Monitoring Patient Vital Statistics

The Goals of Monitoring:

Monitor Consciousness – Verification of the patient's level of consciousness is critical to determining the level of sedation. A patient that readily responds to verbal stimulation is in anxiolysis (aka minimal sedation) or purposefully responds is in conscious sedation (aka moderate sedation). Any patient sedated by the enteral method should be in one of these two levels of sedation.

Monitor Physiological Parameters – Four vital physiological statistics must be monitored at all times while the sedation patient is seated in the operatory. These parameters include heart rate, blood pressure, oxygen saturation, and end-tidal carbon dioxide.

Pre-Sedation Baselines:

Obtaining baseline values for physiological parameters is necessary to determine the "normal" range of these statistics for the sedation candidate. The healthy adult patient (ASAI or ASAII), should have a heart rate of >60 & <100, a blood pressure of <120 systolic, <80 diastolic, an oxygen saturation of >96%, and a end-tidal CO_2 of between 20-30 mmHg (non-intubated).

When the preoperative heart rate and/or blood pressure is above these "preferred" levels, then it is quite likely that the patient's anxiety is playing a part. Often times, taking readings later in the appointment without the doctor in the room will give a more reliable and more "normal" measurement.

Lower than normal heart rate and blood pressure readings are usually found in patients of small stature who are in excellent physical condition. When abnormal cardiovascular baseline values cannot be explained by any either anxiety alone or unusually good physical condition, a medical consultation should be obtained.

Lower oxygen saturation baseline values usually reflect the presence of smoking/vaping and/or respiratory disease, and require further inspection as to the exact nature of the cause of the abnormally low reading.

The preferred end-tidal carbon dioxide reading should be between 35 and 45mm Hg when measured through an endotracheal tube. When measured nearby, such as when attached to the nasal hood supplying supplemental oxygen or oxygen-nitrous oxide, the reading will be less.

As with any aberrant measurement, the inaccuracy of the monitoring equipment must also be ruled out.

Key Points:

- Do not sedate without high quality monitoring equipment as described! Know how to use your equipment and to set all the alarms!
- You must have pulse, blood pressure readings, oxygen saturation, and end-tidal CO2 measurements throughout treatment.

Monitoring Heart Rate

Under normal conditions, and without the influence of medications or medical conditions, heart rate is determined by physiologic demand. Simply put, when the body has a higher oxygen demand the heart rate accelerates, and the opposite occurs when there is a lower oxygen demand.

The normal range of heart rate for the adult population is between 60 and 100 beats/minute. But within the general population for some individuals, outside of this range can be considered normal. For instance, if the patient's heart rate is less than 60 beats/minute (bradycardia), it is often the result of an extremely efficient cardiovascular system in the presence of good physical condition.

Likewise, when a patient is anxious, the sympathetic autonomic system kicks in, resulting in the release of endogenous catecholamines (epinephrine, norepinephrine, and dopamine) and/or the activation of their receptors, accompanied by an increase in heart rate (tachycardia).

When a patient is sedated, a corresponding decreased in pulse rate is likely due to activation of the parasympathetic system and the release of acetylcholine and/or the activation of its receptors. Therefore, it is normal for a sedated patient's heart rate during treatment to be lower than their pre-sedation baseline.

If the patient's pre-sedation baseline heart rate is outside the normal range of 60-100 beats/minute, then of the two extremes, tachycardia is more of a concern. A fast beating heart has a higher oxygen demand because it is working harder. However, heart muscle gets its blood-carrying oxygen supply in between beats, when in the case of tachycardia there is less time for this to happen. Given the shorter interval between beats, there is also less time for pre-load, the filling of the atria with blood, to occur. All of this means that tachycardia increases the risk of the occurrence of an adverse cardiovascular event. There is special concern when the tachycardia is accompanied by an absence of a P wave on an EKG. This may be the result of a heart block or ventricular tachycardia or fibrillation.

If a patient's pre-sedation baseline heart rate is 100 beats/minute or higher, after repeated attempts without the doctor in the room, a judgment decision must be made by the clinician as to whether this is related to anxiety or not. If it cannot be attributed to anxiety-related tachycardia, which should abate during sedation, then the patient should be referred for medical evaluation.

