Complications in IVCS and Management

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The three main reasons for complications during intravenous conscious sedation (IVCS) are:

1. Inappropriate patient selection
2. Unanticipated effects or responses from patient or equipment
3. Overmedication

Risk management strategies should be developed in each of these problem areas to reduce the incidence of complications.

Patient Selection

Careful attention must be paid to the patient's history and physical examination, the American Society of Anesthesiologists (ASA) Physical Status Classification, and airway assessment.

Unanticipated Events

Personnel involved in conscious sedation should be able to formulate a differential diagnosis for problem occurrences. They should be familiar with essential pieces of monitoring and resuscitation equipment and understand the limitations of these devices. In emergency situations, they should know how to summon help quickly and reliably.

Oversedation

Understanding the pharmacology of the drugs used in IVCS is essential for their safe administration. All drugs should be carefully titrated for

optimum effect. Factors such as patient age, concurrent medical conditions, and treatment need to be taken into account. Reversal agents must be readily available, but their use should never be routine. A supply of emergency drugs is essential.

■ Patient Selection

The baseline assessment of patients undergoing IVCS should include height, weight, and vital signs as well as oxygen saturation. A systems review should include documentation of cardiopulmonary and neurological status. Establishing baseline values is important because it allows more individualized care to be given during the procedure. For example, if a patient's baseline oxygen saturation on room air is only 93%, then it is unrealistic to be looking for values of 100% during IVCS, even with supplemental oxygen. Conversely, this same patient's pulmonary reserve is likely to be limited, and respiratory depression may be accompanied by a rapid oxygen desaturation.

It is important to be aware of any previous adverse responses to medication, including allergic reactions as well as abnormal responses to sedatives and narcotics. The ASA classification can be used as a broad indicator of risk analysis, but the supervising physician must carefully evaluate all patients. Some ASA Class III and most ASA Class IV and V patients are not suitable for sedation administered by nonanesthesiologists. These guidelines must, however, be flexible. The case involving a patient with unstable angina undergoing a procedure in the cardiac catheterization laboratory is clearly different from that involving the same patient having a colonoscopy.

Some simple screening questions may be of value and may raise "red-flag" alerts to potential problem areas:

> Do you have a medical condition that restricts your physical activity, necessitates frequent visits to a physician, or requires frequent changes in medication?
>
> In the past, when you have had sedation, anesthesia, or surgery, did you have any unexpected reaction to the medications or were there problems with your breathing or placement of a breathing tube?

The importance of airway examination is often underappreciated. Although airway evaluation methods are designed to predict the difficult intubation, abnormal findings may also herald airway problems during IVCS, such as a tendency for early airway obstruction. During IVCS there will always be a fine line between respiratory depression and apnea. If an intubation is anticipated to be difficult or appears on examination to be potentially difficult, the safety margin for the procedure is considerably decreased should respiratory arrest occur. Emergency airway management may prove perilous and consume precious time for the hypoxemic patient. If there are known or suspected airway issues, it may be prudent to perform the procedure in an operating room or involve members of the anesthesia team from the outset.

Anesthesia consultation should also be considered under the following circumstances:

Patient has limited neck motion or cervical instability.
Patient has abnormal craniofacial anatomy.
Patient is morbidly obese.
Patient has a history of sleep apnea.
Patient is pregnant.
Patient has not been classified as "NPO".
Patient has raised intracranial pressure.

■ Unanticipated Events

When there is any unanticipated event during IVCS, the first response should be to exclude respiratory depression or airway obstruction as a cause. Hypoxia and hypercarbia are precipitating factors common to a wide variety of destabilizing medical conditions.

Cardiovascular Instability

Hypotension. The most likely cause of hypotension is hypovolemia from dehydration. A patient who has been kept NPO for a procedure may become hypotensive when given even small amounts of sedative medication. The anxiety related to a procedure is often sufficient to maintain a sympathetic response and sustain blood pressure. Once sedative drugs are administered, this response is lost, and the effect, combined with the mild vasodilating effect of agents such as midazolam and propofol, is a fall in blood pressure. This may be exaggerated by concurrent antihypertensive medication, especially angiotensin-converting enzyme inhibitor drugs.[1] The hypotension usually responds to a fluid bolus. If the low blood pressure does not respond to volume replacement and remains significantly below baseline (e.g., 30%), the supervising physician must be informed. Small doses of vasoactive agents may be administered intravenously at this point, but other causes for the hypotension should be considered. Vasoactive agents include ephedrine in 5-mg increments or phenylephrine in 25- to 50-μg increments, or a combination of both. Active causes for hypovolemia should also be considered such as gastrointestinal bleeding or the development of a retroperitoneal hematoma during cardiac catheterization.

