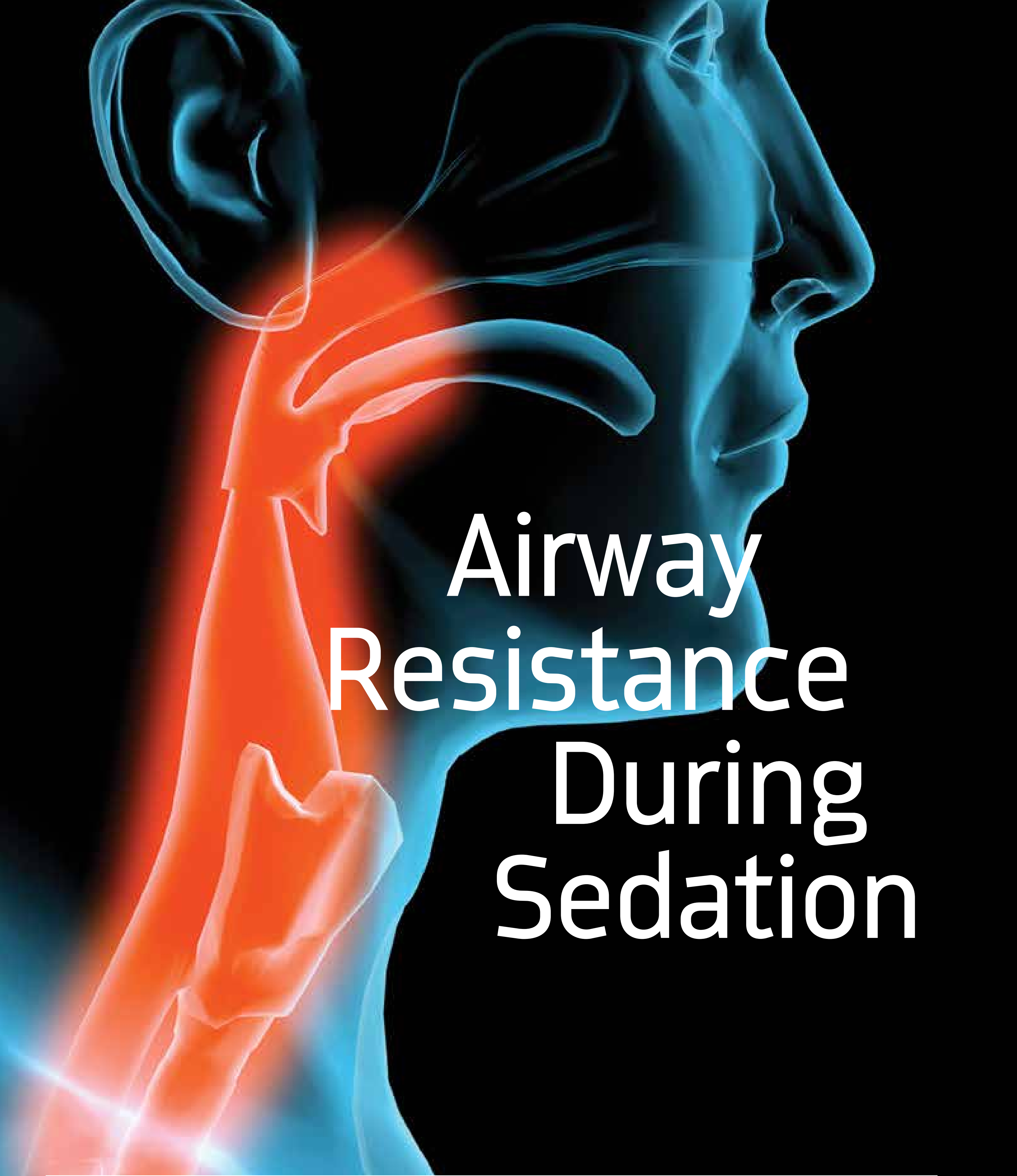

Airway Resistance During Sedation

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The 2 major principles that can affect how anesthetized patients breathe

Course description

This course is intended to introduce the sedation dentist to two principles governing airway resistance. Understanding these concepts will help sedation practitioners more rapidly diagnose the troubled airway.

