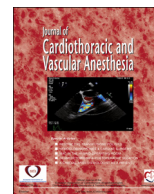


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## Review Article

## Noninvasive Ventilation During Endoscopic Procedures: Rationale, Clinical Use, and Devices

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Endoscopic procedures, such as transesophageal echocardiography, gastroscopy, and airway fibroscopy, routinely are performed in a heterogenous population of patients for diagnostic/interventional purposes (eg, transfemoral aortic valve replacement, airway fibroscopies, and intubation). Sedation frequently is administered to achieve an appropriate degree of patient compliance and procedure success. Patients with reduced respiratory reserve or those who are overly sedated, however, may develop hypoxia and respiratory failure during endoscopies, necessitating premature termination of the examination itself.

In recent years, periprocedural noninvasive ventilation has been used to improve oxygenation and avoid general anesthesia. New technology has been developed, and noninvasive ventilation masks that allow for the insertion of an endoscopic probe have become available in clinical practice.

Positive preliminary results have been reported in several clinical contexts, including traditional and hybrid operating rooms and intensive care units. Ventilatory support has been delivered during prolonged transesophageal cardiac examinations and interventions, broncoscopic maneuvers, and in difficult airway scenarios. Furthermore, the availability of innovative dedicated devices has allowed for some interventional procedures that require endoscopy to be performed with the patient under sedation and on ventilatory support with noninvasive ventilation instead of general anesthesia. These approaches might be further expanded in the future and possibly reduce costs, organizational requirements, and complications compared using standard management with general anesthesia.

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**Key Words:** noninvasive ventilation; endoscopy; respiratory failure; anesthesia; intensive care unit

CARDIAC, GASTROINTESTINAL, and airway endoscopic procedures are performed routinely in a heterogenous population of patients for both diagnostic and therapeutic purposes. Transesophageal echocardiography (TEE), for example, provides unique diagnostic information compared with the transthoracic approach; however, as with other endoscopic maneuvers, it needs to be performed in a protected environment by expert personnel.

The indications for performing endoscopic maneuvers of the cardiac, airway, and gastrointestinal tracts currently are expanding in different clinical contexts because they represent a less invasive approach compared with surgical interventions in an operating room. These procedures usually do not require any sedation but require the full compliance of patients (not always easy to obtain) to allow the procedure to run smoothly and avoid severe possible complications due to patient movements, including vascular, gastrointestinal, and airway tract perforation. Furthermore, endoscopic invasive procedures are regarded as unpleasant by patients themselves, which often affects both the clinical outcome and a patient's relationship with the attending physician team. For these reasons, many procedures in spontaneously breathing patients normally are performed with a mild degree of sedation, which is

L. Cabrini and G. Landoni patented the Janus mask that is described in this manuscript.

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advantageous because the need for general anesthesia is avoided, resulting in fewer complications and shorter hospitalization (when needed), and less organizational commitment is required from treatment facilities. At the same time, however, this approach is associated with the not uncommon occurrence of hypoventilation and desaturation episodes, which may jeopardize the completion of the procedure or even lead to acute respiratory failure and intubation in fragile patients.<sup>1</sup>

This issue is even more critical in intensive care unit patients who frequently experience respiratory pathologies (possibly also the cause of admission) and cardiovascular pathologies, present with extremely reduced physiologic reserve, and often have undergone prolonged mechanical ventilation. In this specific cohort of patients, endoscopic procedures, especially TEE assessments and bronchoscopy, are more frequently performed but are much less tolerated, even if they are short maneuvers and in spontaneously breathing patients; gases and metabolic alterations may occur and aggravate the clinical condition, potentially necessitating intubation and mechanical ventilation in a negative vicious circle.

Because the effects of cardiac, gastrointestinal, and airway endoscopic procedures on gas exchange, hemodynamics, and lung mechanics are well known,<sup>2</sup> the opportunity to provide noninvasive ventilatory support during such procedures is of particular interest. The aim of this narrative review is to present the rationale, clinical use, and existing devices for noninvasive ventilation (NIV) in patients undergoing endoscopic procedures while spontaneously breathing, with a particular focus on devices specifically designed for periprocedural NIV.

## Methods

The authors searched PubMed for all articles providing data on devices used for NIV during airway, cardiac, and gastrointestinal endoscopic procedures. All types of articles were included, except articles older than 35 years and not written in English. Authors, year of publication, study design, number of patients, clinical setting, anesthesiologic management, device and technique used, and main findings were recorded for all articles. Data are presented with a narrative rather than systematic structure, according to the type of manuscript (narrative review).

Therapy with high-flow nasal oxygen is not discussed here because it is not considered a type of NIV.<sup>3</sup>

### *Rationale of Periprocedural NIV and Features of the Ideal Mask*

NIV can be used in many ways in a patient undergoing endoscopy in order to improve the tolerability of the procedure, including the following: it can be performed before the procedure to prepare and preoxygenate the patient with the aim of increasing the respiratory reserve and avoiding deleterious consequences; it can be used to support the patient during the procedure to prevent hypoventilation and hypoxia or to treat

the same conditions in case of occurrence; and it can be used to enhance recovery of the patient after the procedure, which, especially in sick and frail patients, is challenging.<sup>4</sup>

Even though the rationale for the use of NIV during cardiac, gastrointestinal, and airway procedures in selected patients is strong, it is, however, important to assess whether NIV use leads to significant quantifiable clinical benefits. Scientific evidence seems to support the advantages and benefits resulting from the use of NIV; an increasing number of studies (although of low quality) have reported the periprocedural use of NIV during endoscopy in different clinical contexts.<sup>3</sup>

Despite the strength of the rationale, however, standard NIV masks are not suitable for intraprocedural ventilation due to technical limitations because they must form a closed system, which is mandatory to provide positive pressure ventilation; insertion of an endoscopic probe into the closed system is not possible; and consequently NIV cannot be provided during the procedure itself.

Thus to apply NIV to endoscopic procedures, the current available NIV masks should be rethought or modified to match a challenging mixture of conflicting characteristics and technical features. Namely, the system should be closed enough to provide an effective positive pressure and effective ventilation but, at the same time, it should be versatile enough to be opened to insert an endoscopic probe during the intraprocedural time. In addition, it should be possible to place the mask before the insertion of the probe, during the procedure itself, and anytime in case of need.

### *Clinical Uses of NIV During Endoscopies*

Historically, the first periprocedural NIV masks were used during procedures involving the airways, followed by specific indications for gastrointestinal maneuvers. NIV in TEE assessment during interventional procedures was the first approach in the cardiology field, and it has become the most compelling indication in the author's experience with some recent innovative clinical applications. Cardiovascular anesthesiologists and intensive care specialists commonly are involved in the management of endoscopic procedures for any of the aforementioned indications. Standard routine monitoring of patients treated with sedation during NIV for endoscopic procedures includes continuous electrocardiography, noninvasive arterial pressure measure, pulse oximetry, and capnography (whenever available).

### *Cardiovascular Procedures*

TEE is performed routinely in a large variety of clinical settings and in heterogeneous groups of patients, who often have a reduction in cardiovascular reserve. It is used in many interventional cardiovascular procedures, such as transaortic valve implantation, routinely performed with the patient under sedation, for which prolonged TEE may be useful periprocedurally, and in other interventions, including Mitraclip procedures and left atrium appendage closure interventions, which require prolonged TEE assessment and traditionally have been

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