NORA Airway Management

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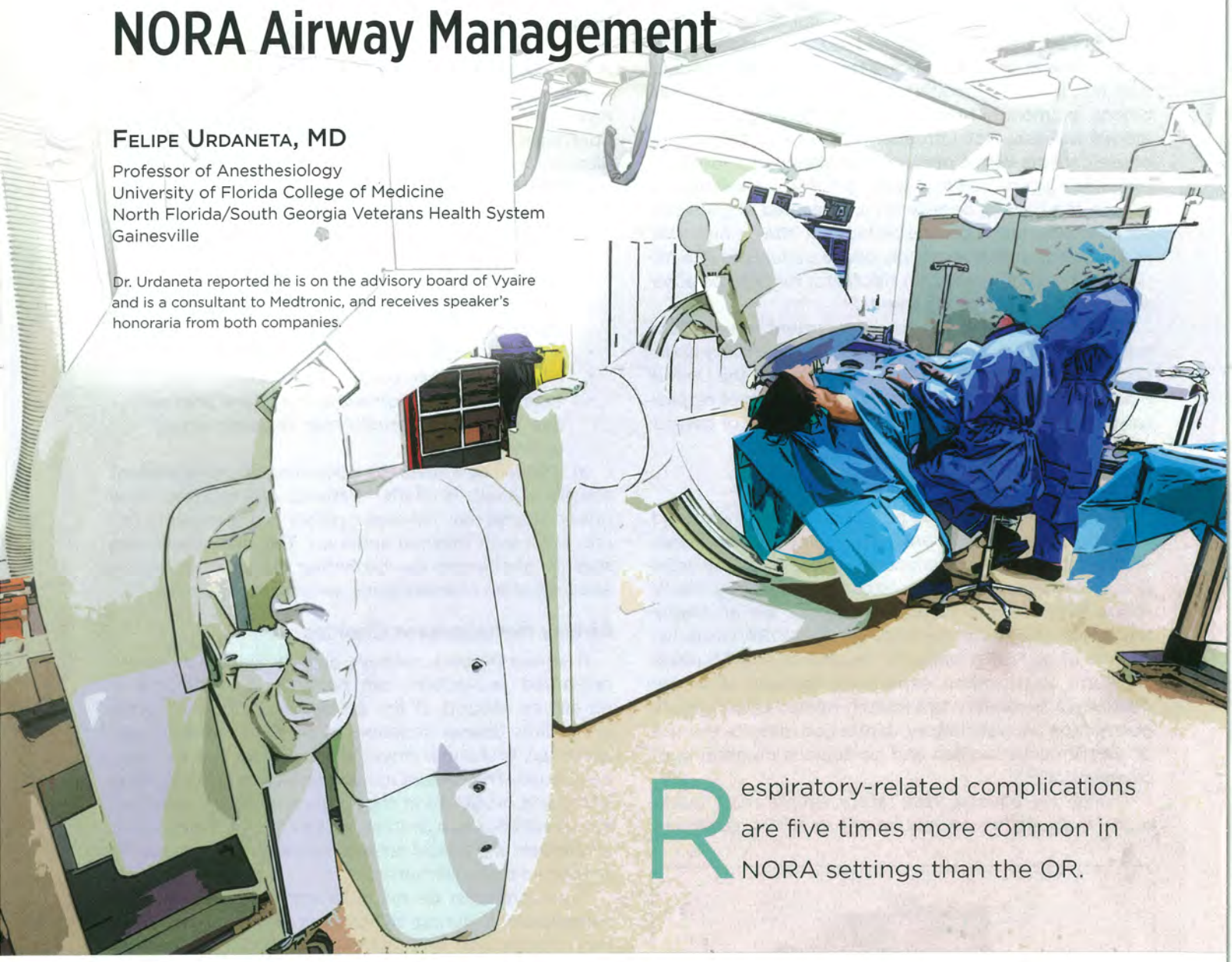

Respiratory-related complications are five times more common in NORA settings than the OR.

Introduction and Scope of the Problem

An expanding challenge in anesthetic practice is the steady growth in cases that occur outside the OR, what is commonly known as non-OR anesthesia (NORA).[1,2] Supporting airway management is an essential piece of the puzzle of NORA. Newer devices and ventilation options such as noninvasive ventilation and high-flow nasal humidified oxygen have been introduced and are being used not only for procedures that require general anesthesia, but also for those performed under sedation. In this review, modalities for airway management in the NORA setting are discussed.