Abstract

Sedation is becoming a more common service both offered by dentists and expected by patients. Practitioners who offer sedation often express the desire for more formalized knowledge at the pre-doctoral level. This article introduces two airway resistance concepts, the Bernoulli effect and Poiseuille's law, to the reader with explanations how their principles work to impede adequate airflow to the lungs. The airway anatomy is defined and divided into upper and lower segments to aid the reader in understanding where the actions of each principle most easily occur.

Airway resistance leading to complete obstruction and subsequent apnea is a leading cause of sedation-related emergencies in the dental office. Understanding the dynamics of the Bernoulli effect and Poiseuille's law will aid the sedation dentist in reacting quicker to airway difficulties.

Learning objectives

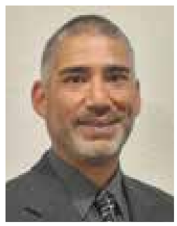
After reading this article, the participant should understand the following:

- Sedation services are an option that dentists can provide safely and patients expect, especially given the increasing complexity of general dental surgeries.
- Dentistry is unique compared with other surgical procedures, in that sedation dentists must balance a safe, patent airway with the occlusive nature of dental procedures.
- The principles of the Bernoulli effect and Poiseuille's law.
- That upper airway structures are more prone to collapse because of the Bernoulli effect.
- And that lower airway structures are more prone to effects from Poiseuille's law.

Introduction

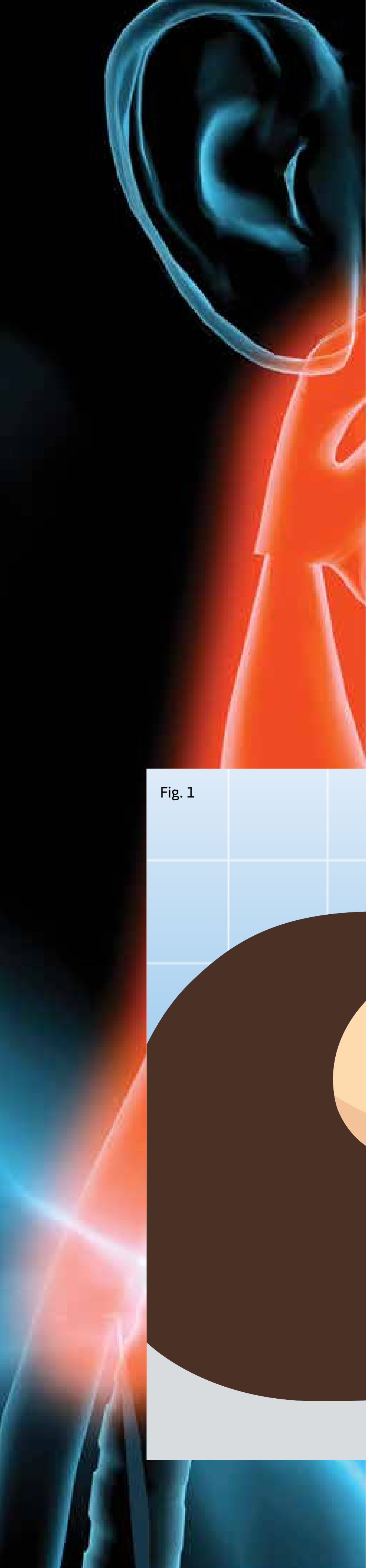
Sedation is becoming a more prevalent and expected service in dental offices. Nearly 94 percent of dental providers recognize the need for patient sedation instead of local injections, 65 percent of dentists surveyed

By Jason R. Flores, BSN-RN, DDS



Jason R. Flores, BSN-RN, DDS, completed undergraduate studies in biology and nursing at Lamar University. He worked as a critical care registered nurse before and during dental school at the UT Dental Branch–Houston, receiving the Anesthesiology Safety Practice and Horace Wells Award for Anesthesiology. He completed dental anesthesiology residency at the University of Pittsburgh School of Dental Medicine and holds ADBA and NDBA Diplomate and ADSA Fellow status. He serves the University of New Mexico as ASC director of dental anesthesiology and also is an AEGD assistant professor, an adjunct faculty for the College of Nursing, and a member of the New Mexico Anesthesia Committee and the Prescription Drug Overdose Prevention and Management Council. Dr. Flores is completing his master's degree in health administration.

