Anesthetic drugs: a comprehensive overview for anesthesiologists

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Abstract

The purpose of this document is to provide a unique white paper on the use of different anesthetic drugs and the key clinical pearls for ensuring patient safety in humans. This paper is designed to be a convenient guide that can be placed in work rooms for residents and medical school trainees to improve their learning and to provide reminders about drug-drug interactions. Finally, it is designed to be a potential living document - the first of its kind within the field. Unlike other white papers, this could be added to and modified based on the current literature and amended as newer drugs are discovered and made available. This document is intended to become a ‘go-to-guide’ for clinical anesthetic drug use on humans that houses an in depth, yet condensed encyclopedia of the most pertinent, necessary information for anesthesiologists.

Keywords: Anesthesia drugs, Drug-drug interactions, Dosage, Side effects, Brand Names, Reference document

Introduction

This paper is a unique document as it is unlike other papers whose main focus is on expanding knowledge or summarizing it, whereas the purpose of this document is to provide a white paper on the use of different anesthetic drugs and the key clinical pearls for ensuring patient safety. This paper is designed as a convenient guide that can be placed in work rooms for residents and medical school trainees to improve their education. Additionally, it is designed to exist as a reference tool for anesthesiologists on the move who may need to have quick reminders about pharmacological tips and interactions to be aware of. Finally, it is designed to be a potential living document - the first of its kind within the field. Unlike other white papers, this could be added to and modified based on the current literature and amended as newer drugs are discovered and made available. Similar ideas have been proposed in other fields including neurology, but are seldom followed through on. This ‘go-to-guide’ for anesthetic drugs serves as a living document where further reviewers can be added as contributors as well as provide additional edits as the document as it continues to ‘live and breathe’ for the most pertinent information. Similar to that of a Wikipedia page, the intention of this document is to exist for the purpose of being modified and added to over time.

The rationale behind the need for this type of paper is the increasing difficulty in finding this information in one centralized location. Often times, the newest and most pertinent clinical information is restricted behind pay walls as a way to force the purchase a subscription to individual journals to gain access to the information. Additionally, this information may also be buried under small randomized control trials or lost in the never-ending list of novel studies that show minor benefits. The hope of the authorial team is to create a centralized document that gets updated and edited as necessary with the potential for growth and modification based on the information as it becomes available. This first, improves patient safety; second, ease in teaching and educating on the topic of the different and numerous anesthetic drugs is increased; and third, providers feel more comfortable with utilizing a more diverse array of medications to treat the specific individualized needs of the patients.

Opioid/Narcotic Anesthetics (3)

Fentanyl [1-5] (fentanyl systemic) – an opioid pain medication used to treat acute, severe, or
chronic pain through the selective binding and activation of mu-receptors that encourages the exchange of GTP and GDP that will then inhibits adenylate cyclase that leads to the mimicking of other opiates.

**Usage:** Fentanyl is an incredibly versatile anesthetic drug that is used preoperatively, during surgery, and in immediate postoperative periods. In general, fentanyl is used for treating acute pain, used in treating malignant cancer patients, and in patients with chronic pain conditions.

**Dosage:** The FDA has approved many programs to assist physicians for fentanyl preparations, called REMS programs.

- The typical preoperative dosage should be 50-100 mcg/dose IM or slow IV over 30-60 minutes prior to surgery where adjunct to regional anesthesia should be 25-100 mcg/dose slow IV over 1-2 minutes.
- For minor surgical procedures, a dosage of 0.5-2 mcg/kg/dose IV should be used, whereas for a major surgery, the proper dosage should be 2-20 mcg/kg/dose initially with maintenance 1-2 mcg/kg/hr IV.
- Infusion should be discontinued 30-60 minutes prior to the end of surgery and adjunct to general anesthesia, although rare, should be 20-50 mcg/kg/dose IV.
- The total doses should not exceed 10-15 mcg/kg for fast tracking and early extubation.
- In children greater than 12-years-old, 0.5-1.0 mcg/kg/dose IV should be given every 1-2 hours as needed.
- In children 1-12-years-old, a dose of 1-4 mcg/kg/dose IV should be given every 4-8 hours as needed.

**Major interactions:** Common interactants may include, but are not limited to any drugs that cause sleepiness or slow breathing such as opioids, sleeping pills, muscle relaxers, or medication for anxiety or seizures.

**Side effects:** Some of the most common side effects associated with alfentanil systemic include: blurred vision, confusion, chest pain or discomfort, dizziness, faintness, or lightheadedness, headaches, nervousness, sweating, or unusual tiredness or weakness.

**Name Brands (6):** Duragesic, Fentanyl Transdermal System, Sublimaze, Ionsys, Lazanda, and Fentora

**Remifentanil [6-17] (remifentanil systemic) –** an opioid medication that is used to treat and/or prevent pain during and after surgery or other medical procedures. This drug acts as a mu-opioid receptor agonist, as well as an opioid analgesic.

