During endotracheal intubation patients are exposed to a brief apnea period that is usually well tolerated. Traditional preoxygenation techniques may not provide a safe apnea period in all populations. Emergent endotracheal intubation further increases the risk of hypoxemia. Apneic oxygenation in conjunction with conventional pre-oxygenation techniques has been shown to safely increase the duration of apnea without desaturation and improve intubation first pass success rates. Multiple techniques have been evaluated for providing apneic oxygenation, nasopharyngeal catheters, nasal prongs, and modified laryngoscopes, all demonstrated to be effective at prolonging the duration of apnea, by delaying the time to desaturation.

During endotracheal intubation patients are exposed to a brief apnea period and are at risk of becoming hypoxemic. Conventional preoxygenation techniques may not be adequate in providing a safe apnea period in all populations. The risk of hypoxemia is especially high during emergent endotracheal intubation. Obese, obstetric, and pediatric patients are also considered at high risk for desaturation, due to a reduced functional residual capacity and increased oxygen (O$_2$) consumption that hastens the development of hypoxemia.$^{1,2}$

Continuous O$_2$ administration during the apneic period, termed apneic oxygenation (AO), has been shown to safely increase the duration of apnea without desaturation and improve intubation first pass success rates.$^2$ Clinical studies have evaluated the efficacy of AO during laryngoscopy using nasal cannulas, nasopharyngeal catheters, and modified laryngoscopes. All of which support extending the safe apnea period by prolonging the time to desaturation.$^3$-$^7$

**Physiology of Apneic Oxygenation**

Prior to induction, patients are preoxygenated with 100% O$_2$ via face mask. Preoxygenation denitrogenates the lungs, creating an alveolar O$_2$ reservoir that helps reduce the frequency and severity of desaturation. In an adult weighing approximately 70 kg, conventional preoxygenation techniques provide 4 to 8 minutes of safe apnea.$^8$ During regular breathing, O$_2$ flows from the alveoli into the blood stream at about 250 mL/min, and carbon dioxide (CO$_2$) returns from the blood stream to the alveoli at 200 mL/min. In apnea, O$_2$ continues to diffuse from the alveolus into the bloodstream at a rate of about 250 mL/min; however, the elimination of CO$_2$ is almost completely halted and diffuses into the alveolar space at a rate of approximately 10 mL/min. The pressure difference results in a net gas flow of 240 mL/min from the alveoli into the blood, generating a negative pressure gradient. Negative pressure that is created from the diffusion of O$_2$ causes entrainment of ambient gases into the lungs. Normally, room air gases (79% nitrogen and 21% O$_2$) are entrained into the lungs, and as nitrogen accumulates, desaturation occurs. Provided that a patent airway exists from the pharynx to the lungs, insufflation of O$_2$ into the pharynx extends the reservoir, allowing for the entrainment of O$_2$ into the alveoli. The clinical use of this procedure, regarded as AO, allows for persistent oxygenation without ventilations.$^9$

**Nasopharyngeal Catheter**

Apneic oxygenation requires a patent airway to allow for the delivery and entrainment of O$_2$ from the pharynx to the lungs. A nasopharyngeal catheter effectively delivers O$_2$ to the pharynx, extending the O$_2$ reservoir during apnea. Nasopharyngeal oxygenation is achieved by placing an O$_2$ catheter in the naris to the depth of the nasopharynx. Several studies have examined the efficacy of AO using a nasopharyngeal catheter and found it was more efficacious in prolonging the apneic period compared with preoxygenation alone.$^3$-$^5$

After preoxygenation and induction, a nasopharyngeal catheter was placed and O$_2$ was insufflated at 3 L/min$^{3,5}$ or 5 L/min.$^4$ Study end-point
times were 6 minutes\textsuperscript{3,5} and 10 minutes\textsuperscript{4} or until the oxyhemoglobin saturation (Sp\textsubscript{O\textsubscript{2}}) fell to 92% or 95%, whichever occurred first. All patients in the AO groups maintained their Sp\textsubscript{O\textsubscript{2}} concentration at 97% or higher for the duration of the apneic period. Conversely, all patients in the control groups desaturated to 92%\textsuperscript{4} or 95%\textsuperscript{3,5} before the study cutoff time; mean apnea times were 3.65 minutes\textsuperscript{3} 4.04 minutes\textsuperscript{5} and 6.8 minutes\textsuperscript{4}.