Disclosure:
The author declares that neither he nor any member of his family has a financial arrangement or affiliation with any corporate organization offering financial support or grant monies for this continuing dental education program.



use some form of sedation in their practices; and 78 percent of new graduates support increasing tuition to support faculty that can offer more advanced sedation training.[1] And 85 percent of patients agree that sedation is a service that they'd like to have access to in dental settings because of dental fear.[2]

So what stops most dentists and specialists from providing sedation services? More than 58 percent of recent dental graduates consider sedation training in dental schools inadequate.[1] Sedation training, according to a program sponsored by the American Dental Association (ADA), consists of didactic education over sedatives, direct administration and advanced airway management.[3] Sedation, regardless of the route of delivery, causes some level of airway impediment, so depending on dosing amounts, more responsibility of airway protection may rest squarely on the shoulders of the dental provider. The purpose of this article is to more clearly explain two advanced principles, the Bernoulli effect and Poiseuille's law, and their influence on airway resistance during sedation.

Upper airway anatomy

For this discussion, the upper airway will be discussed as four main sections: the nasopharynx, oropharynx, laryngopharynx and subglottic segments. The upper airway consists of more detailed structures but for clarity, general segments and structures will be discussed.

• The **nasopharyngeal** segment is located from the internal nares down to the level of the soft palate. It includes the superior portion of the uvula and soft palate, as well as adenoid and Waldeyer's tonsillar tissue.

• The **oropharyngeal** segment is at the posterior of the mouth and extends from the uvula down to the epiglottis. It includes the

