

**Respiratory Arrest**

**Stanley F. Malamed, DDS**

Dr. Malamed graduated from the New York University College of Dentistry in 1969. He then completed a dental internship and residency in anesthesiology at Montefiore Hospital and Medical Center. Dr. Malamed joined the faculty of the University of Southern California School of Dentistry, in Los Angeles, where today he is Professor of Anesthesia & Medicine.

Medical emergencies can, and do, occur in the practice of dentistry

In pediatric dentistry respiratory depression or respiratory arrest (apnea) in the normal healthy child [ASA II] most commonly occurs secondary to the administration of CNS depressant drugs used for conscious sedation, deep sedation, or general anesthesia in conjunction with local anesthetic administration.8

Undiagnosed and improperly managed respiratory depression can lead to a dental office catastrophe: cardiac arrest and severe, permanent neurological damage.

Safety in conscious sedation is predicated upon a number of items including (1) titration and (2) monitoring.

The ability to *titrate* is the ultimate safety factor in drug administration. Only drugs administered intravenously or by inhalation possess this ability and therefore represent the most controllable [and therefore safest] routes of drug administration. Drugs administered orally, IM (intramuscularly) or IN (intranasally) have significantly slower onset of action and cannot be titrated. Pediatric dosages of drugs administered by these routes are determined by a formula of ‘x’ mg, of drug per kilogram of body weight. Unfortunately this calculation is based upon the response of the approximately 70% of persons who respond ‘normally’ to a given drug dosage. 15% of patients will not achieve the desired level of sedation with this dosage [so-called ‘hyporesponders’] while the remaining 15% demonstrate exaggerated responses – the ‘hyperresponders’.

**Monitoring** of the sedated patient is the second essential requirement in safety. As a patient becomes more CNS depressed [as sedation becomes ‘deeper’] their ability to respond to verbal and physical stimulation is progressively impaired. Assessing the level of CNS depression represents THE most important monitor during conscious sedation. This is achieved by communicating with the patient and evaluation of their response. A conscious patient must be capable of ‘an appropriate response to verbal and/or physical stimulation’. A conscious patient must also be able to maintain the patency of their airway.

The pulse oximeter and pretracheal stethoscope enable the doctor to quickly recognize the onset of respiratory depression or arrest and provide timely management.

Cardiac arrest, when it occurs in children, is rarely a sudden event, and non-cardiac causes predominate.9 Cardiac arrest in children typically represents the terminal event of prolonged respiratory failure, respiratory arrest or airway management problems.10 The heart of a healthy young child will cease to pump blood when deprived of oxygen for a period of time.

Inadequate monitoring and inadequate airway management during conscious sedation are frequent findings in cases of pediatric cardiac arrest.1

In the dental environment the unrecognized development of respiratory depression or respiratory arrest can lead to cardiac arrest. Survival rates from pediatric out-of-hospital cardiac arrest in the USA are variously estimated at from 2% to 17%.12 and survivors are frequently neurologically devastated.13 Conversely, survival rates from respiratory arrest in children are approximately 70%.14 Neurologically intact survival rates of 70% or greater have been reported of children with respiratory arrest alone.15,16

Proper airway management and the ability to ventilate the apneic patient are primary considerations in the prevention of neurologic damage and pediatric cardiac arrest.8

**Airway! airway! airway!**

The infant and child are at greater risk for the development of airway obstruction and respiratory arrest than the adult.11 Compared with the adult, the airway of the infant and smaller child has relatively large adenoids and tonsils; a tongue that is proportionately large in relation to the size of the oropharynx; small nasal passageways; and a smaller and more compliant trachea which is easily collapsed in the presence of increased airway resistance.

Additional factors increasing the risk of respiratory or cardiac arrest in infants and smaller children include a metabolic rate with up to double the oxygen consumption of adults; a smaller functional residual lung capacity with a limited oxygen reserve;
physiological collapse of smaller airways (atelectasis) with increases in airway resistance, and the rapid development of hypoxia with airway obstruction. 

Management of respiratory depression or arrest

American Heart Association 2005 definitions of patients follow:  

**Neonate:** Infants during the first 28 days of life  

**Infant:** Includes the neonatal period and extends to the age of 1 year.  

**Child:** The ages 1 to 8 years (for lay rescuer) 1 year to adolescent for Healthcare Provider  

**Adult:** 8 years of age through adult years (for lay rescuer). Adolescent and older (for Healthcare Provider)  

The following is meant as a review of the management of respiratory depression or arrest in the small child.