Myocardial ischemia can cause hypotension, and this may be secondary to hypoxemia or respiratory acidosis. It is important to remember that even with a significant respiratory depression, a normal or low normal oxygen saturation may be maintained by a high inspired oxygen concentration from a face mask or nasal cannula. The carbon dioxide levels, however, may rise dramatically under these circumstances, and the resulting respiratory acidosis may be severe.

A sudden fall in blood pressure should always make the practitioner consider an allergic reaction, especially if there is a temporal relationship to the administration of antibiotic medication or intravenous contrast solutions. Accompanying bronchospasm, airway edema, and rash support a diagnosis of anaphylaxis, and this should be treated aggressively with epinephrine, 0.5 mg subcutaneously or titrated intravenous dosages of 25 to 50 μg, or a combination, until symptoms improve and hemodynamic stabilization is achieved.

Cardiac Dysrhythmias. The most common change on the electrocardiogram (ECG) during IVCS is a sinus tachycardia. This is frequently due to anxiety and pain. Sinus bradycardia is less common but may also be a manifestation of anxiety and pain, especially in younger patients with increased vagal "tone." It is always important to study the ECG carefully to exclude heart block as a cause of a slow heart rate. Severe bradycardias (and even sinus arrest) occasionally occur during surgical manipulation, such as traction of the spermatic cord during hernia repair or sudden visceral distension during endoscopy.[2] For this reason, it is always worth asking the operator to stop what he or she is doing as a first response to a bradycardia. If the bradycardia persists, it may be treated with atropine, 0.3 to 1.0 mg, or glycopyrrolate, 0.2 to 0.4 mg. Premature ventricular contractions (PVCs) may also occur and are cause for concern if they are multifocal, are in runs, or occur close to the T wave of the preceding beat. Hypercarbia from oversedation may be one cause of PVCs, but cardiac ischemia must always be considered. If treatment is required, lidocaine, 50 to 100 mg intravenously, may be administered initially, but it is wise to terminate the procedure at this point and seek medical advice for further management.

Atrial dysrhythmias such as new atrial fibrillation, atrial flutter, or supraventricular tachycardias should prompt an urgent medical consultation because the precise diagnosis and treatment may be more complex. If the patient becomes unstable as a consequence of the rhythm disturbance, immediate treatment should be given according to ACLS guidelines. The same may also be said for ventricular rhythm disturbances, although these are, fortunately, rare during IVCS. One note of caution with any rhythm disturbance is to pay attention to the amounts of local anesthetic administered. Frequently, the maximum dosages of drugs such as lidocaine and bupivacaine are exceeded, and their systemic absorption may lead to a wide variety of cardiac and neurological abnormalities (see Neurological Disconnection). Bupivacaine is particularly dangerous because it binds avidly to myocardial tissues, leading to malignant dysrhythmias and cardiac arrest, both of which can be very resistant to treatment. Inadvertent intravenous injection of local anesthetic will rapidly manifest these neurological and cardiac complications at a much lower dose.

Respiratory Instability

Airway Obstruction and Apnea. The most common cause of airway obstruction during IVCS is increased sedation and loss of upper airway muscle tone. The tongue falls back into the pharynx and obstructs respiration. The patient can be observed to develop a "seesaw"respiratory pattern, with the abdomen appearing to suck inward rather than outward on inspiration. The accessory muscles of respiration in the neck become tense as they work to overcome the obstruction, and there may be an audible inspiratory noise. This situation is usually easily remedied by the jaw-thrust maneuver, which pulls the mandible forward and, with it, the tongue to which it is attached. Once a patient has reached this point, he or she has become oversedated and may need the jaw thrust to be maintained to ensure a patent airway. In most cases, this situation improves provided no further sedatives are administered. I do not advocate the use of reversal agents routinely for airway obstruction until these simple measures have been unsuccessful or there are mitigating circumstances such as persistent hypoxia. It is important to realize, however, that airway obstruction may be a prelude to respiratory arrest, especially if the sedative drugs have been recently administered and may not have reached peak effect. Reversal under these circumstances may be justified relatively early. Patients who reach the level of airway obstruction are no longer able to protect their airway if regurgitation of stomach contents occurs. This is another factor to consider during IVCS. The importance of titrating all drugs cautiously and allowing sufficient time for the last dose to take effect cannot be overemphasized. With the exception of propofol, none of the drugs routinely used in IVCS act in fewer than 2 to 3 minutes, and many take considerably longer.

