Non-invasive ventilation-aided transoesophageal echocardiography in high-risk patients: a pilot study

Fabio Guarracino1*, Luca Cabrini2, Rubia Baldassarri1, Claudia Cariello1, Remo Daniel Covello2, Giovanni Landoni2, Sonia Petronio3, and Nicolo Ambrosino4

1Cardiothoracic Anaesthesia and Intensive Care Medicine, Cardiothoracic Department, University Hospital of Pisa, Via Paradisa 2, Pisa, Italy; 2Anaesthesia and Intensive Care Medicine, Universita` Vita-Salute San Raffaele, Milano, Italy; 3Catheterization Laboratory, Cardiothoracic Department, University Hospital of Pisa, Pisa, Italy; and 4Pulmonary Rehabilitation and Weaning Unit, Auxilium Vitae, Volterra, Italy

Received 22 December 2009; accepted after revision 3 February 2010; online publish-ahead-of-print 25 February 2010

Aims
Transoesophageal echocardiography (TEE) may require patient sedation, eventually leading to respiratory depression, a risky condition in severe cardiac disease. Non-invasive ventilation (NIV) has been applied during diagnostic manoeuvres, but its use during TEE has not been reported. We describe NIV-aided continuous TEE monitoring under sedation in the supine position in three consecutive orthopnoeic patients with severe aortic valve stenosis: two of them underwent percutaneous aortic valve implantation, and one underwent aortic valvuloplasty.

Methods and results
The TEE probe was passed through a hole performed with a surgical cutter in an NIV face-mask. Pulsoximetry, heart rate, arterial blood pressure, respiratory rate, arterial blood gases, patients’ comfort, and patient’s sedation were monitored throughout the procedure. Percutaneous aortic valve implantation procedures lasted almost 2 h, while the valvuloplasty procedure lasted 70 min. Non-invasive ventilation and continuous TEE were performed throughout the procedures without technical problems or respiratory or haemodynamic complications, and all patients felt always comfortable.

Conclusion
Non-invasive ventilation through a modified face-mask allowed to perform continuous TEE examination and to avoid tracheal intubation and general anaesthesia in three high-risk patients undergoing beating heart treatment of aortic valve stenosis.

Keywords
Transoesophageal echocardiography • Non-invasive ventilation • Percutaneous • Aortic valve stenosis • Implantation • Valvuloplasty

Introduction

When transthoracic echocardiogram does not provide adequate visualization, a transoesophageal echocardiogram (TEE) may be necessary in patients undergoing several interventional procedures such as transcoronary ablation of septal hypertrophy (TASH), patent foramen ovale (PFO) closure, percutaneous aortic valve implantation (PAVI), and aortic valvuloplasty for aortic valve stenosis. The percutaneous approach to aortic valve stenosis minimizes the surgical trauma and haemodynamic changes associated with general anaesthesia and positive pressure ventilation, and is increasingly used in critically ill patients with severe aortic stenosis and severe comorbidities even under local anaesthesia.2–4

Transoesophageal echocardiography examination is associated with temporary arterial oxygen tension worsening during and after uncomplicated echo examination, and patients with severe cardiac disease are at risk of developing respiratory failure or serious cardiac arrhythmias under these circumstances. On the other hand, general anaesthesia is associated with significant potential complications and sedation carries a high risk of acute respiratory failure in orthopnoeic patients.

* Corresponding author. Tel: +39 050 995 295/96; fax: +39 050 995 264, Email: fabiodoc64@hotmail.com

Published on behalf of the European Society of Cardiology. All rights reserved. © The Author 2010. For permissions please email: journals.permissions@oxfordjournals.org.
Non-invasive ventilation (NIV) may avoid many of the complications of invasive mechanical ventilation while ensuring a similar degree of efficacy in a wide range of conditions.\textsuperscript{4,6} so far, NIV has never been reported as an aid to TEE examination.

