Critical Care CME Program

Module 8

Module 8 of CSA's Critical Care CME Program appears in this issue of the *Bulletin*; this is the final module of this program. To receive CME credit, submit your registration page, answers to the questions, and the evaluation to the CSA office. Your CME certificate will be mailed to you. Alternatively, the full text of each module will be accessible through the CSA Web Site, **www.csahq.org**, in the Online CME Program section. Instructions to complete Module 8 online are given in the Information pages. After completing the assessment, print your CME certificate. Members will need their usernames and passwords to do the modules online.

The following Important Information about Critical Care Module 8 must be read and acknowledged before proceeding to the rest of the module. Check the acknowledgement box on the registration page.

Faculty/Disclosures

All faculty participating in continuing medical education activities sponsored by the CSA are required to disclose any real or apparent conflict(s) of interest related to the content of their presentation(s) or any of the industry sponsors of the meeting. In addition, speakers must disclose when a product is not labeled for the use under discussion or when a product is still investigational.

Nitin Shah, M.D. (Co-author of Modules 2 and 8, Editor and Chair of the Critical Care CME Program)
Clinical Professor of Anesthesiology
University of California at Irvine Medical Center, Orange, California
Chief, Surgical ICU, Long Beach Veterans Healthcare System, Long Beach, California

Dr. Shah has received honoraria from Masimo, Abbott, and Baxter for his role as speaker. He owns stock in Masimo Corporation.

Levina Tran, M.D. (Co-Author of Module 8)
Resident Physician, Department of Anesthesiology
University of California at Irvine, Orange, California

Dr. Tran has no relevant financial relationships with any commercial interests.

Registration/Instructions

Method of Participation: The physician will read and study the materials and complete a quiz and an evaluation of the module. Some modules may have slides available online. To register for and complete this module: Complete the registration page, complete the test questions and the evaluation that can be found after the article, and submit your quiz to the CSA office by mail or fax (650-345-3269). Your CME certificate will be mailed to you.

Estimated Time to Complete the Module: One hour

Please check the box on the registration page acknowledging that you have read everything in these introductory pages.

Availability

Module 8: ICU Sedation

Release Date: December 31, 2009
Expiration Date: December 31, 2012

CME Sponsor/Accreditation

The California Society of Anesthesiologists is accredited by the Accreditation Council for Continuing Medical Education to sponsor continuing medical education for physicians.

The California Society of Anesthesiologists Educational Programs Division designates this critical care program for a maximum of 8 *AMA PRA Category 1 Credit(s)*™. The program consists of eight modules with 1 credit per module. Physicians should claim credits commensurate with the extent of their participation in the activity.

Fees, Target Audience, Evaluation

The modules are free to CSA members. Nonmembers pay $30 for each module. Each module is worth *one AMA PRA Category 1 Credit*™. This program is intended for all licensed physicians, including residents. An evaluation of each module of this series is offered after the test questions.

Privacy Policy

CSA has a privacy policy that is a general policy for information obtained regarding all online interactive pages, including online CME activities. To review this policy, please go to www.csahq.org/privacy.vp.html.

Objectives

Upon completion of this activity, participants will be able to:

- Discuss the role of sedation in management of patients in ICU
- Describe the advantages and disadvantages of different methods used to assess sedation
- Learn about pharmacology of various drugs available for ICU sedation
- Understand pros and cons of available drugs for ICU sedation

* * * * * *

ICU Sedation

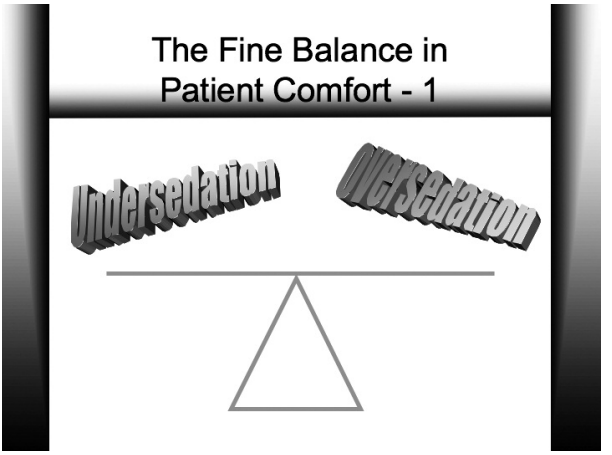
By Nitin Shah, M.D., and Levina Tran, M.D.

