PSNet
PATIENT SAFETY NETWORK

Medication Safety Events Related to Diagnostic Imaging

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The Cases

Case #1: *A 42-year-old woman admitted with aphasia, severe headache, and right-sided facial droop was taken for magnetic resonance imaging (MRI). The MRI was unsuccessful due to agitation, requiring a repeat attempt the next day. Before the second MRI, the patient was given lorazepam 2 mg intravenously (IV) as premedication to reduce agitation. The MRI was again unsuccessful, despite anxiolysis. After returning to the medical unit, flumazenil 0.2 mg was given due to somnolence, with subsequent improvement in mental status.*

Case #2: *A 71-year-old man with a history of alcoholism, hypertension, and arthritis s/p hip replacement surgery was treated in a community hospital for sepsis due to pyelonephritis and bacteremia. Ten days later, he was transferred to an academic medical center for treatment of L3-L4 discitis and possible epidural phlegmon versus abscess. He was admitted by Neurosurgery and given lorazepam 2 mg IV prior to transport for an MRI with contrast. The patient was unable to tolerate the scan due to back pain, so the acute care nurse was instructed to administer hydromorphone 0.5 mg IV. The patient remained restless, so the physician ordered additional doses of lorazepam 1 mg IV and hydromorphone 0.4 mg IV. After the patient received a 3rd dose of lorazepam 1mg IV, he became obtunded, hypotensive, and developed respiratory depression with oxygen saturation around 60%. The rapid response team was called, and naloxone and flumazenil were administered. The patient was placed on bilevel positive airway pressure (BiPAP) and given a fluid bolus before being transported to the intensive care unit (ICU), where he was emergently intubated. The patient remained intubated for several days due to severe acute respiratory distress syndrome (ARDS), which was attributed to aspiration while in the MRI machine.*

The Commentary

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Background

Medications are routinely used prior to imaging procedures, such as MRIs, to reduce pain (e.g., in patients with conditions where pain may be exacerbated by positioning for imaging) and anxiety. Varying levels of sedation prior to imaging can be appropriate given the need for patients to remain still during the imaging process. MRIs can cause anxiety due to the confined space as well as the loud noises created by the machine. Specifically, 1-15% of patients either cannot complete imaging procedures due to claustrophobia or they require pre-procedural medication.[1] Procedural sedation for imaging should encompass the minimal amount of sedation or anxiolysis needed to provide benefit while mitigating unwanted side effects such as oversedation and respiratory depression. These two cases highlight the risks of minimal-to-moderate sedation for imaging procedures, especially in high-risk patients, when multiple medication doses are required, and when monitoring is limited or inadequate (e.g., inside an MRI machine).

Patient Safety

Opioids and benzodiazepines are commonly used medications in the acute care setting. In the United States, over half of hospitalized patients receive opioids and 48% receive benzodiazepines.[2,3] Opioids and benzodiazepines can be beneficial; however, their respiratory depressant effects are synergistic, thus the combination is associated with higher risk than either medication alone. Concurrent opioid and benzodiazepine use is associated with a two-fold increase in all-cause mortality.[4] Furthermore, one study reported that 7% of documented safety events involved diagnostic imaging.[5] Without appropriate guidance, protocols, and patient monitoring strategies, it can be challenging to identify which patients are at higher risk of experiencing adverse events from imaging-related opioid or benzodiazepine administration. In case 1, the MRI could not be completed due to persistent agitation, yet by the time the patient was evaluated back on the medical unit, she was somnolent and required a reversal agent. In case 2, the healthcare providers' desire to complete the MRI quickly led to repeated dosing of both opioids and benzodiazepines within a short period, which in turn caused obtundation, respiratory depression, and aspiration.

Assessing Patient Risk Factors for Oversedation

Prior to diagnostic imaging with anticipated sedation, patients should be assessed for sedation-related risk factors that can lead to adverse drug events. Nurses are at the forefront of patient care in the acute care hospital setting and play a critical role in assessing patient-related risk factors and identifying oversedation.[6] This assessment should encompass both subjective and objective criteria. Subjective assessments include the patient's ability to respond purposefully to verbal commands, the patient's non-verbal behavior, and patient-reported pain scores, such as the Numeric Pain Rating Scale (NRS). Objective data such as heart rate, blood pressure, and respiratory rate illustrate the patient's cardiorespiratory function. End-tidal CO2 monitoring is added for patients who need moderate or higher-level sedation and can be used for high-risk patients regardless of the intended depth of sedation. Validated sedation assessment tools should also be used for clinician decision support. Common sedation assessments used in practice include the Richmond Agitation and Sedation Scale (RASS), Inova Health System Sedation Scale (ISS), and Pasero Opioid Sedation Scale (POSS). It should be noted that the POSS is only applicable when opioids are being administered; however, RASS is a more generalizable tool that can be used with either opioid and/or benzodiazepine administration.