Should the patient experience tachycardia during sedation, then after confirming they are conscious, they should be asked if they feel well. The most common causes of tachycardia during sedation are anxiety (inadequate sedation), or discomfort (inadequate local anesthesia, systemic discomfort, or the need to go to the bathroom), all of which can be addressed by the clinician. If after doing so, the patient's heart rate remains >100 beats/minute, then an early ending to the sedation appointment followed by referral for medical evaluation should occur. If at any time during the sedation procedure, the patient's accelerated heart rate is accompanied by symptoms such as chest discomfort and/or headache, emergency response personnel should be summoned.

Certain medical conditions and medications can influence the patient's heart rate. Examples of medical conditions that can increase heart rate include:

- Atherosclerosis
- Congestive Heart Failure
- Myocardial Infarction
- Congenital Heart Defects
- Inflammatory or Degenerative Heart Disease
- Myocarditis (Infection of the Heart)
- Chronic Lung Disease
- Hypertension
- Hyperthyroidism
- Electrolyte Imbalance
- Emotional Stress

Medications can also cause tachycardia, and include:

- Asthma Medicines
- Antibiotics
- Cough, Cold, and Allergy Medicines
- Thyroid Medicine
- Antidepressants
- Supplements

If a patient should experience bradycardia during sedation in the absence of a serious pre-existing medical condition or medication that can cause a slow heart rate, there is much less concern compared to tachycardia, especially if the patient is conscious and says they feel well.

Medical conditions that may cause bradycardia include:

- Heart Tissue Damage Related to Aging
- Heart Tissue Damage Related to MI
- Congenital Heart Disease
- Myocarditis (Infection of the Heart)
- Complications of Heart Surgery
- Hypothyroidism

Medications that may cause bradycardia include:

- Antihypertensives (calcium channel blockers, alpha/beta adrenergic blockers)
- Digoxin
- Neuromuscular Blockers
- Antidepressants

Monitoring Blood Pressure

Blood pressure is the resistance within the circulatory system to the pumping cycle of the heart. It is typically measured at the height of the force for a particular location (the arm usually) after blood is pumped out of the left ventricle (systole), as well as when the left ventricle relaxes (diastole).

Blood pressure must be sufficient to provide oxygen-carrying blood to the vessels that infuse body tissues. When that pressure is too low (hypotension), tissues may not receive enough blood perfusion for the physiologic function of those tissues. An example is dizziness or syncope when brain tissue is not properly perfused. When the systolic and/or diastolic pressure is too high (hypertension), then damage to the heart or rest of the circulatory system as well as the organs they perfuse can result.

Abnormal Blood Pressure

According to guidelines established by the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, the following blood pressure readings are classified as normal and abnormal*:

Blood Pressure Classification	SBP mmHg	DBP mmHg
Normal	<120	and <80
Prehypertension	120-139	or 80-89
Stage 1 Hypertension	140-159	or 90-99
Stage 2 Hypertension	>160	or >100

*This same committee made classification adjustments and treatment recommendations to specifically address different age groups and those with chronic kidney disease.

It should be noted that if one of the numbers (systolic or diastolic) is in a blood pressure classification that is higher than the other number (systolic or diastolic), then the higher number's classification is the classification for the patient. For example, if the patient's BP is 125/70, since the systolic reading is in the pre-hypertension category and the diastolic is in the normal category, the patient is considered pre-hypertensive.

Certain medical conditions can result in hypertension or hypotension Hypertension is a medical condition in itself, but other medical conditions can indirectly result in hypertension (aka secondary hypertension) such as:

- Diabetes
- Kidney Disease (Polycystic, Glomerular, and Renovascular)
- Cushing Syndrome
- Aldosteronism
- Pheochromocytoma
- Thyroid Disease (Hypo- or Hyperthyroidism)
- Hyperparathyroidism
- Aorta Coarctation
- Sleep Apnea
- Obesity
- Pregnancy

Medications may also cause hypertension and include:

- Analgesics (eg. Acetaminophen and Aspirin)
- Antidepressants (eg. Effexor, MAOIs, TCAs, and Prozac)
- Birth Control Medications
- Caffeine
- Decongestants (eg. Pseudoephedrine and Phenylephrine)
- Herbal Supplements (eg. Ginseng, Licorice, and St. John's Wort)
- Biologic Therapies (eg. Avastin,)
- Immunosuppressants (eg. Cyclosporine and Tacrolimus)
- Stimulants (eg. Ritalin and Concerta)
- Recreational Drugs (Alcohol, Methamphetamine, and Cocaine)