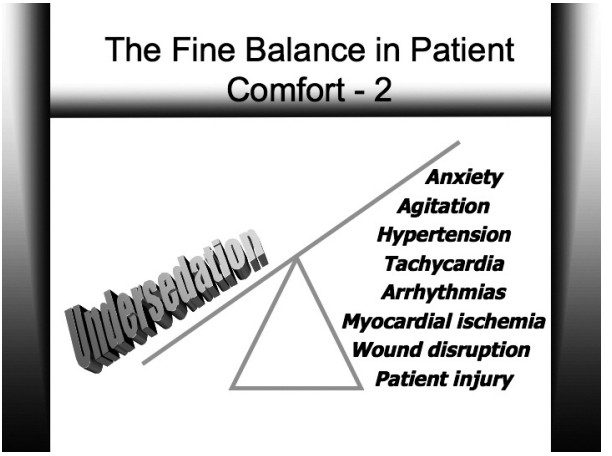
Nitin Shah, M.D., has been a co-chair of "preventing harm to 5 million patients" committee of Long Beach VAHS. The committee is charged with reducing VAP, Catheter-related infection, reduction in complications of central venous line, and Rapid Response Team (RRT). He is also responsible for the Conscious Sedation policy of the hospital since 1997. His research interests include "Impact of Titration of Propofol versus Bolus dosing of Propofol during Induction of Anesthesia."

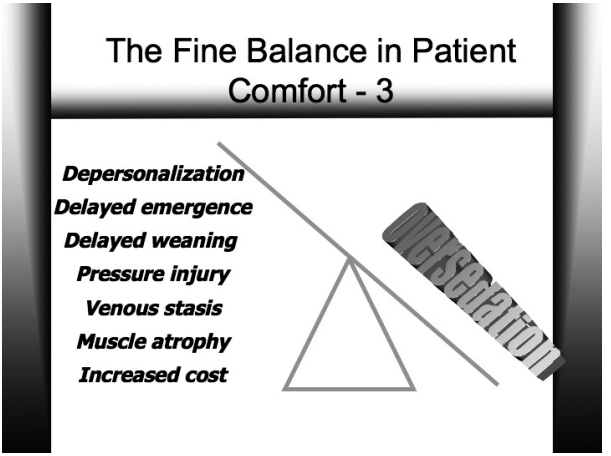
Levina Tran, M.D. is an Intern in Internal Medicine who will be an Anesthesia resident at UC Irvine Medical Center from July 2010.

Management of patients in the Intensive Care Unit (ICU) presents a quadrangular problem. Patients need analgesics and/or neural blockade for pain, sedation for anxiety, amnesic agents to prevent recall of events during their ICU stay, and a few of the sicker ones will require paralytic agents! Drugs also are required to reduce the stress response, alleviate anxiety, increase comfort, reduce pulmonary complications, assist diagnostic tests, and help in therapeutic interventions. Many factors, such as severity of illness, type of ventilator, and need of diagnostic and therapeutic procedures, will influence drug requirements. Use of intravenous infusion of sedation among mechanically ventilated patients in the U.S. has increased from 39.7% in 2001 to 66.7% in 2007.[1] While the technical tools for assessment are generally unreliable, evaluation of analgesia and sedation is important for critically ill patients.[2]

Assessment of Sedation







Monitoring of sedation is critical for patients in the ICU, and it is a challenge for clinicians to find a fine balance while navigating between the extremes of over-sedation and under-sedation, as they both carry morbidities.