Less common causes of airway obstruction should also be considered, such as the presence of foreign bodies (including dentures and surgical equipment, e.g., endoscope components), vomitus, and airway edema from an acute allergic reaction. It is also important to remember that many of these airway problems can become clinically significant only after the procedure has been completed.[3] When apnea occurs and the patient fails to respond to stimulation, the practitioner should immediately summon help from the operator or an anesthesiologist. Respiration will have to be supported initially with bag-mask ventilation while reversal agents

are administered. If bag-mask ventilation is difficult or the patient fails to respond to reversal drugs, endotracheal intubation will be necessary.

A relatively new device, the laryngeal mask airway, is frequently used in anesthetic practice as an alternative to bag-mask ventilation and endotracheal intubation. Although this device is not yet routinely used for resuscitation purposes in the United States, it has been used successfully in this setting in Europe.[4] It is relatively easy to insert and may, in the future, be readily available to nonanesthesiologists for emergency airway management.[5,6]

Bronchospasm. The occurrence of bronchospasm during IVCS is usually related to an exacerbation of preexisting obstructive pulmonary disease. It can generally be managed by terminating the procedure and administering nebulized bronchodilators, such as albuterol or ipratropium. A medical consultation is almost always necessary because steroid therapy and follow-up may be indicated. Severe, sudden bronchospasm may be the result of an allergic reaction, and this should be managed aggressively as outlined in the Cardiovascular Instability section. The other condition worthy of exclusion in this setting is "cardiac asthma," or pulmonary edema presenting with wheezing. This is clearly more likely if there is a history of heart failure and cardiac disease.

Neurological Disconnection

Agitation and Loss of Cooperation. During the course of IVCS, it is important to remain "connected" to the patient. The ability to converse with, reassure, and obtain feedback from the patient is actually a prerequisite for conscious sedation, and these are elements that distinguish IVCS from other deeper forms of sedation and anesthesia. Unfortunately, this is frequently forgotten by many involved in IVCS. Often the operator expects the patient to be rendered comatose for the procedure. Those administering IVCS should strongly resist demands for what amounts to unconscious sedation!

Awareness of a patient's baseline mental status and neurological status is vitally important. The patient should be talked to frequently, and if the procedure itself will not allow the patient to talk (e.g., gastroscopy or bronchoscopy), then some nonverbal means of communication must be established from the outset. Sedation and analgesia should be carefully administered to relieve anxiety and discomfort. Response to medication and need for further doses should be regularly discussed with the patient. In almost all circumstances, the patient who becomes uncooperative, agitated, or combative has received too much medication, not too little.

Disinhibition. States of disinhibition may also be related to overmedication, but occasionally these patients will settle with further incremental dosages of sedation. Once again, it must be emphasized that hypoxia and hypercarbia may cause a significant change in neurological

state. Sustained hypotension may lead to cerebral hypoperfusion in some individuals with a compromised cerebral circulation. This is particularly true for hypertensive patients with carotid stenosis. Mechanisms of cerebral autoregulation may be "shifted," requiring higher perfusion pressures than may otherwise be expected.

A relatively common (and underappreciated) cause of agitation and confusion is systemic local anesthetic toxicity. Cardiovascular manifestations of toxicity may accompany these neurological changes (see Cardiovascular Instability). Examples of maximum dosages are bupivacaine, 3 mg/kg, and lidocaine, 4 mg/kg (or up to 7 mg/kg with epinephrine). These are only guidelines, however, because absorption rates from the different tissues and sites may vary. A high degree of vigilance is needed, and the operator should be warned when the maximum dose has been reached. Those involved in using local anesthesia close to the central nervous system (e.g., during a retrobulbar block) should also be aware of the rare but serious complications that result from inadvertent intrathecal injection. Relatively small doses of local anesthetic can render the patient unconscious, apneic, and severely hemodynamically unstable.