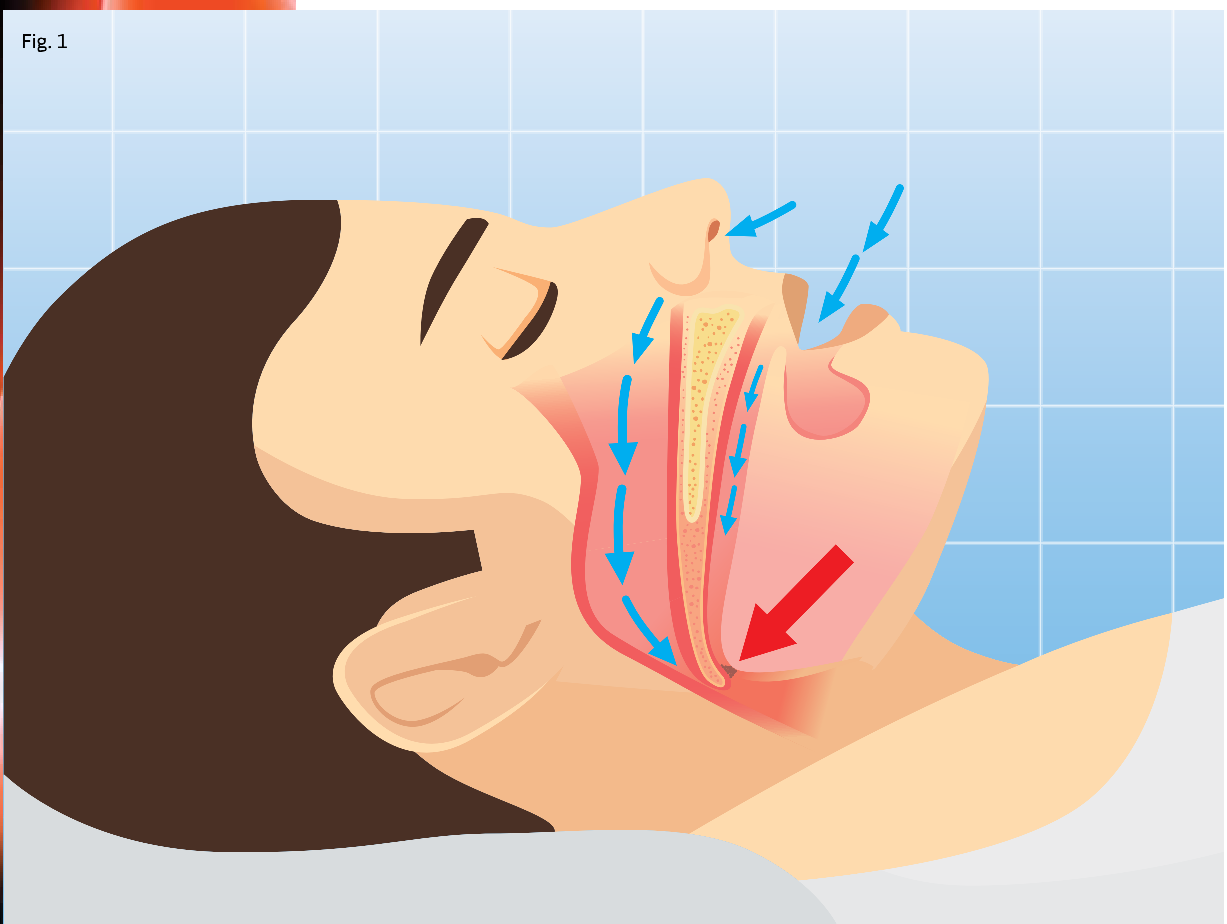


Fig. 1

inferior portion of the soft palate, palatine tonsils, and base of the tongue. Its tissue is composed of nonkeratinized squamous stratified epithelium.

• The **laryngopharynx** segment is located from the epiglottis down to just past the glottal (vocal cord) opening. It includes the hypopharynx (caudal portion of the pharynx that leads to the esophagus), epiglottis, glottis and larynx.

The **subglottic** segment is located from just below the glottal opening down to the first tracheal cartilage. Innervation of the pharyngeal segments is mainly cranial nerves IX and X, with adjunct motor control from cranial nerve XI. Cranial nerve XII assists in motor control of the tongue, and cranial nerve V contributes to soft palate movement.[4,5,6,7,8]

Lower airway anatomy

The lower airway structures are located below the glottal opening, and consists of the trachea, left and right primary bronchi, smaller bronchioles, and alveoli.[4] There are more detailed bronchus and alveolar structures, but detail is not needed for this discussion. Cranial nerve X, the thoracic sympathetic trunk and varied unmyelinated sensory nerve fibers innervate these segments.[6,9]

Upper airway resistance: the Bernoulli effect

Regardless of delivery route, immediate sedation delivery causes three primary physiological changes: level of consciousness depression, muscle relaxation and minimized respiratory processes. Sometimes inaccurately termed "side effects," these three processes are actually the desired sedation effects that providers are looking to achieve. At sedation onset, muscle relaxation occurs. For the airway, this muscle tone reduction primarily affects the oropharynx and superior portion of the laryngopharynx, causing closure of the upper airway during inspiration.[10,11]

The airway resistance seen in the upper airways can be understood by exploring the Bernoulli effect. The Bernoulli effect is a principle that explains how a kinetic, linear fluid or airflow-pressure differential affects the dynamics of a compressible conducting conduit.[11,12] This is an impressive way to say "the faster air flows through a nonrigid tube, open at one end, the more the tube will collapse." Tube collapse occurs because of the pressure changes from a sucking pressure applied to the unopen end. The more sucking pressure is applied, the faster air will flow and the more the tube will collapse (obstruct). Translate this to the airway of a sedated patient, and it means the more sucking force applied by the diaphragm (struggling to increase oxygen to the lungs) on the airway, the more the most compressible portion (the oropharynx and superior portion of the laryngopharynx) will obstruct (Fig. 1).

The reason this mostly occurs in the oropharyngeal and superior laryngopharyngeal segments of the airway is because these portions are the least supported by rigid bone or cartilaginous structures.[4,5,6] Acute airway obstruction occurs as the sedate airway starts to lose muscle tone and the pliable soft tissue of the oropharynx and superior laryngopharynx starts to collapse. As the obstruction worsens, the lungs become deprived of oxygen and the body's oxygen reserves are depleted. As oxygen depletes, metabolic waste such as CO_2 rises. The increasing systemic CO_2 causes an acidotic imbalance that the body compensates for by increasing quality of diaphragmatic contraction, which further increases the sucking force on the oropharyngeal and superior laryngopharyngeal soft tissue.

The increase of inward pulling force toward the lungs further collapses the airway, and obstruction apnea (complete airflow cessation) occurs.[13,14,18] During even a light sedation, this phenomenon can occur, leading to a prolonged obstructive apneic event.[15,16,17] If the patient cannot wake himself to re-establish patent airflow, then provider intervention with a head-tilt chin lift or tongue thrust will be required (Figs. 2–4, page 108).[16,17,18]

Up next: Steps to rectify breathing problems in sedated patients

Dr. Jason R. Flores' next CE course for *Dentaltown* magazine will discuss how the Bernoulli effect and Poiseuille's law could lead to worsening outcomes for sedated patients, as well as interventions that could stop those effects (and why they work).