Hypotenstion, like hypertension, is a medical condition itself, but may be caused indirectly by other medical conditions such as:

- Pregnancy
- Heart Disease (Previous MI or Faulty Heart Valves)
- Endocrine Disorders (Diabetes, Adrenal Insufficiency, and Thyroid Disease)

- Dehydration
- Blood Loss
- Septicemia
- Anaphylaxis
- Malnutrition

Medications may also cause hypotension and include:

- Beta-Blockers
- Nitroglycerin
- Diuretics
- Tricyclic Antidepressants
- Erectile Dysfunction Medications

Hypotension, like bradycardia, in the patient without any accompanying medical conditions or medications that may cause hypotension is often the result of a healthy cardiovascular system. When in the presence of accompanying medical conditions or medications, the patient's pre-sedation baseline hypotensive reading should be evaluated by their primary care physician (PCP) or cardiologist.

During sedation, a lower than pre-sedation baseline blood pressure reading is expected. As long as the patient was properly evaluated before sedation, and the patient is conscious and feels well, the hypotensive reading is of little significance.

Hypertension During Pre-Sedation Evaluation

Patients with normal or prehypertension readings are acceptable candidates. All other things considered equal, it is acceptable for a patient with stage 1 hypertension to be sedated, as long as the outcome of the consult with the patient's PCP or cardiologist is that the patient's hypertension is under acceptable control.

Patients with stage 2 hypertension (either number) are not candidates for sedation until their condition is under acceptable control.

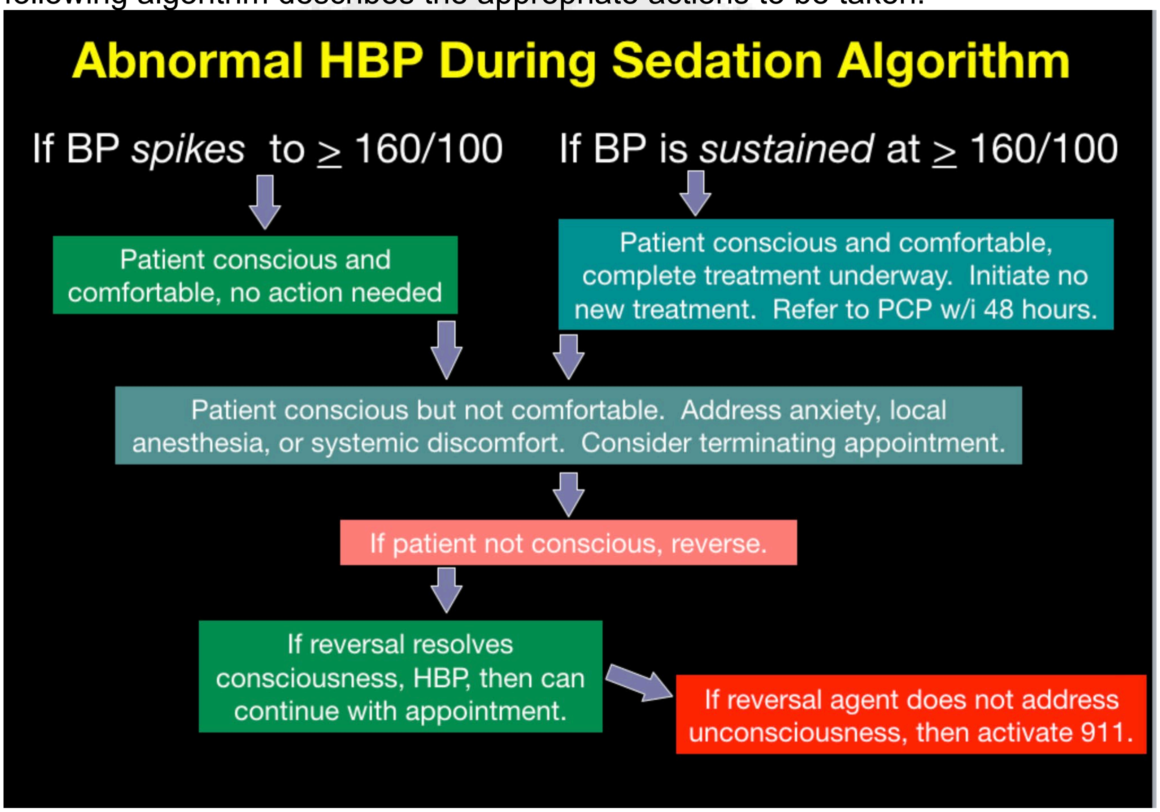
Abnormal Blood Pressure During The Sedation Appointment