The frequency and types of procedures being performed outside of an OR continue to increase. It is estimated that more than 50% of NORA procedures in the United States are performed using some form of anesthesia care, and this may be an underestimation.[3,4] NORA care presents a unique set of challenges for health care providers. Procedures are performed outside of familiar OR confines, and some are in remote locations within health care facilities that are often staffed with personnel that are not trained or familiar with safe anesthetic or airway management. There may be limited access to equipment that is normally found in the OR.[2,5,6]

The procedures themselves are very diverse in terms of complexity, invasiveness and duration. The procedures involve a variety of medical specialties; are performed on different parts of the body, such as the gastrointestinal tract, cardiac, pulmonary and dental, to name a few; and have different anesthetic and sedation requirements. NORA procedures often involve frail and elderly patients with multiple comorbidities, such as cardiovascular conditions, pulmonary hypertension, diabetes and chronic kidney disease. Not infrequently, these cases involve obese patients with a presumptive diagnosis of obstructive sleep apnea (OSA; Figure 1).[1,7] The prevalence of OSA in the general population is estimated at between 3% and 24%, but it can be as high as 70% in high-risk populations, such as morbidly obese patients.[8,9] In addition, OSA is an independent risk factor for perioperative cardiopulmonary adverse events.[10]

Gastrointestinal procedures represent the largest number of NORA cases. Approximately 18 million endoscopic procedures are performed annually in the United States, and in 50% of these cases, some form of respiratory complication occurs, such as an episode of desaturation (SpO_2 <90%).[11,12]

Pathophysiology

NORA cases are usually performed under monitored anesthesia care (MAC) and, depending on the needs of the patient or the procedure, involve the administration of sedatives and/or anesthetics, usually by the IV route. Sedation-related adverse events are an important cause of injury and liability among NORA cases. Up to 54% of all NORA patients, regardless of ASA physical status classification, experience episodes of severe hypoxemia secondary to sedation-related upper airway obstruction and respiratory depression, despite the use of supplemental oxygen and continuous monitoring of oxygenation.[10,13]

Claims for adverse respiratory events (e.g., inadequate oxygenation or ventilation) in NORA cases are more common than in an OR setting: 53% compared with 23%. Respiratory-related complications (hypoxemia, aspiration, difficult intubation and esophageal intubation) are five times more common in NORA settings than the OR.[14] Claims for death in NORA cases are nearly double those in OR cases: 61% versus 30%, according to one study, and 54% versus 29% in another one.[14,15]

Many NORA patients have reduced respiratory reserve, are obese, or have OSA and other chronic conditions, such as asthma and chronic obstructive pulmonary disease. Patients who are obese or have OSA demonstrate alterations in their respiratory physiology, such as:

- decreased lung and chest wall compliance;
- increased airway resistance;
- decreased respiratory muscle strength;
- increased work of breathing;
- alterations in V/Q (i.e., ventilation/perfusion) matching;
- reduced functional residual capacity;
- increased oxygen consumption; and
- excess fat deposition within the lateral pharyngeal walls, which predisposes to upper airway obstruction.

In the United States, the age-adjusted prevalence of obesity in adults is 42.4%.[16] Patients with reduced respiratory reserve may develop hypoxia and respiratory failure, even with minimal sedation. The magnitude and severity of changes can be further exacerbated by the administration of anesthetics, sedatives and opioids.[17,18]

Airway Management Choices

If airway patency, reflexes and ventilatory drive are preserved, procedures can be done with minimal or no airway support. If the procedure is more invasive or requires deeper sedation, in order to maintain adequate gas exchange, airway management support may be needed. The chosen modalities should provide ventilatory and oxygenation support, establish and maintain airway patency and protection, and allow monitoring of ventilation, and should not interfere with or interrupt the procedure being performed.

Providers must be ready to address airway-related complications during NORA procedures, such as airway obstruction and hypoxemia. Basic and rescue airway devices, such as face masks, oral and nasopharyngeal airways, supraglottic devices and bougies, and advanced airway equipment, such as video laryngoscopy, should always be available. Until recently, there were limited choices and a binary approach to airway management during NORA cases: either traditional oxygenating devices or endotracheal airway support. Considerable advances have been made, and newer and more effective modalities and devices to support the airway in NORA settings have been introduced.