**Respiratory Distress:**

Recognition: It has been this author's experience that maintenance of a patent airway in the child receiving conscious sedation is not difficult and is commonly accomplished by the treating dentist. O₂ saturations (sats) are normally maintained in the range of 98% or 99% during treatment of maxillary teeth. Given the positioning of the doctor, usually seated behind the sedated patient, the very act of working on maxillary teeth extends the patients neck into an almost ideal airway position known as head tilt. Difficulties in airway management more often develop with mandibular treatment. Regardless of the doctors position (behind or in front of the sedated patient) the pressures placed onto the teeth and mandible force the jaw downwards toward the chest moving the pliable soft tissues closer together and, in the much younger patient, potentially compromising the integrity of the tracheal rings. Though most pediatric conscious sedation cases transpire uneventfully the O₂ sat frequently drops slightly at the time of transition from maxillary to mandibular treatment.

The quality of sound heard through the pretracheal stethoscope may change from a normal quiet and sometimes hard-to-hear, ‘whooshing’ to that of ‘snoring’, indicative of a partial airway obstruction, the most common cause of which is the tongue or other soft tissues.

The alarm on the pulse oximeter for ‘low’ oxygen saturation is usually set at 90%. With comprise of the airway the sat readings will steadily decrease (either slowly or rapidly) until the alarm activates when the reading falls below 90%.

**Management of respiratory depression:**

Management of this, and all, emergency situations follows the **P A B C D** algorithm. On recognition of respiratory depression the patient is immediately placed into the supine position [P] (if not already supine as per the sedation protocol). Extend their neck and tilt the head with the ‘head tilt – chin lift’ maneuver [A]. Place one hand on the child’s forehead and gently tilt the head back. At the same time place the finger-tips of your other hand on the symphysis of the mandible and lift the chin to open the airway. These simple and basic procedures stretch the soft tissues in the oro- and nasopharynx, lifting the tongue, reestablishing airway patency. Snoring ceases, the patient’s chest is seen to rhythmically move up and down, and the O₂ sat rapidly returns to its previous level [B]. This situation, in the hands of a pediatric dentist trained in conscious sedation and BLS, does not constitute an ‘emergency.’

**Respiratory arrest:**

Recognition: Following administration of a CNS depressant drug it is noted that the patient is quiet and not moving. The assistant gently shakes the patient but elicits no response. The patient is placed into the supine position [P] and the doctor is called. While maintaining head tilt – chin lift [A], the assistant places his/her ear 1” (2.5 cm) away from the patients mouth and nose and **looks for the rise and fall of the chest and abdomen, listens** at the patients mouth and nose for exhaled breath sounds, and **feels** for air movement from the patients mouth against their cheek [B]. **Look, listen, and feel**, is done for not more than 10 seconds.

[As soon as it becomes available the pulse oximeter should be placed on the patient (by a 2nd person)].

Once recognized, respiratory arrest (apnea) must be managed immediately. Rescue breathing is started. All dental office personnel should undergo regular training [at least annually, if not more often] in basic life support (P A B C D). This course should include training in the use of a face mask to aid in ventilation of apneic persons.

Absent the immediately availability of positive pressure O₂ mouth-to-mouth ventilation is provided.

**Rescue breathing should never be delayed while a rescuer searches for a device or tries to learn how to use it.**

Maintaining head tilt-chin lift, take a deep breath and deliver rescue breaths. In the larger child or adult seal their mouth with yours and pinch their nose tightly with your thumb and forefinger. In smaller patients you can cover their mouth and nose with your mouth to deliver ventilations. The volume of air delivered with each breath must be sufficient for you to see the chest of the patient rise. Two effective breaths at 1 second per breath (child and adult) are delivered, taking a breath between each ventilation, followed by 12 to 20 breaths/minute in the child up to adolescence or 10 to 12 breaths per minute in the adult. The goal of assisted ventilation is delivery of adequate O₂ and the removal of CO₂ with the smallest risk of injury to the patient. The volume of each rescue breath must be sufficient to cause the chest to visibly rise without causing excessive gastric distention.

**Improper opening of the airway is the most common cause of airway obstruction and inadequate ventilation during resuscitation.**

Use of a mask (mouth-to-mask), a bag-valve-mask device or positive pressure oxygen is more efficient but requires training to be used effectively. Training can be received during a BLS Healthcare Provider or PALS training.
Regardless of the device used for ventilation [mask, bag-valve-mask, positive pressure] the rescuer should use only the force and tidal volume necessary to cause the chest of the patient to rise visibly.