While it is expected that the sedated patient's blood pressure should be lower than their baseline blood pressure, significant differences may be encountered. Reasons for this include the following:

- Sedation medications – should lower blood pressure
- Patient's existing meds – if the patient is taking blood pressure reducing medication, then when relaxed may experience exaggerated rebound hypertension

- Patient not taking meds – patients should take all of their medications prior to the sedation appointment as usual. However, should they not take their anti-hypertension medication, then they may experience hypertension during the appointment
- Patient is not comfortable – discomfort may result in hypertensive readings
- Patient's condition – although highly unlikely, hypertensive or hypotensive readings during sedation could be an indication of an adverse cardiovascular event
- Equipment – abnormal readings could be the result of malfunctioning or improperly applied equipment. For instance, if the cuff is too small, the BP will be artificially high, and the converse is true if the cuff is too small. If the extremity used is above the level of the heart, the BP will be artificially low.

Should the sedated patient's blood pressure rise to stage 2 hypertension, the following algorithm describes the appropriate actions to be taken:



Other Considerations if Heart Rate or Blood Pressure Fall Outside Normal Baseline Values:

- If the monitoring equipment malfunctions as a result of the finger clip becoming displaced, then the heart rate reading can be either elevated (partially displaced), or completely absent (completely displaced).
- If the there is excessive movement of the patient's arm that has the blood pressure cuff attached, then the blood pressure reading may be artificially elevated.
- If the blood pressure cuff is too large for the patient's arm, then the blood pressure reading will be artificially low, if it is too small, it will be artificially high.

Certainly, in the presence of a true adverse cardiovascular event, the heart rate and blood pressure will be affected, and other signs (EKG changes, arrhythmic heart rate, loss of consciousness), and symptoms (pain in the upper torso, arms, head and neck) may be encountered as well.

Mean Arterial Pressure (MAP)

Blood pressure monitoring equipment often calculates the Mean Arterial Pressure (MAP) - the average blood pressure in a person's blood vessels during a single cardiac cycle. It's significance lies in its relationship to the pressure necessary for adequate perfusion of the organs of the body. In general, most people need a MAP of at least 60 mmHg to ensure enough blood flow to vital organs, such as the heart, brain, and kidneys. A MAP between 70 and 100 mmHg is considered normal.

The mean arterial pressure is not a true average, but is weighted more towards the diastolic number, and is calculated by adding the systolic pressure to twice the diastolic pressure, and divided by three:

$$MAP = SBP + (2 \times DBP) / 3$$

In terms of monitoring during conscious sedation, the MAP is less significant than monitoring individual systolic and diastolic measurements.