There are three ways to assess for the pharmacological needs of the patients in the ICU:

1. **Informed Anecdote:** Experiences of healthcare professionals who have required ICU care in their life. Their opinions will be considered biased, as they also have garnered knowledge from having practiced in the hospital and ICU.
2. **Subjective Impressions:** Impressions of patients who have survived their ICU confinement. Sixty patients who needed ICU care during their illness were asked whether they recalled various of their experiences and, if so, whether they found their experiences to be unpleasant.[3]

Experience	Recall of Experience (%)	Reported Experience Unpleasant (%)
Anxiety	55	78
Pain	40	67
Thirst	67	60
Tracheal Tube (N=50)	38	57
Face Mask	67	52
Physiotherapy	75	33
Urinary Catheter	75	17
Nausea	13	12
Paralysis	13	100

While anxiety and pain were high on the list of unpleasant recall, all of those paralyzed reported that experience to be unpleasant. This underscores the need for education in the use of amnesic agents in patients who are paralyzed during their stay in the ICU. Indeed, amnesia remains the most understudied aspect of ICU care.

3. **Objective Assessments:** The most widely used approach is the clinical evaluation of awareness and responsiveness to stimulation, using instruments such as the Ramsay Scale, Sedation-Agitation Scale (SAS), or Motor Activity Assessment Scale,[4] Adaptation to The Intensive Care Environment Scale (ATICE), and Behavioral Pain Scale.[5] The benefits of implementing the SAS and accompanying clinical guidelines for ICU patients has been demonstrated.[6] Although the SAS and other scoring tools are valid and reliable resources, they are observer-dependent, necessitating stringent educational requirements of the nursing and medical staffs.

   Other assessment methodologies also are available, such as the Glasgow Coma Score, Visual Analog Score (pain assessment), Bispectral (BIS) Index, and ENTROPY.

   The *BIS* is a processed EEG monitor that provides values that can be followed and compared. Electrophysiological monitoring can be helpful to directly assess stability of the central nervous system during clinical situations where an adequate neurologic examination is limited—such as neuromuscular blockade, deep sedation, and loss of consciousness due to structural or metabolic brain injury.[7] BIS range guidelines for different hypnotic states from awake [100], to deep hypnotic state [40] to EEG suppression [<40].[8] Comparing SAS and BIS, it was found that when the clinical assessment is equivocal, BIS monitoring may have an adjunctive role in sedation assessment. BIS values should be interpreted with caution, however, because electromyography activity and other factors can confound BIS scores.[9]

   Entropy & BIS with the Ramsay score. A significant correlation was found between ENTROPY, BIS, and Ramsay score values in sedated postoperative ICU patients. The authors concluded that ENTROPY did not appear superior to BIS for the assessment of sedation.[10]

The daily interruption of sedative infusions is another tool available as an approach to improve outcomes in the ICU. Interruption protocols such as spontaneous awakening trials (SATs) and spontaneous breathing trials (SBTs) can be performed with the goal of ensuring patient comfort and avoiding unpleasant memories. In addition, these protocols aim to reduce time spent on

the ventilator, reduce ICU and hospital stay, and decrease mortality.[11] However, in critically ill trauma patients, an analgesia-delirium-sedation assessment protocol *without* daily interruption of medication infusion has been shown to decrease ventilator time and hospital length of stay.[12]

Pharmacology of Available Agents

The ideal ICU sedative should lack respiratory depression, have analgesic effect, be titratable with rapid onset and offset, produce amnesia and anxiolysis, and provide hemodynamic stability.

Each drug comes with its own pros and cons. The agents that will be discussed include benzodiazepines, propofol, dexmedetomidine, haloperidol, opioid analgesics, sevoflourane, etomidate, and ketamine.

Benzodiazepines are a commonly used sedative, and they act by modulating post-synaptic receptors in the central nervous system. By enhancing the binding and action of the inhibitor neurotransmitter gamma-aminobutyric acid, they hyperpolarize cells and cause them to become more resistant to excitation.

The following benzodiazepines are available intravenously: midazolam, lorazepam, and diazepam. Midazolam is the most commonly used for sedation due to its rapid onset and shortest duration of action. It often is used as a continuous infusion. However, infusions lasting more than a few hours can result in its accumulation in patients with hepatic insufficiency, leading to prolonged recovery and, if used with opioids, it may increase incidence of hypotension.[13-17]

Lorazepam has a slower onset and longer duration of action than midazolam. It also provides sedation, anxiolysis, and amnesia,[13-17] and is the benzodiazepine of choice if the goal is less hypotension and prolonged sedation in patients who will not require rapid awakening.

