BJA Advance Access published January 19, 2014

British Journal of Anaesthesia Page 1 of 10
doi:10.1093/bja/aet465

BJA

Intraoperative prophylactic and therapeutic non-invasive ventilation: a systematic review

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Editor's key points

- This review has identified 30 papers which included 618 patients who underwent intraoperative non-invasive ventilation (NIV).
- In 92 patients, NIV was used to treat acute respiratory failure.
- In the majority of the patients, NIV was used during sedation.
- When tracheal intubation is best avoided, feasibility and usefulness of intraoperative NIV are confirmed.

Summary. Non-invasive ventilation (NIV) has been used to prevent or to treat perioperative acute respiratory failure (ARF). Intraoperative prophylactic and therapeutic use of NIV could be of interest to patients with anticipated difficulty in postoperative weaning from mechanical ventilation or to patients refusing tracheal intubation. Intraoperative NIV might also be useful when deep sedation is required, as this can cause respiratory depression. PubMed, Embase, Google Scholar, and Cochrane Library were searched for pertinent studies. Inclusion criteria were NIV use during surgery and adult patients; the exclusion criteria were NIV application only in the preoperative or postoperative periods, paediatric patients, NIV applied as negative pressure ventilation. Thirty papers including 618 patients were included for final analysis. Intraoperative therapeutic NIV to treat ARF was reported for 92 patients and in all those cases, including six Caesarean sections, surgery was completed uneventfully. Intraoperative prophylactic NIV to avoid ARF was described in 24 patients with severe respiratory limitation and in 502 healthy patients during deep sedation. Three patients could not be successfully ventilated due to upper airway obstruction, but no further complication was reported. Intraoperative NIV appears feasible, safe, and potentially useful, particularly when tracheal intubation is best avoided. However, high-quality, randomized studies are required.

Keywords: deep sedation; intraoperative care; intraoperative complications; non-invasive ventilation; respiratory insufficiency

Non-invasive ventilation (NIV) is widely used to treat chronic or acute respiratory failure (ARF) in selected cases, such as exacerbation of chronic obstructive pulmonary disease (COPD), cardiogenic pulmonary oedema, and ARF in immunocompromised patients.[1] NIV is also applied to prevent or to treat perioperative ARF: several reviews in fact suggest that patients at higher risk of postoperative ARF (obese or affected by lung diseases), and those undergoing surgeries at higher risk of postoperative respiratory complications (thoracic, cardiac, or upper abdominal surgery), would benefit mostly.[2–4]

To date, no review about the use of intraoperative NIV has been published as yet. By avoiding tracheal intubation, muscle relaxation, and general anaesthesia, NIV could be of particular interest for patients with labile respiratory function, a condition predisposing to difficult or impossible postoperative weaning from mechanical ventilation.[5 6] In daily practice, when postoperative weaning is deemed difficult, surgery poses an ethical dilemma and patients can choose not to undergo an otherwise recommended surgical procedure.[7] Moreover, intraoperative NIV might be useful when deep sedation, but not general anaesthesia, is required in patients with respiratory depression.[8–10]

Therefore, we performed a systematic review of all published studies reporting intraoperative application of NIV, whether prophylactic or therapeutic, in adult patients.

Methods

Search strategy

PubMed, Embase, Google Scholar, and Cochrane Library were searched for pertinent studies (updated October 1, 2012) by three investigators (L.C., L.N., V.P.P.). The full search strategy was performed as follows: [(NIV(tw) OR {[non-invasive(tw) OR noninvasive(tw)] AND [ventilation(tw)]} OR BiPAP(tw) OR CPAP(tw) OR NIPPV(tw) OR 'positive pressure'(tw)) AND ('surgical procedures, operative'(mh) OR intraoperative*(tw) OR intraoperative*(tw) OR perioperative*(tw) OR perioperative*(tw) OR theater(tw) OR surgery(tw) OR operation(tw) OR {operating(tw) NEAR [room(tw) OR theater(tw)]} OR {[care(tw) OR surgical(tw)] NEAR room(tw)})] AND 'anesthesia'(mh) NOT [animals(mh) NOT humans(mh)].

Further searches were focused on conference proceedings from pertinent congresses. The references of retrieved articles were carefully checked. No language restriction was enforced.

Study selection

References obtained from database and literature were first independently examined at the title/abstract level by the same three investigators, with divergences resolved by consensus and with supervision of two investigators (G.L., A.Z.) and

then, if potentially pertinent, retrieved as complete articles. The following inclusion criteria were used for potentially relevant studies: (i) NIV use during surgery; and (ii) study performed in adult patients. Exclusion criteria were as follows: (i) NIV application only in the preoperative or postoperative periods, (ii) paediatric patients, and (iii) NIV applied as negative pressure ventilation. Two investigators (L.C., L.N.) independently selected studies for the final analysis assessing their compliance with the selection criteria. Divergences were resolved by consensus.