**Usage:** Remifentanil is most widely used in patients that require or have recently undergone a surgery or another medical procedure.

**Dosage:**

- If given through intubation, the induction of anesthesia should be 0.5-1 mcg/kg/minute by continuous IV infusion.
- An initial dose of 1 mcg/kg over 30-60 seconds may be administered as well. With nitrous oxide at 66%, the maintenance of anesthesia should be a continuous IV infusion at 0.4 mcg/kg/min.
- During post-op, continuous IV infusion should be used at 0.1 mcg/kg/min with every 5 minutes being adjusted in 0.025 mcg/kg/min increments, where the maximum rate is 0.2 mcg/kg/min.
- For a child 1-12 years of age, the initial dose should be 1 mcg/kg IV over 30-60 seconds, where maintenance dosing should be 1 mcg/kg every 2-5 minutes.

**Major interactions:** Common interactants may include, but are not limited to any drugs that cause sleepiness or slow breathing such as opioids, sleeping pills, muscle relaxers, or medication for anxiety or seizures.

**Side effects:** Some of the most common side effects associated with alfentanil systemic include: quick respiratory depression, quick onset of bradycardia, blurred vision, confusion, chest pain or discomfort, dizziness, faintness, or lightheadedness, headaches, nervousness, sweating, or unusual tiredness or weakness.

**Name Brand (1):** Ultiva

**Hydromorphone [18-24] (hydromorphone systemic) –** an oral opioid medication that is seven times more potent than morphine used to treat moderate to severe pain. Treatment of pain is achieved through the binding of the mu-opioid receptor, stimulating the exchange of GTP to GDP, inhibiting cAMP, and hyperpolarizing voltage-gated potassium pumps that will reduce neuronal excitability.

**Usage:** Short-acting formulations of hydromorphone are used to treat moderate to severe pain whereas extended-release hydromorphone is used as an around-the-clock treatment for pain management.

**Dosage:**

- Oral solution should be used at 2.5-10 ml every 3-6 hours as needed for pain.
- If using tablet form, 2-4 mg should be taken orally every 4-6 hours.
- In pediatric patients, the typical dosing is 0.03-0.08 mg/kg/dose orally every 4-6 hours or 0.01 mg/kg/dose IV every 4-6 hours.

**Major interactions:** Common interactants may include, but are not limited to any drugs that cause sleepiness or slow breathing such as opioids, sleeping pills, muscle relaxers, or medication for anxiety or seizures.

**Side effects:** Some of the most common side effects associated with alfentanil systemic include: blurred vision, confusion, chest pain or discomfort, dizziness, faintness, or lightheadedness, respiratory depression, headaches, nervousness, sweating, or unusual tiredness or weakness.

**Name Brands (4):** Dilaudid, Dilaudid-5, Exalgo, and Palladone

**Inhaled Anesthetic Agents (3)**

**Desflurane [25-32] (desflurane systemic) –** a common general anesthetic that comes in many forms for use in surgery. This drug is administered through inhalation, and the mechanism of action is believed to be on the GABA receptor, thus acting on the lipid matrix of the neuronal membrane that leads to the disruption of neuronal transmission to the brain.
**Usage:** Desflurane can be used by inhalation to cause loss of consciousness both before and after surgery in adults. Desflurane is also used as a maintenance anesthetic after receiving other anesthetic agents during surgery in both children and adults.

**Dosage:**
- Although the below values are considered the normal accepted minimum alveolar concentrations (MAC), each should be adjusted as needed based on the patient's age, comorbidities, additional medications, and substance use history.
- For inhalation in adult patients, the minimum alveolar concentration, or MAC, for which 50% of patients do not respond to surgical incision ranges from 7.3%, for 25-year-olds, to 6%, for 45-year-olds. The concentration at which loss of awareness and amnesia occur is 2.4%, and surgical levels of anesthesia are achieved with consciousness between 2.5-8.5% with or without nitrous oxide.
- For geriatric patients, the typical MAC is reduced to 5.2% for 70-year-olds, where amnesia and loss of awareness occurs at 2.4%, and surgical levels are achieved at 2.5-8.5% with or without nitrous oxide.
- In pediatric patients, the MAC should be highly individualized, however, the surgical levels of anesthesia will increase to 5.2-10% with or without nitrous oxide.

**Major Interactions:**
- Droperidol can increase the risk of an irregular heart rhythm that may be serious or potentially life-threatening, although rare, when used with desflurane. Individuals with congenital long QT syndrome or other cardiac diseases, conduction abnormalities, or electrolyte disturbances may be more susceptible.
- Epinephrine or norepinephrine, when taken concurrently, with isoflurane can affect the heart's rhythm and may cause blurred vision, nausea, or seizures. Additionally, however, these can be used to correct life-threatening hypotension or cardiac failure.
- Isocarboxazid, phenelzine, selegiline, or tranylcypromine may significantly affect blood pressure when taken with isoflurane and should be avoided for 24 hours after receiving inhaled anesthetics.
- Sodium oxybate may increase side effects such as dizziness, lightheadedness, drowsiness, confusion, low blood pressure, shallow breathing, depression, or impairment in thinking, judgement, and/or motor coordination. Severe reactions may occur in rarer cases that include coma or death and should be avoided for 24 hours after receiving inhaled anesthetics.