Diazepam is least favored due to increased risk of a cumulative over-sedation with repeated drug administrations.[18]

Pros	Cons
• Amnesia	• Prolonged Weaning
• Anxiolysis	• Polyethylene glycol toxicity
• Sedation	• Respiratory Depression
• Relief of Muscle Spasm	• Hypotension
	• Lack of analgesia
	• Over sedation/deep sedation
	• Dependence/tolerance
	• Paradoxical Agitation

Propofol is a phenolic derivative whose mechanism is not well understood but believed to also function via GABA-receptor modulation. Propofol is highly lipophilic and is transported as an isotonic, pH-adjusted emulsion. Propofol is given to patients for titratable sedation due to its quick onset and offset, which is useful for short-term sedation and rapid weaning from the ventilator. Its highly lipid soluble characteristic allows it to cross the blood brain barrier rapidly. In patients with neurological injury, propofol can improve neurological and clinical outcomes because it reduces intracranial pressure and cerebral oxygen consumption. Its use is limited because it decreases heart rate and blood pressure. Propofol should be used with caution in patients who are hypotensive, hypovolemic, or hemodynamically unstable. Propofol can also cause elevated triglycerides during prolonged continuous infusions (>2 days) and lipid levels should be monitored. There is also a risk of infection due to bacterial contamination; thus bottles and tubing must be changed regularly. Propofol Infusion Syndrome, a rare but lethal reaction associated with prolonged, high-dose (>4mg/kg/hr) propofol infusions, characterized by the abrupt onset of bradycardia, hyperlipidemia, rhabdomyolysis, lactic acidosis, and heart failure.[18]

Pros	Cons
• Sedation	• Decreased contractility
• Hypnosis	• Lack of analgesic effect
• Anxiolysis	• Respiratory depression (enhance by opioids)
• Amnesia	• Hypotension
• Muscle relaxation	• Hypertriglyceridemia
• ↓ICP	• Preservative issues
• Relief of bronchospasm	• Potential of infection necessitates need for regular changing of lines
• ↓CMRO2	• Metabolic acidosis (high doses)

Dexmedetomidine is a medication approved for ICU sedation in the early post-operative period for up to 24 hours. It is an alpha-2 adrenoreceptor antagonist and induces sedation and anxiolysis via receptors within the locus ceruleus and analgesia via receptors in the spinal cord, respectively.[19-20] Dexmedetomidine is a unique agent because it produces sedation and analgesia without causing respiratory depression. Compared to midazolam, patients on dexmedetomidine spent less time on the ventilator, had fewer episodes of delirium, and were less hypertensive or tachycardic.[21] Dexmedetomidine also had improved outcomes in the setting of infection.[22] Unlike patients with other sedatives, those sedated with dexmedetomidine were arousable and oriented and were not required to have sedation discontinued before extubation. Bradycardia and hypotension are the most common side effects, particularly in

patients with severe heart block.[23] Agitation and sympathetic rebound can occur with prolonged infusion and initial infusion guidelines recommended a limit of 24 hours.[24] However, multiple other studies since then have suggested that patients may require higher doses and can be treated for longer than 24 hours.[25, 26, 27]

Pros	Cons
• Sedation	• Bradycardia
• Analgesia	• Hypotension
• Anxiolysis	• Agitation
• Respiratory stability	• Dry mouth
• Predictable hemodynamic response	• Cautious use in hypovolemia and heart block
• Decreased ventilator time	• Sympathetic rebound
• No need to discontinue before extubation	• Potentiates effects of opioids, sedatives, anesthetics
• Arrousable and oriented patient	

Haloperidol induces sedation and antipsychosis by antagonizing the dopamine D2 receptor in the central nervous system. Haloperidol has a delayed onset of action and lasts for hours. Its sedative and antipsychotic effects are useful in sedating ventilator-dependent patients, as it does not cause respiratory depression. Haloperidol is also useful in controlling delirium. It can cause extrapyramidal reactions such as acute dystonic reactions, Parkinsonism, tardive dyskinesia, and akathesia due to dopamine antagonism in the basal ganglia. However, these reactions are rare when used intravenously. Neuroleptic malignant syndrome is a rare adverse effect characterized by severe muscle rigidity, rhabdomyolysis, and hyperthermia. Haloperidol can also cause torsades de pointes, particularly in patients with prolonged QT interval, electrolyte abnormalities, dilated cardiomyopathy, and hepatic dysfunction.[18]