Current common modalities used in NORA cases include, in order of invasiveness:

Nasal cannulas and non-rebreather masks. These are considered traditional oxygenating devices and can provide higher concentrations of oxygen, but in many

Figure 1. An obstructive sleep apnea patient, showing the site of obstruction of the upper airway at the level of the soft palate and nasopharynx.

Figures courtesy of the author unless otherwise noted.

cases are ineffective or inadequate because they cannot maintain airway patency and overcome upper airway obstruction, which occurs with the administration of sedatives. Regular nasal cannulas are usually set at maximal oxygen flows of 5 to 6 L per minute. Higher flows are not tolerated because of discomfort and drying of the nasal mucosa, creating the possibility of epistaxis. They provide a maximum fraction of inspired oxygen (FiO_2) of 0.35 to 0.44 (4% increase for every liter of O_2 flow). Venturi masks provide a fixed flow based on the adapter chosen, which entrains a set amount of ambient air. They can provide an FiO_2 of up to 40%.

Non-rebreather masks that can set flows up to 15 L per minute provide an FiO_2 of 100%. These masks (Figure 2) are designed to provide oxygenation support but are not well suited for procedures. They require a constant seal between the mask and the patient's face and cannot be used during endoscopy cases (e.g., gastrointestinal [GI] cases, transesophageal echocardiography [TEE] and bronchoscopy), since the probe cannot be placed through a closed system.

High-flow nasal oxygen (HFNO). This modality employs flows that are higher than the rates used during conventional nasal cannula administration (Optiflow, Fisher & Paykel Healthcare; Figure 3). HFNO provides oxygen with an FiO_2 of up to 100%. The oxygen is humidified and heated in order to prevent nasal mucosal dryness and preserve respiratory mucociliary function, which facilitates removal of secretions. The precise mechanism of action of HFNO is unknown.[19] High-flow nasal cannulas can deliver oxygen at high rates, improve the efficiency of ventilation, and enhance oxygen delivery by washout of nasopharyngeal dead space. HFNO also increases positive end-expiratory pressure (PEEP) by 0.7 cm H_2O for every increase in 10 L per minute of flow. HFNO can be used with spontaneously breathing patients and during periods of apnea. The use of HFNO does not interfere with instrumentation of the airway or access to the oral cavity. HFNO decreases episodes of desaturation, but does not allow ventilatory monitoring unless transcutaneous carbon dioxide is used. HFNO is increasingly used in critical care settings and in the OR, but in the NORA setting, widespread adoption has not occurred. It has been used for dental procedures and GI and bronchoscopy cases.[20-22]

Schumann et al reported that use of HFNO was associated with decreased general anesthesia utilization and improved oxygenation for endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic ultrasound (EUS) during sedation.[23] Riccio et al compared HFNO with a traditional oxygenating nasal cannula at 4 L per minute flow in 59 morbidly obese patients undergoing colonoscopy. Interim analysis showed that the desaturation rates between the HFNO and traditional oxygenating devices groups did not differ significantly (39.3% vs. 42.5%), so the study was stopped.[24] Other limitations of HFNO include the complexity of setup and the need for additional investment in capital equipment.

MAUGE Device. The Mask Adaptor for Upper GI Endoscopy (MAUGE) is an adaptor that allows bag-mask ventilation during procedures that require insertion of a small probe via the oral or nasal route (Figure 4). The device, which is used in Europe but not in the United States, is placed in the universal port of conventional ventilation masks and has adaptors for either anesthesia machines or Mapleson breathing systems. Cong et al, in a study of 30 patients, found it was feasible to apply positive pressure ventilation (PPV) with its use and there were no episodes of desaturation. It requires a proper mask seal and the mask must be continually held to prevent leaks.[25]

Goudra Ventilating Bite Block. This device is a bite block with an inflatable cuff that allows administration of PPV, but this requires nasal occlusion. It has a central aperture for placement of an endoscopy probe through an airtight, removable diaphragm. It has two 15-Fr connectors, one to connect to a breathing system and the other to allow insertion of a suction catheter. It also has a soft, flexible oral airway that can be placed either before or after sedation. This device has been recommended for use during ERCP. No comparative study and only a single anecdotal report are found in the literature.[26]