Along with assessing a patient's level of sedation, it is important to consider patient-specific risk factors that can contribute to sedation-related complications such as respiratory depression. Risk factors for oversedation in the setting of opioid administration include obesity; hepatic, renal, and lung disease; substance use disorder, obstructive sleep apnea, and higher American Society of Anesthesia (ASA) physical status classification (Table 1).[7,8] Additionally, the STOP-BANG score can be calculated to assess patient-specific risk factors for obstructive sleep apnea,[9] which has previously been associated with imaging-related oversedation. Age, female sex, and lower body mass index (BMI) appear to be risk factors for oversedation requiring reversal agents, although their independent effects are uncertain.[7] Lower BMI values are associated with higher plasma concentrations of fentanyl or midazolam, both of which are commonly used medications for diagnostic imaging.[6] Risk of aspiration is another factor to consider; NPO (nothing by mouth) orders should be considered prior to diagnostic imaging procedures with sedation.[10]

Table 1. American Society of Anesthesia Physical Status Classification System[8]

ASA Class 1	Healthy patients
ASA Class 2	Mild to moderate systemic disease not limiting activity
ASA Class 3	Severe systemic disease that limits activity but is not incapacitating
ASA class 4	Severe systemic disease that is constant threat to life
ASA Class 5	Moribund patients not expected to survive 24 hours with or without operation
ASA Class 6	Brain death

Levels of Sedation

The ASA has identified four levels of sedation (Table 2).[8] Typical sedation for MRI falls in the minimal sedation category, also known as anxiolysis. If a patient is at increased risk for respiratory depression or needs a deeper level of sedation, such as moderate, deep, or general anesthesia, institution-specific guidelines for enhanced patient monitoring should be followed. Additionally, anesthesiologists may be asked to provide sedation for patients who are at higher risk of sedation-related complications, and to proceed with general anesthesia, if clinically appropriate.

Table 2. ASA Levels of Sedation[11]

	Minimal Sedation	**Moderate Sedation**	**Deep Sedation**	**General Anesthesia**
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal/tactile stimulation	Purposeful response to repeated or painful stimulation	Unarousable even with painful stimulation

Airway	Unaffected	No intervention required	Intervention may be required	Unarousable even with painful stimulation
Spontaneous Ventilation	Unaffected	Adequate	May be inadequate	Intervention often required
Cardiovascular Function	Unaffected	Usually maintained	Usually maintained	May be impaired

Medication Dose Stacking

Patient sedation assessments are not confined to the pre-procedural timeframe. Reassessments should be implemented into workflows throughout each procedure to ensure safe and appropriate tolerability of medications. While the effects of benzodiazepines tend to be predictable, opioids have significant interpatient variability in response.[12,13] Given this interpatient variability and risk for oversedation, patients must be assessed before and after each dose or medication administration. Consistent sedation assessments are highly encouraged throughout the duration of action of the medication(s) administered. Continuous electronic monitoring is indicated for moderate levels of sedation or higher and should be considered for high-risk patients receiving opioids and/or benzodiazepines.

Prior to procedures, patients may receive oral and/or IV pre-medications involving multiple doses from the same drug class. Although this practice is often appropriate to ensure adequate image quality and improve patient experience, it allows the possibility for medication "dose stacking."[14] Dose stacking occurs when a patient receives medications multiple times and/or from various routes before each dose reaches its peak therapeutic effect.[14] Oral medications tend to have a longer onset and time to peak effect than IV medications, which can lead to potential complications such as oversedation.[13,15]

Risk reduction strategies include implementing institutional policies that outline, standardize, and consolidate administration of analgesic and anxiolytic medications. Practice guidelines that specify appropriate timing of patient reassessments should be implemented to ensure safety and to avoid medication dose stacking.

Beyond Medication

Given the multidimensional nature of anxiety, medication is not always warranted. A variety of anxiety-inducing scenarios can be managed with non-pharmacologic modalities. For example, the position of the patient during an MRI can make a difference in their anxiety, agitation, and claustrophobia. Having a patient lay prone rather than supine has shown some benefit, with less claustrophobia noted as well.[16] Some portion of anxiety can be attributed to cognitive perception and processing. Movie goggles designed specifically for the MRI environment produce distraction and increase the success of diagnostic imaging without sedation for all ages.[17] A mirror on the head coil provides a view outside the scanner to decrease claustrophobia. Two-way speaker communication between the radiology team and the patient is important, and a patient call button allows the patient to alert the technician of any concerns, decreasing anxiety.[18]

Cognitive strategies such as guided imagery and deep breathing and relaxation techniques, have been effective in reducing anxiety.[17] Fragrance administration has also been used to reduce anxiety in MRI studies correlating olfactory stimuli to reduced anxiety.[17] Ultimately, clinicians should optimize non-pharmacologic anxiolysis prior to administering sedative medications.

Take Home Points

- MRIs and similar diagnostic imaging are most often associated with minimal sedation.
- Policies to guide continuous reassessment of a patient's level of sedation and continuous electronic monitoring can help mitigate oversedation events.
- Risk stratification tools such as the ASA Physical Status Classification System and STOP-BANG can help care teams better understand a patient's risk for oversedation and ensure that appropriate monitoring is in place.
- Holistic management techniques and two-way communication tools provide additional support in addressing the multifactorial nature of anxiety and can limit the need for premedication prior to imaging.

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