Once rescue breathing has been successfully started the circulatory status of the patient is assessed [C]. The pulse is checked for not more than 10 seconds. In infants the brachial arte on the medial aspect of the antecubital fossa is palpated, while the carotid artery is checked in children and adults. In the absence of a palpable pulse cardiac arrest is present and chest compression commenced. A subsequent paper discusses pediatric cardiac arrest.

With a palpable pulse but an apneic patient, rescue breathing is continued at the age/size appropriate rate with the patient being monitored [D (definitive care)]. Whether emergency medical services need be activated is dependent upon the treating doctor's training and clinical experience as well as the nature of the unfolding event. A simple maxim to remember: When in doubt, seek help!

Administration of a drug-specific reversal agent might also be considered at this time [D (definitive care)]. However, the effectiveness of naloxone or flumazenil is dependent on the route by which it and the offending drugs are administered. If both are administered IV then the reversal agent should produce an observable effect in less than one minute. It is important to note that if the CNS depressant drug has been titrated intravenously it is highly unlikely that this event would have occurred. Following oral, IN or IM administration of both the offending drug and reversal agent, its efficacy will be both delayed and less pronounced.

Continue ventilation until spontaneous respiration returns. Stimulate the patient throughout this time. Stimulation can be verbal, photic [shine the dental light in their eyes], or physical [pinching the trapezius muscle is an excellent stimulus for breathing]. The conscious patient responds to peripheral pain by grimacing and by taking in a breath.

With return of spontaneous breathing and consciousness, the 'situation' is essentially over. Continue monitoring the patient’s vital signs and determine if EMS has not been summoned when the patient is suitably recovered to permit them to be discharged home in the company of their parent or guardian.

Summary

Respiratory depression or respiratory arrest can be the prelude to a dental disaster... pediatric cardiac arrest... if not recognized promptly and not managed promptly and effectively.

The most common scenario for this occurrence is the use of conscious sedation by a route of drug administration that does not permit titration [oral, IM, IV].

Monitoring of the sedated patient is one of two important factors in a successful outcome [return to consciousness with no residual (neurological) injury]. Pulse oximetry does not prevent these events from developing but it does allow for a more rapid detection of an incipient problem.

Successful management of respiratory depression or arrest should not be difficult. Prompt implementation of the P A B C D treatment algorithm will provide a successful outcome in almost all instances.

Training all members of the dental staff to (1) recognize respiratory depression and arrest, and (2) to manage respiratory depression and arrest should be mandatory in dental offices employing conscious sedation.

Respiratory depression, respiratory arrest and airway management problems are the most common cause of cardiac arrest in healthy children.
Cardiac arrest in the young, healthy child occurs most often as a result of respiratory depression, respiratory arrest and airway management problems.

**NOTE:** This version of the Cardiac Arrest paper includes changes in BLS set forth by the AHA on 28 November 2005.

Cardiac arrest is an uncommon event within the pediatric population. However, when cardiac arrest does occur in this younger age group its consequences are devastating: death of a previously healthy child or a successful resuscitation with the patient suffering massive permanent neurological damage.

Cardiopulmonary arrest in healthy infants and children is rarely a sudden event and does not often result from a primary cardiac cause. Undetected airway problems, prolonged respiratory depression and apnea are frequent causes of cardiac arrest in the pediatric population. In contrast, cardiopulmonary arrest in adults usually develops suddenly and is primarily cardiac in origin. Approximately 1,000 adults die daily in the USA alone from sudden cardiac arrest (SCA).

The heart functions to pump blood to all cells and parts of the body. The myocardium contracts in a well-coordinated manner to achieve this effect, termed ‘normal sinus rhythm’. (figure 1) During contraction (systole) blood is pumped from the heart into the arterial circulation while during diastole the ventricles refill.

Cardiac arrest is the ‘cessation of cardiac mechanical activity, determined by the inability to palpate a central pulse, unresponsiveness, and apnea (ie, no signs of circulation or life).’

Respiratory arrest is the ‘absence of respirations (ie, apnea) with detectable cardiac activity. Recognition and management of respiratory depression and arrest are reviewed in an earlier paper in this journal.’

Pediatric cardiac arrest in a dental situation is all-too-often associated with administration of CNS depressant drugs either for behavior management (oral, intranasal or intramuscular sedation) or pain control (local anesthetics).

Once recognized, the management of cardiac arrest is essentially the same regardless of the victim’s age. The goal of BLS is to deliver oxygen-containing blood to all cells and organs of the body, particularly the brain and myocardium, so as to enable resuscitation to be successful with little or no permanent neurological damage.

Management of ALL medical emergencies is predicated on the **P A B C D** algorithm.