Data abstraction and study characteristics

First author and year of publication, study design, country of the corresponding author, number and characteristics of patients, clinical setting, type and length of surgery, decubitus, device and technique used, preoperative use of NIV, intraoperative events, and follow-up were independently extracted by two investigators (G.B., M.M.).

Results

The search strategy retrieved 893 publications and a further 20 studies were found by cross-checking the references in bibliographies of the articles and manually searching other databases. After examination of the title, the abstract, and finally the full text, 31 papers, for a total of 618 patients, were included in the final analysis according to the inclusion and exclusion criteria.[7–37]

Six papers reported intraoperative therapeutic NIV application to treat an established ARF in 86 patients (Table 1).[11–16] Surgery was completed uneventfully in all cases. Another six papers reported intraoperative therapeutic NIV application in six pregnant women (five of which already on domiciliary NIV) undergoing Caesarean section and presenting with ARF (Table 2).[17–22] In all cases, the mothers and the newborns survived surgery. In one case, the mother developed pneumonia on day 7, was intubated the following day, and died on day 10 due to cardiac failure; post-mortem examination revealed completely non-aerated congestive lungs.[17] In all these 92 cases, tracheal intubation and general anaesthesia were refused or considered to be avoided.

Sixteen studies reported the prophylactic intraoperative use of NIV in a total of 24 patients with severe respiratory function limitation, seven of which already on domiciliary NIV (Table 3).[7 23–37] In these patients, the respiratory function was chronically limited. As weaning was expected to be difficult or impossible, tracheal intubation and general anaesthesia were considered unsafe or not appropriate, even though the preoperative labile respiratory status was not worse than the usual one. Surgery was completed in all cases without respiratory complications. No cases of intolerance to NIV or NIV-related complications were reported.

Finally, we identified four papers including a total of 502 patients with no pre-existing or intraoperative respiratory deficits who received prophylactic NIV to avoid hypoventilation during deep sedation (Table 4).[8–10 26] It is to be noted that all but one patient in this group came from the same centre and received deep sedation with propofol during spinal anaesthesia. Three out of 502 patients (0.6%) could not be successfully ventilated with NIV due to upper airway obstruction. One case was resolved by increasing end-expiratory pressure to 10 cm H_2O, the second one was resolved by inserting a nasal cannula, and the third was resolved by the insertion of a laryngeal mask. Furthermore, in one of the studies, a preliminary evaluation of 10 patients sedated with propofol, initially ventilated by nasal continuous positive airway pressure (CPAP) and then by nasal bilevel positive airway pressure (BiPAP), revealed that the patients showed insufficient ventilation with hypoxaemia and hypercapnia while on CPAP.[8] Ventilation was always adequate after crossing to BiPAP. The remaining patients did not present major complications.

Discussion

This is the first review of the use of intraoperative prophylactic or therapeutic NIV. NIV during surgery seems to be feasible, safe, and potentially useful, but only limited and low quality data are available. No randomized trial evaluated NIV efficacy and safety compared with other forms of mechanical ventilation or no mechanical ventilation. However, in all these very heterogeneous cases, NIV allowed the avoidance of tracheal intubation and general anaesthesia.

NIV has an established role in the treatment of chronic respiratory failure or ARF due to common causes like COPD or cardiogenic pulmonary oedema.[1] NIV is contraindicated in patients in respiratory arrest, unable to fit the mask, unable to manage the secretions, uncooperative, or with haemodynamic shock.[1] Several complications have been reported, such as intolerance, skin lesions, or excessive air leaks; moreover, failure rate can be as high as 50% in hypoxaemic patients.[1] Recently, NIV has been evaluated in the perioperative setting as a prophylactic or therapeutic tool. So far, the evidence available is still limited, but NIV seems especially promising when applied to prevent ARF, particularly in patients at higher risk of postoperative respiratory complications or after surgery at higher risk of postoperative ARF.[2–4]

In patients with ARF or at high risk of ARF, the supine position required in most surgeries can worsen the respiratory function; moreover, neuraxial anaesthesia has the potential to interfere with the intercostal muscle function.[22] In the abovementioned conditions, NIV may improve ventilation reducing work of breathing, improving alveolar ventilation, reducing atelectasis, and reducing left ventricular afterload.[2] An improvement in diaphragmatic ventilatory excursion was observed by ultrasonography.[13]

Our systematic review showed that intraoperative NIV has been mainly used in two conditions:

(i) In a few cases, NIV was applied as a therapeutic tool while surgery was performed despite an ongoing severe ARF.[11–22] Interestingly, even if not fulfilling our inclusion criteria and therefore not further discussed in this paper, we identified five case reports on successful therapeutic NIV during labour and vaginal delivery in patients with ARF.[38–42]