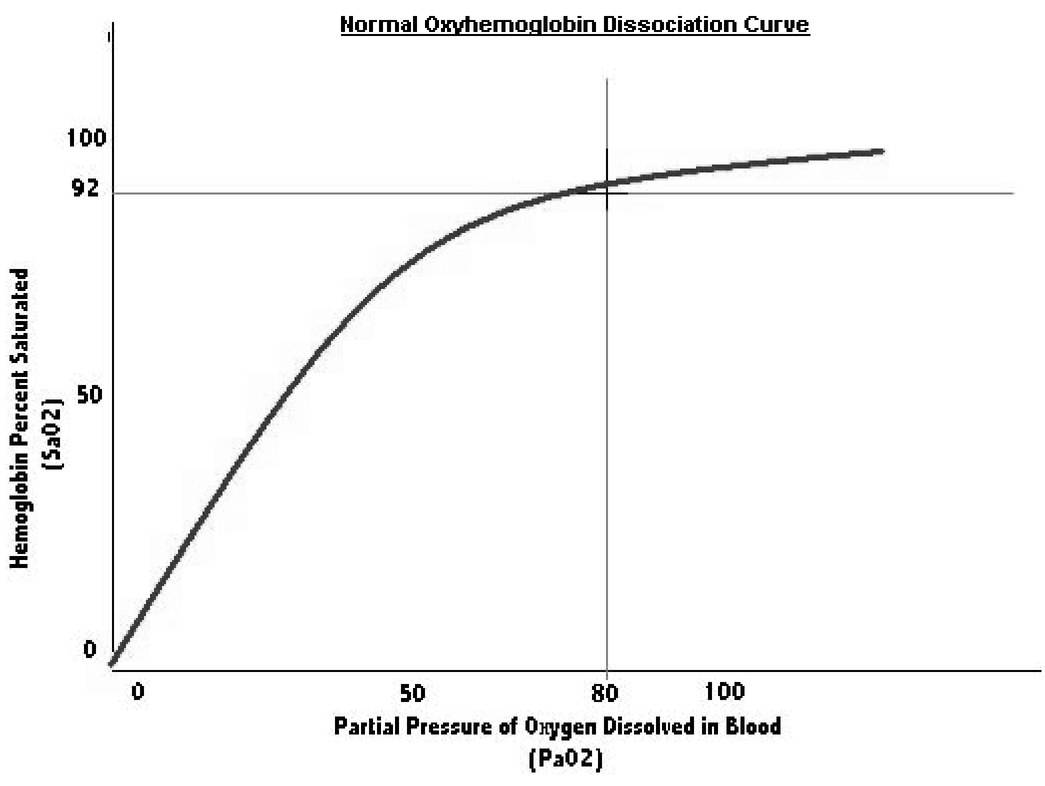
Monitoring Oxygenation

Of all the physiologic parameters measured during conscious sedation, oxygenation is arguably the most important. Whereas heart rate and blood pressure are primarily cardiovascular parameters, both of these measurements are likely to be supported by sedation, not harmed by it. And while end-tidal CO2 measures ventilation which can be considered a more revealing number than oxygenation, the fact that the conscious sedation patient is not intubated makes the reliability of capnography/capnometry measurement less pertinent. It is oxygenation that has the potential to reveal the most important information about the most likely potential negative impact of conscious sedation.

Oxygenation measured by the pulse oximeter reflects percentage of available hemoglobin sites that are occupied by oxygen. In order for oxygen to be most efficiently delivered to tissues that need oxygen, then the difference between these two gradients (the hemoglobin carrying oxygen and the tissues that need it) must be as high as possible. Therefore, it is most desirable that the percentage of oxygenated hemoglobin measured by the pulse oximeter be as high as possible.

The Oxyhemoglobin Dissociation Curve further explains the significance of this percentage. This curve describes the relationship between the amount of oxygen dissolved in the blood and the amount attached to the hemoglobin molecule. The physical force that drives the movement of oxygen (or any gas for that matter) around the body are partial pressure gradients. Therefore, the most important number is not the oxygenation percentage measured by the pulse oximeter, but rather the partial pressure of oxygen in the blood.

Unfortunately, we don't have non-invasive methods of measuring partial pressures of gases in the blood, but we can extrapolate those pressures if we know the oxygenation percentage of the blood from pulse oximetry. This extrapolation is depicted and calculated through the oxyhemoglobin dissociation curve (as seen here).



On the x-axis of the curve is the partial pressure (PaO2) of oxygen dissolved in the blood, whereas on the y-axis is the oxygenation saturation percentage of hemoglobin (SaO2). Since we can measure SaO2 (we actually measure SpO2 with the instrument), we can determine the partial pressure of oxygen dissolved in the blood.

At the 97% O2 level of saturation, that is ~97 mmHg partial pressure of oxygen dissolved in the blood. Due to the shape of the curve, if the oxygen saturation should drop to 90% then the partial pressure of oxygen dissolved in the blood is ~60 mmHg.

The human body, in order to drive ventilation, has its own methods of measuring partial pressure of gases in the body. The primary mechanism is the hypercarbic drive, centered in the respiratory center of the brainstem, which when stimulated by high levels of CO2 (>45 mmHg), sends signals to the respiratory muscles to contract.

There is a backup mechanism to drive ventilation that is meant to support ventilation when the primary mechanism is not enough. This secondary process is located peripherally in the aortic and carotid bodies, and is a hypoxic drive that responds to partial pressures of O2 that are 60 mmHg or less. As we've already discussed, the SaO2 number that corresponds to 60 mmHg on the Oxyhemoglobin Dissociation Curve is 90%. At this percentage, the body has determined that the backup system for ventilation needs to operate, which explains the significance of the 90% SpO2 number on the pulse oximeter, and why the alarm for SpO2 is set to sound when that percentage goes below 90%.