Pros	Cons
• Sedative	• Delayed onset
• Antipsychotic	• Arrhythmias
• Controls delirium	• Neuroleptic malignant syndrome
• Respiratory stability	• Extyrapyramidal reactions (rare if used intravenously)

Opioids produce analgesia via the mu and kappa receptors and some enhance sedation via the kappa receptor. Opioids act by inhibiting adenylate cyclase,

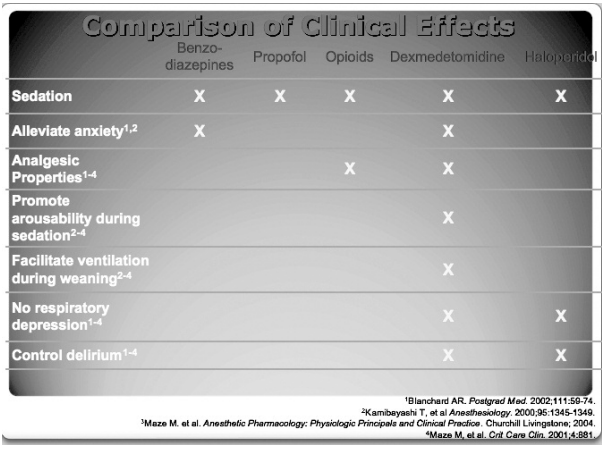
thus hyperpolarizing neurons and suppressing discharge. Opioids act synergistically with other sedatives in addition to providing effective analgesia. Morphine and fentanyl are the most frequently used opioids in the ICU. The primary role of the short/fast-acting opioids such as remifentanil, sufentanil, alfentanil is to provide or enhance analgesia.

Pros	Cons
• Analgesia	• Respiratory depression
• Adds to sedation	• Tolerance
• Antagonist available (naloxone)	• Withdrawal symptoms
	• Hypotension
	• Bradycardia
	• Constipation
	• Immunosuppression (22)
	• Chest wall rigidity

Sevoflourane Halogenated gases are powerful general anesthetics, but they also are suitable to provide dose-dependent sedation. **Sevoflurane** is an ideal gas, due to its lower solubility and its minimal cardiac depression, allowing for more stable hemodynamics. It also is a powerful bronchodilator and has a protective action on the myocardium. Compared to sedation with propofol and remifentanil, Migliari showed that sevoflourane required more time to sedate and awaken patients, caused an increase in PaCO2 and minute ventilation, and increased heart rate; however, they recommend that sevoflourane could be used effectively and safely for short-term sedation in ICU patients with stable hemodynamics.[28]

Etomidate and **ketamine** are other agents that can be used in sedation. Both drugs were compared for rapid sequence intubation in critically ill patients. The mean sequential organ failure assessment and intubation time did not differ significantly between the two drugs. However, there was a significantly higher incidence of adrenal insufficiency in patients who received etomidate compared to ketamine. It was concluded that ketamine is a safe and valuable alternative to etomidate for endotracheal intubation in critically ill patients with hemodynamic instability and also should be considered in those with sepsis.[29]

The following tables compare clinical and adverse effects of commonly used drugs for sedation in ICU.