Lower airway resistance: Poiseuille's law

Dentistry is unique among surgical specialties. The act of performing dental surgery, especially in a sedated patient, is aggravating to the airway. Comparatively, most medical sedations during surgery do not share the airway between both surgeon and anesthesia provider, because differing regions are usually the focus. Those medical procedures that do share the airway during a sedation, endoscopy, bronchoscopy or ENT procedure are not concurrently creating airway-irritating conditions such as tooth debris, blood, saliva and water spray. Add to this fingers, mouth props, retraction, rubber dams, handpieces, suction and local injection administration, and one can see how dental procedures create hazards to a sedated airway. Environmental irritations to the airways will usually result in several protective reflexes being initiated.

Upper airway irritations from dental debris can initiate the gag, cough, swallow or vomit reflex, while lower airway irritations can initiate the laryngospastic or bronchospastic reflex.[18] These reflexes should remain intact during light to moderate sedations; however, during a sedation the lower airway's bronchospastic reflex can be problematic. Reflexive bronchoconstriction increases airway constriction and mucus production, increasing airflow resistance to the functional gas-exchanging portions of the lung.[18,19] Reflexive bronchoconstriction is a symptom of chronic illnesses like asthma, but can also be acutely induced in nonasthmatic patients when airway smooth muscle becomes aggravated.[19,20]

Airway resistance seen in the lower airways can be understood by exploring Poiseuille's law. Poiseuille's law is also a

Fig. 2

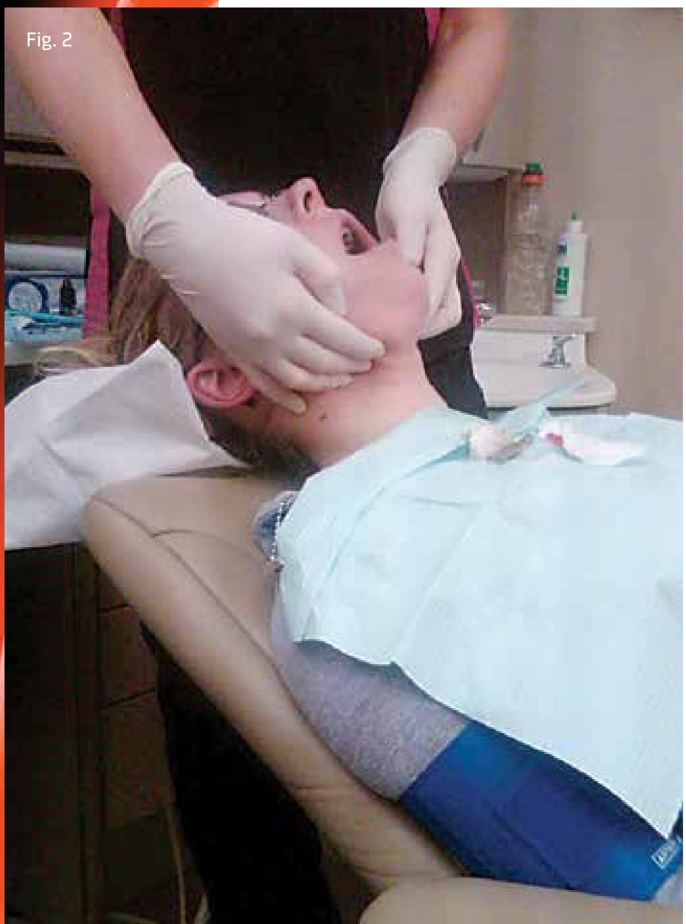


Fig. 3

Fig. 4

pressure dynamic for a kinetic, linear fluid or airflow column that explains how acute airway changes can increase resistance, which in turn can compromise a sedated airway.[21] Poiseuille's law states that airflow varies directly with the internal radius (half the diameter) of the airway, and inversely with resistance in the airway (Fig. 5). Like the Bernoulli effect, Poiseuille's law is based on incredibly complex mathematical equations, but in a nutshell, halving a conducting tube's internal diameter will increase the resistance (reduce flow) 16-fold.[21,22,23]