Endoscopy masks. These devices are standard face masks designed for such endoscopic procedures as bronchoscopy, GI endoscopy and TEE (Figures 6 and 7). They have a central access port designed to create a seal around endoscopic or TEE probes. In a study from Belgium that included 173 patients, the mask was effective 92% of the time; in the remainder, hypoxemia, laryngospasm or bronchospasm, cough and rescue intubation were seen in 7.5%, 2.89%, 2.89% and 0.58%, respectively.[27]

Procedural Oxygen Mask. This is a clear plastic face mask (POM Medical; Figure 8) that looks similar to traditional face masks, and provides oxygen delivery, with FiO_2 of up to 0.90 to 0.95 at flow rates of 10 to 15 L per minute. This mask allows access to the nose and mouth via the self-sealing endoscopy ports, and also has a capnography sampling port. The mask can be connected to any standard oxygen flowmeter. There are no published studies of the device to date.

SuperNO$_2$VA Mask. This mask is a simple, no-leak, flow-dependent, disposable device that is secured with a strap around the bridge of the nose (Vyaire; Figure 9). It provides ventilatory support (oxygenation and ventilation) while maintaining upper airway patency in patients with OSA or those undergoing procedures requiring deep sedation. The device is compatible with readily available oxygen systems, such as an anesthesia machine or Mapleson circuit.

The SuperNO$_2$VA mask overcomes upper airway obstruction with a flow-dependent positive pressure mechanism known as "pneumo-stenting." When upper airway obstruction occurs at the junction of the soft palate and retropharyngeal wall in patients with OSA or from administration of sedatives/anesthetics, positive

Figure 2. A non-rebreathing mask without reservoir bag.

Figure 3. Optiflow provides high-flow nasal oxygen.

Figure 4. A MAUGE device must be held to prevent leaks.

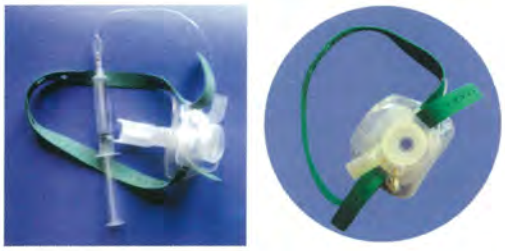

Figure 5. Two views of the Goudra ventilating bite block.

Photos courtesy of B.G. Goudra.

Figure 7. Explorer Endoscopy Face Mask.

Picture courtesy of Intersurgical.

Figure 8. The Procedural Oxygen Mask allows access to the nose and mouth.

Figure 9. The large-size SuperNO$_2$VA mask.

Photo courtesy of Vyaire.

Figure 10. The Gastro-Laryngeal Tube has a dedicated channel for endoscopy.

Photo courtesy of VBM Medizintechnik.

Figure 11. The LMA Gastro is a supraglottic airway device designed for endoscopy.

Photo courtesy of Teleflex.

pressure can be generated and optimal oxygenation and ventilation can be achieved, relieving obstruction and resistance in the upper airway. The airtight mask is attached to a fresh gas source, either an anesthesia machine circuit or Mapleson device; the gas flows at 10 L per minute or higher and is adjustable with a pressure-limiting valve.[28] On inhalation, if a drop in pressure occurs, it may be augmented by manually squeezing the reservoir bag.[29] The nasal ventilatory approach is anatomically more favorable to address the site of upper airway obstruction (i.e., the soft palate and nasopharynx). The nasal approach also promotes a better mask seal by using the solid bony prominence of the facial structures for the mask and avoiding the mouth, which allows unobstructed access to the oral cavity for intraoral procedures (i.e, TEE, upper endoscopy) and airway instrumentation.[30]

The SuperNO_2VA mask has been shown to be a clinically useful and cost-effective option in NORA cases. Yiping et al compared the use of the mask with a traditional nasal cannula at 5 L per minute flow in patients undergoing colonoscopy under deep sedation.[31] The authors found the mask improved ventilation and decreased the frequency and severity of hypoxemia. There was statistically significant improvement in the number and timing of airway interventions needed due to episodes of desaturation, and the frequency and degree of SpO_2 less than 90%, and minute ventilation was better in the group using the mask than traditional oxygenating devices. This is beneficial for the patient and also the gastroenterologist, who has fewer interruptions during the exam.[31]