The Emergent Situation

It is not my intention to cite all the different varieties of emergent situations, although acute anaphylaxis to contrast dye or cardiac arrest from an intravenous dose of bupivacaine are good examples. My aim is to focus more on the act of preparedness that allows one to deal with these catastrophes most efficiently. There will always be unanticipated life-threatening emergencies. The end results will be variable, but the response should be uniform and rehearsed and allow the practitioner to say that everything was done to strive for a favorable outcome.

When the incident occurs, the supervising practitioner must be told immediately, the procedure should be stopped, and a cardiac arrest–Code Blue call must be made. All sedative therapy, infusions, and transfusions should be stopped. (Intravenous fluid infusions may be continued if hypovolemia or vasodilatation is a significant factor in the event). Advanced cardiac life support measures should be instituted. Emergency drugs and equipment should be prepared for the arrival of the code team. It is important to anticipate what drugs or pieces of equipment may be required. Sometimes simple things may be very valuable, such as readily available disposable gloves and suction equipment. Be prepared to give a succinct patient history and an account of the events that led to the emergency. Some information may be very important to the arriving team. For example, knowing that a patient is on hemodialysis would not only bring hyperkalemia into the differential diagnosis for the event but would also warn the anesthesiologist away from using a drug such as succinylcholine, which would make hyperkalemia worse.

■ Equipment Problems

Monitoring devices are vitally important during conscious sedation, and personnel using the equipment must be familiar with their use. There are a bewildering variety of machines, and it is tempting to assume that they all are the same. This perception is further enhanced by the fact that many of the newer models are very easy to use and require no set-up. This convenience of use may unfortunately be a double-edged sword, because the simplicity deters anyone from needing to know anything more about the equipment other than how to turn it on! The middle of a procedure is not the time to become familiar with the equipment's idiosyncrasies. If a new monitor appears, insist on an in-service training. This may seem overly cautious, but how many of us would stay on a passenger plane if the pilot announced that he or she had never flown that particular plane before but was sure it was like the one flown yesterday?

Electrocardiogram

The main technical problems that occur with the electrocardiogram relate to lead placement and skin contact (Table 1). It is, however, important that the practitioner always feel the patient's pulse before entering into a tirade about the inadequacy of the equipment. Precious minutes can be lost looking for broken leads or faulty connections when the patient actually is asystolic!

Noninvasive Blood Pressure Monitor

Although the noninvasive blood pressure monitor (Table 2) functions reliably assesses over a range of blood pressures, it does tend to become less accurate at the extremes of measurement. It can also fail to detect pressures in some patients with atrial fibrillation. Choosing the appropriate cuff size is important; the cuff width should be 40% of the circumference of the arm.[7] If the cuff is too small, the blood pressure reading will

Table 1. *Equipment Problems: Electrocardiogram*

Problem	Possible Cause
No trace or loss of trace	Asystole!
	Loose leads
Poor quality trace	Dry electrodes
	Greasy skin
	Electrical interference
Intermittent trace	Respiratory variations
	Incorrect lead placement
Interference	Cautery devices
	Unshielded electrical equipment

Table 2. *Equipment Problems: Noninvasive Blood Pressure Monitor*

Problem	Possible Cause
No reading, repetitive cycling	Hypotension
	Hypertension
	Cuff leak
	Dysrhythmia
	Kinked tubing
	Excessive limb movement
Very high or very low reading	Hypertension
	Hypotension
	Wrong size cuff
	Movement artifacts

be falsely high. If the patient comes from a critical care setting, he or she may already have an arterial catheter in place, and this should be used. Although this seems obvious, surprisingly often an arterial catheter is not used because it is not noticed or a monitoring cable needs to be found.

