the intensive care unit; cardiac complications and hospitalization time were not different. At the moment, no study evaluated if NIV could be more effective in high-risk patients (compared to low risk patients) or in high-risk interventions (compared to interventions at low risk for postoperative respiratory complications): studies in other surgical fields found that a positive role can be demonstrated only when NIV is applied to patients at higher risk for postoperative complications. Moreover, no data are available on preoperative preventive NIV application in high risk patients undergoing cardiac surgery, and indications are not clear. So far, routine NIV use in all patients to prevent postoperative ARF cannot be recommended. NIV application to treat postoperative ARF started more than 10 years ago with reported high success rates (31-33), up to 90% for mild to moderate hypoxemic respiratory failure. More recently a randomized study (34) comparing NPPV with standard oxygen therapy found a significantly lower incidence of arrhythmias, a lower intubation rate, a shorter ICU stay and a lower mortality in the NIV group. In a larger study in non-hypercapnic patients meeting predefined criteria for intubation, patients treated using NIV had less need of

catecholamines, lower incidence of pulmonary infection, shorter hospital stay and a better survival rate (35). However, a failure rate of 25% was observed. In a retrospective study with NIV as first-line treatment in patients with ARF after cardiac surgery (799 patients among 2,261 undergoing surgery), the mortality rate was not different between treated patients and patients without ARF (36). Recently, in a retrospective study on NIV application to treat postoperative ARF in cardiac surgery patients, a failure rate of 52% was observed (37); obese patients and patients with lobar atelectasias as a cause of ARF showed better outcomes. In conclusion, few studies evaluated NIV to treat postoperative ARF. A failure rate from 10 to 55% was reported: older ages and pneumonia were the main risk factors for failure. Safety appears preserved, with no relevant hemodynamic complication reported. NIV efficacy in selected subgroups was not evaluated.

NIV has also been applied intraoperatively in settings not strictly requiring general anesthesia (38-43). Currently, cardiac surgery techniques are mainly performed under general anesthesia. However, there is a growing interest in less invasive procedures to be offered to patients unfit for surgery. NIV has been applied during percutaneous aortic valve implant (TAVI) in patients unable to lie supine due to severe respiratory limitation and orthopnea (10-12). Moreover, NIV support allowed a light sedation, increasing patient comfort (10-12). After the first pioneering reports, larger studies are required to demonstrate NIV efficacy in this complex setting, as no study demonstrated the superiority of NIV application versus tracheal intubation in this setting. NIV has been evaluated in the postoperative period as a tool to shorten the length of mechanical ventilation or to allow extubation after failure of weaning trials (25, 26). Its efficacy seems confined to patients at high risk for postoperative ARF. We are not aware of studies focused on cardiac surgery patients; research on this topic is warranted, above all in the difficult-to-extubate subgroup.

Location

Almost all studies were performed in the ICU, due to the inherent better availability of the required equipment, better monitoring, better staffing and better experience and knowledge. However, a worldwide shortage of ICU beds compared to the number of hospitalized critically ill patients is present. As a consequence, NIV application outside the ICU has been increasingly reported (44). Shortening ICU stay or avoiding ICU readmission could also allow a better use of ICU beds without stopping the cardiac surgical activity. Patients commonly develop ARF early after surgery, but ARF can also appear later, often as a consequence of nosocomial pneumonia or cardiac failure.

So far, only one observational, prospective, pilot study evaluated NIV application in a cardiac surgery ward to treat mild to moderate ARF (45). 7% of patients undergoing cardiac surgery developed ARF after ICU discharge and were treated with NIV on the ward; 97% were discharged from the hospital in good condition; 3/85 patients were readmitted to the ICU. The only major complication was a case of hypotension that resolved immediately after NIV interruption. Despite these positive results of NIV applied on the surgical ward, it should be kept in mind that a safe and effective use outside the ICU requires training of the staff, experience, and a cautious selection of patients.

In case of NIV failure, tracheal intubation must be promptly performed; prolonging NIV despite no clear improvement and delaying tracheal intubation has been associated with worse survival rates.

NIV use during trans esophageal cardiography

Many patients scheduled for cardiac surgery must undergo long procedures with different degrees of discomfort. Not rarely patient's comorbidities make these procedures risky or contraindicated. Moreover, patients can be unable to tolerate the supine position for enough time. Trans esophageal echocardiography (TEE) is often a crucial examination in the preoperative evaluation; recently, a case series on NIV application to perform TEE has been published (10).

Home-made interfaces were used, allowing the introduction of the probe thorough a sealing port. Orthopnoic patients tolerated the supine position and a light sedation without respiratory deterioration. Other procedures (ie, coronarography) could be performed under NIV as well.

Fields of research

NIV could be highly useful for cardiac surgery patients both pre- and postoperatively, but so far evidence is scarce. Research is needed to better define who should be treated, when and how. Patients scheduled for cardiac surgery are becoming more and more sicker, at higher risk for pulmonary complications.

A timely application of NIV in selected patients could be markedly cost-effective, but so far we have no data on economic aspects. Larger studies should also address NIV related-complications.

Furthermore, training is required to make NIV effective and safe. Training is fundamental if NIV has to be applied outside the ICU; in this setting data collection is of particular relevance and should include ward staff and patients as a source of data (46, 47).

A constantly available NIV service or a medical emergency team expert on NIV should be offered to the surgical ward hosting NIV treatments (48-52).

CONCLUSION

NIV has the potential to be very useful before and after cardiac surgery to prevent or to treat ARF. So far, results are promising but available data are limited. Training and experience are essential to obtain positive results and to avoid complications. Further studies are needed to better identify indications and contraindications of the technique in this area.

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Cite this article as: Cabrini L, Plumari VP, Nobile L, Olper L, Pasin L, Bocchino S, Landoni G, Beretta L, Zangrillo A. Non-invasive ventilation in cardiac surgery: a concise review. Heart, Lung and Vessels. 2013; 5(3): 137-141.

Source of Support: Nil. **Disclosures:** None declared.