We report the use of NIV delivered by a modified mask in orthopnoeic patients undergoing continuous TEE under sedation during percutaneous treatment of aortic valve stenosis.

**Methods**

**Patients**

We report data from three orthopnoeic patients, two males and one female, respectively, aged 83, 84, and 88, all in NYHA class 3, with severe aortic valve stenosis scheduled for percutaneous treatment on the basis of a logistic EuroSCORE $>20\%$ and coexisting comorbidities. All patients were extensively informed about the anaesthesiological options and gave written informed consent to the procedure, and to the scientific use of anonymous clinical data.

**Percutaneous aortic valve implantation**

All patients underwent transfemoral percutaneous procedures in the cardiac catheterization laboratory with operating theatre-like sterile precautions as described elsewhere.\textsuperscript{3,4} Intraoperative monitoring consisted of five-lead electrocardiogram, pulse oximetry, invasive arterial pressure by radial artery cannulation, central venous pressure through internal jugular vein cannulation, TEE, temperature, urine output, and serial arterial blood gas analysis. In the two patients scheduled for PAVI balloon valvuloplasty with a 20–23 mm balloon under rapid right ventricular pacing was performed before CoreValve\textsuperscript{8} (Medtronic, CV Luxembourg S.a.r.l) deployment. Then the device was directed over a stiff guidewire, placed in the left ventricle, and deployed retrogradely under fluoroscopic and TEE guidance. In the patient undergoing isolated valvuloplasty, the procedure was performed with a 23 mm balloon under rapid right ventricular pacing. Transoesophageal echocardiography was performed using an omniplane probe (4–7 Hz) and IE33 echocardiography system (Philips, Amsterdam, The Netherlands) in all patients.

**Anaesthesia**

All patients were premedicated with intramuscular atropine 0.01 mg/kg 60 min previous the procedure to avoid salivation during NIV. Preoperative fasting, at least 2 h for fluids and 6 h for solids, was requested in order to prevent pulmonary aspiration,\textsuperscript{7} and the TEE probe was maintained in oesophageal position during the procedure to avoid opening of the oesophageal sphincter and regurgitation of gastric content. Local anaesthesia consisted of 1% lidocaine injected subcutaneously at the arterial and venous femoral access sites. The oropharyngeal local anaesthesia was obtained with spray lidocaine 2% in sitting position before starting NIV. Sedation, initiated after TEE probe insertion, was accomplished with remifentanil infusion (starting dose 0.02 $\mu$g/kg/min) adjusted according to the response sedation scale (target level: score 2–3 with modified Wilson scale)\textsuperscript{3} and procedural requirements. Remifentanil, a potent short-acting opioid whose use is approved for only by anaesthesia care providers, was always given by a cardiac anaesthetist.

**Non-invasive ventilation**

Non-invasive ventilation was delivered by a ventilator specifically designed for NIV (Vision, Respironics, Inc.\textsuperscript{6}, Murrysville, PA, USA) connected through a monotube circuit to an adult oro-nasal mask (VIP 75\textsuperscript{TM} 7500 Series Oro-Nasal V masks\textsuperscript{TM} for Non-Invasive Ventilation, Hans Rudolph, Inc., Kansas City, MO, USA). In all cases, the TEE probe was passed through a vertical hole (Figure 1) obtained on the anterior part of the mask by a surgical cutter. Visual monitoring of ventilator display confirmed leak-free ventilation during TEE probe manipulation, thus avoiding inadequate ventilatory support. In all patients, NIV was used in pressure support modality. The ventilator was set at an inspiratory positive airway pressure between 8 and 12 cmH2O, a positive end expiratory pressure of 4–6 cmH2O, an inspiratory oxygen fraction (FiO2) between 0.35 and 0.50 in order to maintain a pulsoximetry arterial oxygen saturation (SaO2) $>92\%$, arterial CO2 tension (PaCO2) $<50$ mmHg throughout the procedure.