If the Spo2 should drop to 80%, then this corresponds to a O2 partial pressure of 45 mmHg - an undesirable, and potentially harmful situation depending on the patient and the length of time the patient experiences partial pressure at that level. In summary:

97% saturation = 97 mmHg (PaO2) – Normal
90% saturation = 60 mmHg (PaO2) – Caution – Take measures to correct
80% saturation = 45 mmHg (PaO2) – Extreme Caution – Take immediate measures to correct

Measuring Oxygenation

The pulse oximeter instrument emanates two different wavelengths of light via the finger clip through the patient's nail bed. Each wavelength absorbs/reflects light differently through oxygenated/deoxygenated blood, allowing the monitoring instrument to calculate the SpO2.

Most pulse oximeters come programmed from the factory to certain standard settings for monitoring heart rate and oxygenation, and when applicable, blood pressure, end-tidal CO2, body temperature, respiratory rate, and EKG.

The Edan Pulse Oximeter settings for SpO2 should be set as follows:

Edan SpO2 Setup (touch the SpO2 box on the screen to pull up setup)

Pitch tone: On	Sensitivity: Med	
Alarm setup	100 – 90 Adult	100 - 92 Peds
	Switch: On	Record: On
	Level: Med	
Printer setup	PR Source: SpO2	Alarm Source: Auto
	Beat Source: Auto	PR Volume: (test it)

Responding to the SpO2 Alarm

The sedation team must be prepared to assist the respiration of a patient if it should become necessary. In order to determine if assistance is needed, the status of the oxygenation of the patient's tissues as well as ventilation must be known. As with preparing for any adverse event, the first step is prevention, including limiting sedation to patients without significant respiratory disease.

Should the pulse oximeter alarm sound indicating an undesirable level of oxygenation, the sedation team should respond in a logical series of steps to correct the desaturation.

Oxygen Saturation Algorithm

1. **Establish <u>Consciousness</u>** – Ask the patient a question, such as "Are you okay"? If the patient responds verbally, they are determined to be conscious.
2. **Open the <u>Airway</u>** – Raise the chin.
3. **Check the <u>Equipment</u>** – Check to make sure the finger clip properly positioned.
4. **Have The Patient Take A Few Deep <u>Breaths</u>**
5. **Administer 100% Supplemental <u>Oxygen</u>**
6. **Reversal with <u>Flumazenil</u>** – 0.2-0.3mg or 2-3cc
7. **Call for Help** – Call 911.

The Acronym for the steps to take when the O2 Saturation Alarm sounds is:

C = Consciousness
A = Airway
E = Equipment
B = Breaths
O = Oxygen
R = Reversal

If when the O2 Saturation Alarm sounds and the patient does not respond to verbal stimulation, then the above algorithm is modified to:

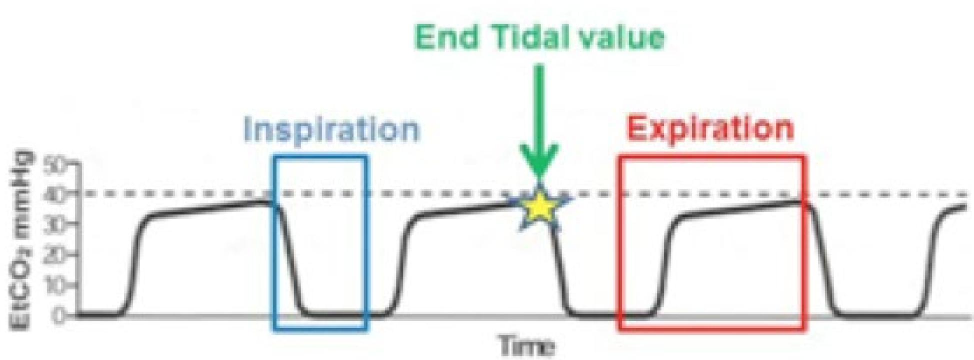
1. **Establish Consciousness (pt. is unconscious)**
2. **Open the Airway**
3. **Administer 100% Supplemental Oxygen**
4. **Reversal with Flumazenil**

Monitoring End-Tidal CO2

End-Tidal CO2 Monitoring (ET CO2) is the ability to measure a patient's exhaled carbon dioxide, which reflects the metabolic process of ventilation. Whereas oxygenation reflects the relative amount of oxygen that the blood is carrying, ventilation measures the result of oxygenation of tissues (cellular metabolism), which produces carbon dioxide as a byproduct.