Comparison of Clinical Effects

	Benzo-diazepines	Propofol	Opioids	Dexmedetomidine	Haloperidol
Sedation	X	X	X	X	X
Alleviate anxiety[1,2]	X			X	
Analgesic Properties[1-4]			X	X	
Promote arousability during sedation[2-4]				X	
Facilitate ventilation during weaning[2-4]				X	
No respiratory depression[1-4]				X	X
Control delirium[1-4]				X	X

[1]Blanchard AR. *Postgrad Med.* 2002;111:59-74.
[2]Kamibeyashi T, et al *Anesthesiology.* 2000;95:1345-1349.
[3]Maze M. et al. *Anesthetic Pharmacology: Physiologic Principals and Clinical Practice.* Churchill Livingstone; 2004.
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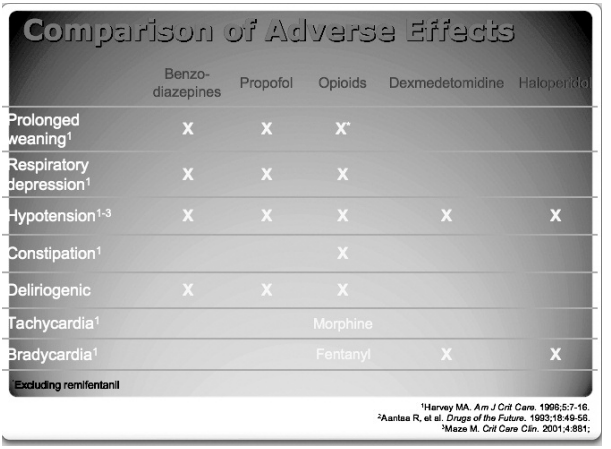

Comparison of Adverse Effects

	Benzo-diazepines	Propofol	Opioids	Dexmedetomidine	Haloperidol
Prolonged weaning[1]	X	X	X*		
Respiratory depression[1]	X	X	X		
Hypotension[1-3]	X	X	X	X	X
Constipation[1]			X		
Deliriogenic	X	X	X		
Tachycardia[1]			Morphine		
Bradycardia[1]			Fentanyl	X	X

*Excluding remifentanil

[1]Harvey MA. *Am J Crit Care.* 1998;5:7-16.
[2]Aantaa R, et al. *Drugs of the Future.* 1993;18:49-56.
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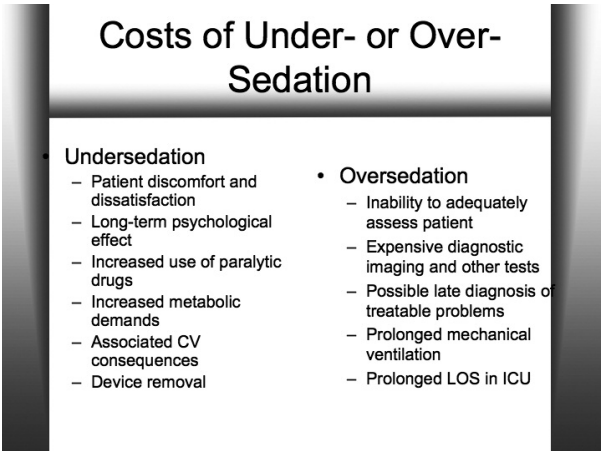
The table below lists the problems encountered with patients being either undersedated or oversedated.



Optimizing sustained use of drugs for sedation in mechanically ventilated ICU patients requires considerations of the pros and cons of the sedative agent and the duration of the sedation. Dexmedetomidine is a reasonable choice for short-term sedation (< 24 hours), as it provides sedation and analgesia without respiratory depression. For sedation for several days, propofol is an appealing agent; however, with prolonged use, hyperlipidemia and propofol infusion syndrome may become potential devastating adverse effects. When sedation is needed for more than a few days, midazolam is a good option as a continuous infusion, yet it can accumulate and prolong ICU and/or hospital length of stay. Lorazepam may also be used for prolonged sedation and can be administered as an infusion or intermittently.

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Questions

1. Which of the following is the purpose of sedation in the ICU?
    a. Diagnostic and therapeutic procedures
    b. Decrease anxiety
    c. Reduce pulmonary complications
    d. A and B
    e. A, B, and C

2. Which of the following is the most unpleasant experience reported by patients in the ICU?
    a. Paralysis
    b. Pain
    c. Nausea
    d. Intubation
    e. Anxiety

3. What of the following is NOT a consequence of oversedation or undersedation?
    a. Increased metabolic demands
    b. Patient discomfort and dissatisfaction
    c. Expensive diagnostic imaging
    d. Prolonged mechanical ventilation
    e. None of the above

4. All of the following are true regarding Bispectral index in ICU sedation, EXCEPT:
    a. BIS provides an objective assessment of sedation.
    b. It is accurate and reliable, as electromyographic activity and other factors do not confound its value.
    c. It is useful in patients who have been paralyzed with a neuromuscular blockade.
    d. BIS and Ramsay score values have a significant correlation.
    e. BIS is an EEG monitor that gives a value that can be monitored and compared.