There exist several substantive differences in basic life support [BLS or CPR] based upon the size or age of the victim. These differences arise from the fact that the etiology of cardiopulmonary arrest differs in children and adults.

**ADULT CARDIAC ARREST:** In the adult victim of SCA a history of coronary artery disease [CAD] is usually present. The advanced age of the typical adult victim helps to explain the onset of SCA. Coronary artery disease leading to the development of a blood clot with-
in a coronary artery produces myocardial injury secondary to ischemia. Ischemic myocardium is predisposed to rhythm irregularities (dysrhythmias) some of which, (pulseless) ventricular tachycardia and (coarse and fine) ventricular fibrillation, are cardiac arrest and are fatal if not treated promptly. (figures 2 and 3) Though no longer pumping blood the myocardium is, initially, still 'alive' (electrical activity exists) though beating chaotically.

Resuscitation (BLS) may prove successful in restoring a functional cardiac rhythm as long as any myocardial activity persists. Survival rates decrease markedly as the cardiac rhythm deteriorates from VT to coarse VF to fine VF and finally to asystole. (figure 4) Defibrillation, the delivery of an electric shock across the chest simultaneously depolarizing every myocardial fiber, is THE most important intervention in adult resuscitation.

The shorter the elapsed time from collapse of the victim to delivery of a 'shock' the greater the likelihood of their being in either VT or coarse VF, both of which respond better to defibrillation than fine VF or asystole. The automated external defibrillator (AED), a computerized, battery-operated device which detects the presence of a shockable rhythm (pulseless VT or VF) has been called 'the greatest advance in life-saving since the introduction of CPR in 1960.' Success of AED's is predicated on the fact that in the adult SCA victim the myocardium contains oxygen and the heart is still 'alive,' though no blood is being circulated.

**PEDIATRIC CARDIAC ARREST:** Healthy children usually have no evidence of CAD. Cardiac arrest commonly results from undetected airway problems, prolonged respiratory depression and apnea. A significant difference from the adult victim is that at the time of cardiac arrest the child's myocardium is already depleted of oxygen. Ventricular tachycardia and ventricular fibrillation are not frequent findings in pedi-
atriac cardiac arrest, VF occurring in approximately 20% of out-of-hospital pediatric cardiac arrests. The occurrence of VF increases with age of the victim, being found in 3% of children from 0 to 8 years but in 15% of victims from 8 to 30 years. In monitored pediatric patients the first dysrhythmia noted during prolonged respiratory depression or apnea is sinus bradycardia, a clinically significant slowing of the normally rapid pediatric heart rate. (figure 5) Untreated or undetected bradycardia may become asystole (‘silent heart’).

Because of these findings defibrillation is of diminished importance in pediatric cardiac arrest. Of primary importance is the implementation of basic life support (P A B C D). The delivery of oxygenated blood to the myocardium and brain can, hopefully, allow a functional cardiac rhythm to be restored and prevent brain damage.

Thus a significant difference in the basic emergency protocol of BLS for adults and children: In adults, when a rescuer finds themselves alone with the victim with no one within shouting distance . . . PHONE FIRST. Activate EMS immediately (before starting BLS) to provide prompt access to defibrillation. In the pediatric situation, as the likely cause of cardiac arrest anoxia, basic life support is started immediately with EMS activated as soon as is possible . . . PHONE FAST.

The technique of BLS for the infant, child and adult, as per the 2005 American Heart Association Guidelines for CPR and ECC is summarized in table 1.

<table>
<thead>
<tr>
<th>TABLE 1 (Comparison of BLS for infant, child, adult)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td><strong>Maneuver</strong></td>
</tr>
<tr>
<td><strong>Airway</strong> (non-trauma)</td>
</tr>
<tr>
<td><strong>Breathing</strong></td>
</tr>
<tr>
<td><strong>Initial</strong></td>
</tr>
<tr>
<td><strong>Subsequent</strong></td>
</tr>
<tr>
<td><strong>Circulation</strong></td>
</tr>
<tr>
<td><strong>Pulse check</strong></td>
</tr>
<tr>
<td><strong>Compression landmark</strong></td>
</tr>
<tr>
<td><strong>Compression method</strong></td>
</tr>
<tr>
<td><strong>Compression depth</strong></td>
</tr>
<tr>
<td><strong>Compression rate</strong></td>
</tr>
<tr>
<td><strong>Compression ventilation ratio</strong></td>
</tr>
</tbody>
</table>

This chart will require revision after 13 December 2006 when the new BLS GUIDELINES are released.