A back-up respiratory rate of 10 bpm was set. Non-invasive ventilation was started in the sitting position and maintained for 15 min in all cases to allow the patient to adapt to both the mask and the ventilator setting. Thereafter, the patient was placed in the supine position under NIV and the TEE probe gently introduced through the hole in the mask. Non-invasive ventilation was administered throughout the procedure in all cases. According to our protocol, after the aortic valve procedure all patients were transferred to the intensive care unit (ICU) where NIV was continued for 2 h.

![Figure 1](image)

**Figure 1** Interventional setting: the transoesophageal echocardiography probe passing through a hole on the anterior part of the mask.

**Table 1** Results from the three patients

<table>
<thead>
<tr>
<th>Procedure duration (min)</th>
<th>97 ± 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative NIV duration (min)</td>
<td>112 ± 10</td>
</tr>
<tr>
<td>Sedation score during procedure (mean)</td>
<td>2</td>
</tr>
<tr>
<td>Basal respiratory rate (bpm)</td>
<td>30 ± 3</td>
</tr>
<tr>
<td>Respiratory rate at 3 min NIV (bpm)</td>
<td>22 ± 2</td>
</tr>
<tr>
<td>Postoperative NIV duration (min)</td>
<td>118 ± 5</td>
</tr>
<tr>
<td>ICU stay (h)</td>
<td>6</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>5</td>
</tr>
<tr>
<td>6-month follow-up</td>
<td>All patients alive</td>
</tr>
<tr>
<td>NYHA class at 6 months median</td>
<td>2 (1–2)</td>
</tr>
</tbody>
</table>
Results

Three patients underwent NIV-aided percutaneous treatment of aortic valve stenosis, with continuous TEE monitoring under local anaesthesia plus sedation. Main results are summarized in Table 1. All the procedures were completed without technical problems. No respiratory or haemodynamic complications were observed. No complications related to TEE insertion and manipulation occurred. In all patients, SaO₂ > 92% and PaCO₂ < 50 mmHg were maintained throughout the procedures. All patients were conscious and comfortable during the procedure. At 6-month follow-up, all patients were alive and in satisfactory conditions showing improved NYHA class.

Discussion

Due to orthopnoea, patients with severe aortic valve stenosis may be unsuitable either for TEE monitored PAVI, neither for TEE monitored valvuloplasty, unless general anaesthesia is performed. However, general anaesthesia is associated with significant potential complications, particularly respiratory complications, and it is poorly tolerated by high-risk cardiac patients. Such patients gain important advantages from minimally invasive anaesthetic techniques. The technique we describe allowed gentle conduction of the procedure, with the patient lightly sedated but always cooperative. The mask and the TEE were well tolerated in all cases while orthopnoeic patients were lying in the supine position throughout the procedure. Non-invasive ventilation proved effective in preventing respiratory failure due to sedation.

The described technique could be used in other settings where critically ill patients with poor cardiac and respiratory function need a TEE examination, such as patients admitted to the intensive care or coronary units for myocardial infarction, or those undergoing TASH or PFO closure.

However it must be emphasized that NIV for TEE procedures under sedation has some limitations: (1) airways are not protected: careful monitoring of the sedation level is therefore mandatory; (2) the patient’s cooperation is essential; (3) the entire procedure must be performed under close monitoring of vital signs and oxygen saturation. Moreover, remifentanil is a potent opioid with potential side effects, like muscle rigidity, which may make NIV difficult or impossible, so it should be always administered by anaesthetists experienced in remifentanil sedation during NIV.

In conclusion, in a case series of three high-risk orthopnoeic patients with cardiac disease, NIV delivered by a modified face-mask with a hand-made vertical hole allowed safe continuous TEE examination in lightly sedated patients. Non-invasive ventilation is promising in that it offers an aid to alleviate dyspnoea and to prevent respiratory failure during TEE under sedation.

Conflict of interest: none declared.

References