Pulse Oximeter

This monitor, perhaps more than any other, has had an enormous impact on patient safety. The ability to obtain a close-to-real-time measurement of oxygen saturation allows for much safer administration of sedative and depressant medications in a variety of settings. Its use in IVCS should be mandatory. This monitor does have limitations, however, which are outlined in Table 3. It is important to remember that the oximeter does not measure respiration. As discussed earlier, a high inspired oxygen

Table 3. *Equipment Problems: Pulse Oximeter*

Problem	Possible Cause
No reading	No pulse!
	Poor perfusion
	Disconnection
	Nail polish
Persistent low reading	Hypoxemia
	Dye injection
	Methemoglobinemia
	Poor sensor positioning
Intermittent trace	Blood pressure cuff cycling
	Electrical interference
	Incident light
Frequent alarm	Electrical interference
	Inappropriate saturation-rate settings
Overestimation of arterial oxygen saturation	Anemia
	Carboxyhemoglobin
	Sickle-cell disease

concentration can maintain a very acceptable level of saturation, even in the face of significant respiratory acidosis. The oxygen saturation measurement is also limited in that it does not give any information on the quantitative delivery of oxygen. This is primarily a function of cardiac output and hemoglobin concentration.

Although the response time of the oximeter is relatively fast, there is a potential for a lag phase between a fall in alveolar oxygen tension and its detection at a peripherally placed sensor. An awareness of this lag is important; the practitioner should respond rapidly to a falling saturation because the actual saturation is probably considerably lower. Fortunately, the reverse is also true, and once oxygenation and respiration are improved the patient's saturation will recover quickly, even though the saturation readings may take some time to catch up.

With all monitors, it is vitally important to address any problems or potential malfunctions before starting a procedure. The problems are unlikely to go away, and the instrument will let you down when you need it most. Fix it before you start!

■ Overmedication

It is helpful to think of overmedication as either relative or absolute. Absolute overmedication is easier to understand because the sedative drugs are administered at inappropriately high dosages for the size of the patient and are repeated too soon. Relative overmedication is more difficult to predict because some patients may simply be more sensitive than others. This is especially true for patients of advanced age. Concurrent medical conditions such as renal or hepatic disease may also cause increased sensitivity to medication, and the agents will last longer than expected. Here again, careful low-dose titration of the medication will reduce complications in these patients.

It often difficult to resist the temptation to administer a second dose too soon, especially in a high-turnover unit with a physician anxiously waiting to proceed. Remember that a respiratory arrest will delay a conscious-sedation schedule considerably longer than allowing a few minutes for a drug to reach its peak effect.

The effects of overmedication are as follows:

Airway obstruction and apnea
Hypoxemia and hypercarbia
Loss of protective reflexes
Loss of contact with the caregiver
Hemodynamic instability
Agitation, irritability, and noncompliance

Reversal

Opiates and benzodiazepines are the only drugs with specific antagonists. Once these reversal agents are used, there must be a mandatory increase in the postprocedure recovery time. The use of these reversal agents should never be routine, and they should not be considered benign rescue agents for overzealous sedation techniques.

Naloxone. This opioid antagonist should be administered in doses of 40 to 400 μg by slow intravenous injection. It has an onset time of 3 minutes, and the duration of action is approximately 40 minutes. The dose should be kept as low as possible because it will reverse the analgesic effects of the narcotic, and it has also been known to cause pulmonary edema.[8] Patients on long-term narcotic use may experience unpleasant withdrawal phenomena.[9] Because the half-life of naloxone is often less than the narcotic it is antagonizing, the dose may need repeating. In rare situations, it may need to be given by infusion.

Flumazenil. This is a specific benzodiazepine antagonist. The intravenous dose ranges from 0.1 to 0.2 mg for partial reversal to 0.4 to 1.0 mg for complete reversal. The onset time and duration of action are similar to those of naloxone. Flumazenil may precipitate withdrawal seizures in patients on long-term benzodiazepine therapy.[10] The half-life considerations are similar to those of naloxone, so repeat doses and infusions may be necessary.

■ Summary

Choose your patients carefully.
Check and understand your equipment.
Be vigilant and prepared for the unexpected event.
Remember basic airway techniques.
Have differential diagnoses for the more common complications.
Have clearly defined personal and departmental plans to deal with emergency situations.
Use medication judiciously; you cannot take it out but you can always give more!
The use of reversal agents should never be routine.

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