**Nasal Prongs**

Nasal prongs necessitate upper airway patency to permit delivery of O\textsubscript{2} to the pharynx. Induction may compromise nasopharyngeal patency in a number of patients, e.g., people who are edentulous, obese, or have obstructive sleep apnea.\textsuperscript{1} Ramachandran et al.\textsuperscript{6} evaluated AO utilizing nasal prongs in a simulated difficult laryngoscopy situation with obese patients. After preoxygenation and induction, O\textsubscript{2} was delivered to the AO group via nasal prongs at 5 L/min vs. no O\textsubscript{2} to the control group. Study cut off time was 6 minutes or until Sp\textsubscript{O\textsubscript{2}} fell below 95%. The AO group had a mean apnea time of 5.29 minutes compared to 3.49 minutes in the control group.\textsuperscript{6} Weingart and Levitan\textsuperscript{10} have recommended insufflation of O\textsubscript{2} at flows of 15 L/min through nasal prongs. Utilizing higher flows may enhance nasopharyngeal patency, allowing for O\textsubscript{2} delivery to the pharynx.

**Laryngeal Oxygen Insufflation**

Another AO technique is the direct insufflation of O\textsubscript{2} into the larynx. Steiner et al.\textsuperscript{7} researched the effectiveness of laryngeal oxygen insufflation in 457 pediatric patients undergoing nasotracheal intubation. Children age 1-17 years were randomly assigned to one of three groups: standard direct laryngoscopy (DL); laryngoscopy with a video laryngoscope, delivering O\textsubscript{2} through the oxygen port (VLO\textsubscript{2}); or direct laryngoscopy, combined with insufflation of O\textsubscript{2} through a catheter attached to the side of a laryngoscope blade (DLO\textsubscript{2}).\textsuperscript{7}

After induction, subjects were mask ventilated for 3 minutes with 70% N\textsubscript{2}O and 30% O\textsubscript{2}. In an effort to simulate a prolonged intubation scenario with limited O\textsubscript{2} supply, a starting O\textsubscript{2} concentration of 30% was utilized. Nasotracheal intubation was then performed with DL, VLO\textsubscript{2}, or DLO\textsubscript{2}, providing O\textsubscript{2} at 2 L/min or 3 L/min to the AO groups. The study was stopped when the trachea was intubated or Sp\textsubscript{O\textsubscript{2}} decreased to 90%. In the DL group, Sp\textsubscript{O\textsubscript{2}} fell below 90% in 49% of the subjects compared with 11% in the AO groups. Mean time to 1% saturation reduction was twice as long for the AO groups, 70 seconds vs. 30 seconds in the standard DL group.\textsuperscript{7}

D R Burton produces a semi-rigid intubating stylet, the J-Wand\textsuperscript{TM} (D R Burton, Farmville, North Carolina, United States), which contains an internal lumen within the stylet that allows for laryngeal O\textsubscript{2} insufflation during intubation. SunMed manufactures a device for providing AO, the Miller Port American Profile Conventional Blade (SunMed, Grand Rapids, Michigan, United States), it features an internal lumen within the blade that permits laryngeal O\textsubscript{2} insufflation. Use of laryngeal O\textsubscript{2} insufflation provides similar benefits, as compared to the nasopharyngeal catheter method by allowing direct delivery of O\textsubscript{2} to the pharynx and maintenance of oropharyngeal patency.

Although there are no clear and consistent guidelines for AO, it has been heavily endorsed by emergency physicians in the United States and is a standard in their practice. A number of organizations around the world also recommend AO, including the Canadian Airway Focus Group; Difficult Airway Society and Obstetric Anaesthetists’ Association, in the United Kingdom; Pediatric Difficult Intubation registry, in the United States; and The All India Difficult Airway Association.

**References**