The opposing relationship between resistance and flow is important for the sedation dentist to appreciate. Increased airway resistance decreases air flow, which decreases oxygen to the alveoli, which decreases oxygen to the body's major organs, which can lead to irreversible systemic ischemic events. A sedated patient may not be able to help re-establish patent airflow from an acute bronchoconstriction. This may require the provider to administer medical interventions to re-establish airway patency.[18]

Conclusion

These two principles help explain how airway changes increase resistance and decrease available oxygen for perfusion. The Bernoulli effect describes how pressure decreases on the nonrigid portion of the upper airway leads to airway collapse, and Poiseuille's law describes how decreasing the internal space of the conducting airway leads to airway collapse. The two concepts presented are not the only physiological changes the body undergoes during sedation, although provider awareness of these two airway mechanisms will aid in rapid diagnosis of airway complications. Most sedation emergencies are respiratory in nature and are usually due to increasing resistance leading to obstruction. Understanding airflow resistance concepts during sedation will aid the practitioner in performing timely corrections. ■

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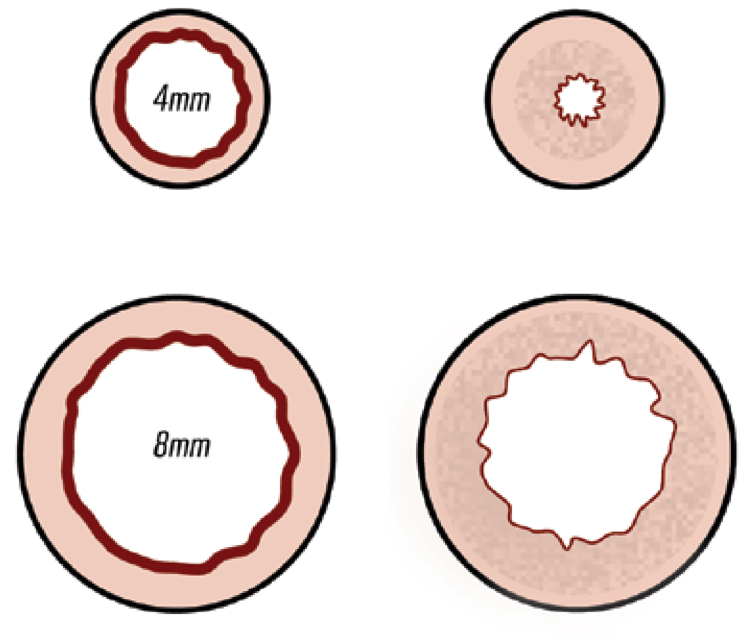
Fig. 5



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1. Sedation causes some level of respiratory impediment

A) regardless of route of delivery
B) only if delivered via intravenous route
C) only if delivered via oral route
D) only if given in combination with nitrous oxide

2. According to the ADA, sedation training should consist of all the following except:

A) didactic education over sedatives
B) opportunities for direct administration
C) research requirements over sedation
D) advanced airway management techniques

3. The upper airway anatomy consists of the following except:

A) nasopharynx
B) oropharynx
C) adenoid tissue
D) trachea

4. The segment most prone to obstruction due to the Bernoulli Effect is the

A) trachea
B) oropharynx
C) alveoli
D) nasopharynx

5. The lower airway anatomy consists of the following except:

A) nasopharynx
B) bronchi
C) bronchioles
D) trachea

6. Poiseuille's Law explains airway obstruction as a consequence of

A) external diameter decrease
B) internal diameter decrease
C) external diameter increase
D) internal diameter increase

7. Dental sedations differ from most medical sedations in that

A) tissue in other areas of the body heal slower
B) the procedure is also an obstruction to the sedated airway
C) dental debris can help stabilize the sedated airway
D) medical sedations do not cause any airway impediment

8. The Bernoulli Effect explains that airway collapse is due to

A) diaphragm paralysis
B) decreasing external airway diameter
C) pressure changes on non-rigid structures
D) dental debris causing acute bronchoconstriction

9. The upper airway anatomy is innervated by

A) Cranial nerves IX, X, XI
B) Cranial nerves I, II, III
C) Cranial nerves V, VI, VII
D) Cranial nerves VIII, IX, X

10. The lower airway anatomy is innervated by

A) Cranial nerve X
B) Cranial nerve III
C) Cranial nerve V
D) Cranial nerve VIII

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Airway Resistance During Sedation

By Dr. Jason R. Flores, BSN-RN, DDS

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8.	a	b	c	d
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