5. What of the following is TRUE regarding sedatives available in the ICU?
    a. Dexmedetomidine provides analgesia and sedation without causing respiratory depression.
    b. Benzodiazepines induce sedation, amnesia, and analgesia via modulating GABA receptors in the central nervous system.
    c. Haloperidol is an ideal sedative to use in patients with intracranial hemorrhage.
    d. Opioids provide sedation and analgesia via the mu receptors.
    e. None of the above

6. Which of the following is NOT an adverse effect of haloperidol?
    a. Torsades de pointes
    b. Rhadomyololysis
    c. Dystonic reactions
    d. Respiratory depression
    e. None of the above

7. What are the advantages of dexmedetomidine?
    a. It provides analgesia and sedation but does not cause respiratory depression.
    b. Patients spend less time on the ventilator.
    c. The occurrence of delirium is less, compared to midazolam.
    d. Patients are arousable and oriented and do not require discontinuation of sedation prior to extubation.
    e. All of the above

8. Which of the following are true of propofol?
    a. There is an increased risk of infection with its use.
    b. Decreased blood pressure and heart rate are common side effects of propofol.
    c. It is a commonly used sedation due to its rapid onset and short duration of action.
    d. Bradycardia-acidosis is an adverse reaction that occurs with prolonged, high-dose infusions.
    e. All of the above

9. Midazolam has which of the following characteristics?
    a. Anterograde amnesia
    b. Available for use as a continuous infusion
    c. Increased risk of hypotension if used with opioids
    d. B and C
    e. A, B, and C

10. Disadvantages of benzodiazepines include all of the following, EXCEPT:
    a. Respiratory depression
    b. Hypertriglyceridemia
    c. Increased risk of infection
    d. Hypotension
    e. Lack of analgesia

Evaluation of Module 8

As part of the CSA Educational Programs Division's ongoing efforts to offer continuing medical education, the following evaluation of this program is requested. This is a useful tool for the EPD in preparing future CME programs.

1. How well were the learning objectives of this program met?

Very Well	5	Above Average	4
Average	3	Below Average	2
Not Well at All	1		

2. How relevant was the information in this program to your clinical practice?

Very Relevant	5	Above Average	4
Average	3	Below Average	2
Not Relevant	1		

3. How would you rate this program overall?

Excellent	5	Above Average	4
Average	3	Below Average	2
Poor	1		

4. Did you detect any commercial bias in this module? Yes No

Registration

Complete this form, the test, and the evaluation, and **mail or fax** all three to the CSA office at 951 Mariner's Island Boulevard #270, San Mateo, CA 94404 or FAX to 650-345-3269. The CSA CME journal courses are also available on the CSA Web Site at www.csahq.org.

Critical Care CME Course, Module 8
Available December 31, 2009, to December 31, 2012

Name _____M.D. D.O.

Address _____

City/State/Zip _____

Phone ( ) _____

E-mail _____

❑ CSA Member No Fee
❑ Non-CSA Physician $30

Total $_____

Please charge my: ❑ MasterCard ❑ Visa

Card # _____ Exp. Date _____

I authorize the California Society of Anesthesiologists to charge my account for the registration.

Signature: _____

OR

Mail with a check made payable to California Society of Anesthesiologists

❑ **I acknowledge that I have read the Important Information about Module 8.**

Critical Care CME Program

In this issue of the *Bulletin*, Module 8 of the Critical Care CME Program is available. This completes the eight modules for this program. Each module is available in the *CSA Bulletin* in this an the previous seven issues. It is posted on the CSA Web Site at www.csahq.org. Each online module uses a self-assessment and evaluation; once these are completed, you may print your CME certificate. You may also contact the CSA office at 800-345-3691 to obtain the materials by fax or mail.