Nasopharyngeal airway (NPA). A tube inserted into the nostrils acts to bypass the site of airway collapse at the level of the nasopharynx and base of the tongue during sedation procedures. Some manufacturers include a universal 15-mm adaptor for connection to a breathing circuit. The most common complication when placing an NPA is trauma, epistaxis and possible aspiration of blood. The use of an NPA is contraindicated in anticoagulated patients and in those with suspected cranial vault fractures or nasal deformities. In a study of patients undergoing GI endoscopy with propofol/midazolam sedation, those who received an NPA had statistically significant decreases in respiratory depression (1.9% vs. 13.5%), fewer episodes of hypotension (5% vs. 11%), and a greater chance of minor nasopharyngeal injury (in 4.7% of cases).[32]

Gastro-Laryngeal Tube. The G-LT (VBM Medizintechnik) is a laryngeal tube with a dedicated channel for insertion of an endoscopy probe (Figure 10). It has two interconnected, high-volume, low-pressure cuffs, one of which is a proximal pharyngeal cuff to seal the pharynx and the other to seal the nasopharynx. Both cuffs are inflated to an intracuff pressure of approximately 60 cm H_2O through a single inflation valve attached to a pilot balloon. Controlled studies show the technique to be effective in maintaining control and airway patency during adult endoscopic procedures in patients under deep sedation or general anesthesia, with either spontaneous or controlled ventilation. There were only minor adverse events. The endoscopic channel allows the insertion of a probe with a maximum diameter of 13.8 mm.[33,34]

In a series of 60 cases, Herbert and Straker reported the G-LT was an effective device that occasionally required some special maneuvers for insertion (rotation and/or elevation of the jaw), and was associated with minor instances of postoperative sore throat and, in one case, severe tongue swelling.[35] In two cases in their series, the device could not be placed: one because of a tumor that did not allow sitting of the device and the other because of poor dentition.

LMA Gastro. The LMA Gastro (Teleflex) is a newer supraglottic airway device designed for upper GI endoscopy (Figure 11). It is a silicone-based, cuffed laryngeal mask airway with an additional separate channel for the passage of endoscopy probes up to 16 mm in diameter.[36] The presence of the endoscopy probe does not affect ventilation or airway pressures. It provides excellent conditions for both simple and more complex upper endoscopy procedures, with only mild complications described, mainly sore throat.[37,38] A recent report of its use during ERCP showed it was an effective and viable option, with no instances of hypoxemia or hypercarbia.[39]

Tracheal tube placement. This option is less often used for NORA cases. It is reserved for prolonged, complex interventional procedures, certain inpatient or emergency procedures, and some procedures performed in a non-supine position, such as ERCP. Placement of a tracheal tube requires laryngoscopy and general anesthesia, and this placement raises concerns about complications with airway instrumentation. Tracheal tube use may negatively affect efficiency, performance and metrics in NORA cases; placement may add expense, increase procedure time, length of stay (e.g., in the recovery room), increase turnover time and therefore may impact negatively in procedure room efficiency metrics compared with sedation cases.[40]

A U.S. study that examined sedation-related adverse events in high-risk patients undergoing ERCP found that patients under MAC sedation had a higher incidence of such events than general anesthesia patients (51.5% vs. 9.9%), and required more airway maneuvers. In 10.1% of the MAC patients, the procedure had to be interrupted to convert to general anesthesia.[41]

Conclusion

Advances in medical technology have enabled more complex and minimally invasive diagnostic and therapeutic procedures to be performed outside the OR. NORA care will continue to expand as we look for ways to reduce health care costs, and decrease perioperative and periprocedural complications.

Best practices for NORA procedures include thorough patient preparation and evaluation, monitoring of respiratory and hemodynamic variables, provision of anxiolysis and amnesia, comfort for the patient, and a

timely and safe recovery with full ambulation. Important advances have been made in devices to support ventilation, oxygenation and instrumentation of the airway during sedation outside the OR. We have evolved from a traditional binary approach to NORA airway management—from minimal traditional oxygenating devices to endotracheal airway support—and now have newer, more diverse, noninvasive and effective methods. The question remains which is the best, most effective and safest method for airway management in NORA. Comparative studies are needed for guidance. We need scientific evidence and fewer anecdotal or observational reports, since NORA cases continue to become more common.

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