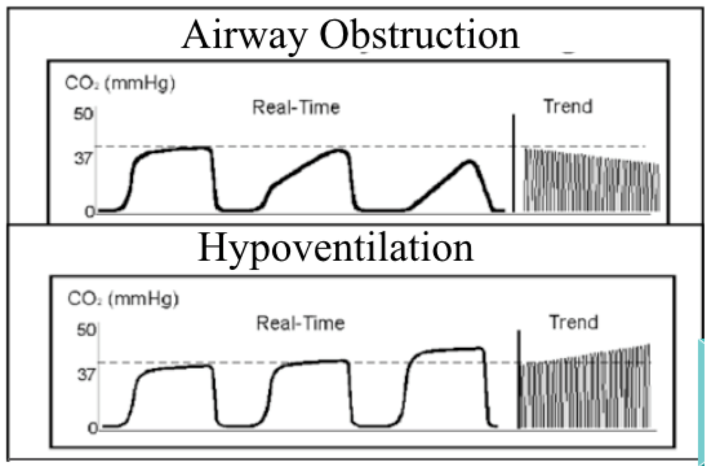
Another advantage of measuring ET CO2 versus SpO2, is that ET CO2 is a more real-time measurement. In general, expired CO2 would rise before oxygen saturation would fall.

Waveform **capnography** is a continuous tracing of CO2 during the respiratory cycle displayed on the monitor:



Capnometry refers to the measurement and display of CO_2 in numeric form only. Normal $PaCO_2$ is 40 mmHg + or – 5 mmHg. A lower CO_2 is to be expected the farther away the monitoring device is from the patient's airway.

An ET CO_2 of O mmHg indicates the patient is not being ventilated. If the capnogram indicates decreasing ET CO_2, this is a sign of airway obstruction. Conversely, if the capnogram shows a trend of increasing ET CO_2, this is a sign of hypoventilation.



Monitoring Blood Glucose

In patients who are susceptible to abnormally low blood glucose, it is important to take preventive measures, monitor their blood glucose at appropriate intervals, and if necessary, address hypoglycemia.

Hypoglycemia is blood sugar below normal (eg. 70mg/dl). The risk is greater in diabetics who have taken medication to control their condition and have eaten less than usual, exercised more than usual, or have drunk alcohol.

Without treatment, such low levels of blood sugar can lead to seizures and become life threatening. It is a medical emergency. However, it is easy to address in the short-term as long as the sedation team recognizes the signs and symptoms:

Signs and Symptoms

- Shakiness, anxiety, nervousness
- Palpitations, tachycardia
- Sweating
- Pallor
- Headache

Treatment
Treatment

- Intake of simple sugars like dextrose, glucagon. These may take the form of a glucose tablet, a sweet juice, a candy, or a sugar lump.

Sedation and the Diabetic Patient

When the diabetic patient is being evaluated as a candidate for sedation, it is important that the control of their condition be determined. The patient should have had a medical evaluation within the last year (within six months when the condition is complicated), with blood work that includes a HgA1c, and daily blood glucose checks.

A Hg A1c of **<6.5 indicates good control** (estimated average glucose of <140 mg/dL), **between 6.5 and 8.5 fair control** (estimated average glucose of between 141 and 184 mg/dL**), and >8.5 poor control** (estimated average glucose of >197 mg/dL). The procedure planned will affect the acceptability of a patient for dental treatment, but generally speaking, a patient with poorly controlled diabetes is not a candidate for sedation.

During the patient's sedation work-up, the diabetic patient's baseline values should include a blood glucose check. The sedation team should be familiar with how to use a glucometer. Recent developments in non-invasive (without a needle) blood glucose measuring devices include sensor patches, along with ear lobe and finger clips that are connected to wireless monitors.

On the day of the oral sedation appointment, the patient should be instructed to take all of their diabetic medications as usual, and eat a light breakfast one hour prior to the appointment (IV sedation instructions are different – Please refer to the DOCS Education IV diabetic sedation protocol). The patient's appointment should be first thing in the morning, and be no longer than 3-3.5 hours so the patient can return home in time to have a normal lunch meal. During the sedation appointment, the patient's blood glucose level should be checked at the time of presentation, every hour after during the appointment, and prior to dismissal.