**Side effects:** Side effects that may occur include, but are not limited to bluish lips or skin, congestion, cough, dryness or soreness of the throat, hoarseness, respiratory depression, runny nose, tightness in the chest, difficulty swallowing, or voice changes.

**Name Brand (1):** Suprane

**Isoflurane** [32-37] (isoflurane systemic) – a general liquid, inhalation anesthesia administered by vaporizing, and while the mechanism of action is not fully established, it is believed to act on the lipid matrix of the neuronal membrane that leads to the disruption of neuronal transmission to the brain.

**Usage:** Isoflurane is used for the induction and maintenance of general anesthesia.

**Dosage:**
- Although the below values are considered the normal accepted minimum alveolar concentrations (MAC), each should be adjusted as needed based on the patient's age, comorbidities, additional medications, and substance use history.
- The typical dose for an adult or pediatric patient should be inspired concentrations of 1.5-3.0% to produce surgical anesthesia within 7-10 minutes. To sustain surgical anesthesia, a concentration of 1.0-2.5% should be used with nitrous oxide, whereas 0.5-1.0% may be required when using oxygen alone.

**Major interactions:**
- Droperidol can increase the risk of an irregular heart rhythm that may be serious or potentially life-threatening, although rare, when used with isoflurane. Individuals with congenital long QT syndrome or other cardiac diseases, conduction abnormalities, or electrolyte disturbances may be more susceptible.
- Epinephrine or norepinephrine, when taking, with isoflurane can affect the heart's rhythm and may cause blurred vision, nausea, or seizures. Additionally, however, these can be used to correct life-threatening hypotension or cardiac failure.
- Isocarboxazid, phenelzine, selegiline, or tranylcypromine may significantly affect blood pressure when taken with isoflurane and should be avoided for 24 hours after receiving inhaled anesthetics.
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**Side effects:** Some side effects that may occur include, but are not limited to signs of high potassium levels such as irregular heartbeat, confusion, lightheadedness, feeling faint, shortness of breath, or numbness, respiratory depression, muscle stiffness, bluish skin, lips, nail beds, fingers, or toes. Isoflurane may also cause malignant hyperthermia, which may onset with tachycardia, fast breathing, fever, or spasms and/or stiffness in the jaw.

**Name Brands (2):** Forane and Terrell

**Sevoflurane** [32,38-48] (sevoflurane systemic) – an inhaled general anesthetic used to cause loss of consciousness postoperatively and during surgery or any other medical procedure. The hypothesized action of this drug is believed to act through the interference of neurotransmitters at the post-synaptic cleft that prevents the release and reuptake of these neurotransmitters.

**Usage:** Sevoflurane is given to patients before and during surgeries or other medical procedures to cause loss of consciousness and loss of awareness.
Dosage:
- Although the below values are considered the normal accepted minimum alveolar concentrations (MAC), each should be adjusted as needed based on the patient’s age, comorbidities, additional medications, and substance use history.
- The average MAC for surgical anesthesia with oxygen is 2.6% in a 25-year-old, 2.1% in a 40-year-old, and 1.7% in a 60-year-old.
- The average MAC for surgical anesthesia with 65% nitrous oxide is 1.4% in a 25-year-old, 1.1% in a 40-year-old, and 0.9% in a 60-year-old.
- For geriatric patients, the average MAC for surgical anesthesia is 1.4% and 0.7% in an 80-year-old with oxygen and 65% nitrous oxide, respectively.
- In pediatric patients, the average MAC for surgical anesthesia in oxygen is 3.3% in a 0-1-month-old, 3% in a 1-6-month-old, 2.8% in a 6-month-3-year-old, and 2.5% in a 3-12-year-old.
- The average pediatric MAC for surgical anesthesia with 60% nitrous oxide is 2% in a 6-month-3-year-old.

Major interactions: Medication such as sevoflurane could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 63 major interactions and 217 moderate interactions should be reviewed fully before prescribing. Epinephrine and norepinephrine can be used to correct life-threatening hypotension or cardiac failure. CNS depressants should be avoided for 24 hours after receiving inhaled anesthetics.

Side effects: Common side effects of sevoflurane may include, but are not limited to coughing, nausea, chills, dizziness, increased saliva, drowsiness, headaches, or vomiting.

Name Brands (2): Sojourn and Ultane

Intravenous (IV) Anesthetic Agents (4)

Etomidate [32,49-52] (etomidate systemic) – a sedative and hypnotic agent that is used for general anesthesia by enhancing the inhibitory effect of GABA on the CNS, through the opening of chloride channels and hyperpolarizing the membrane.

Usage: Etomidate is used for its dose-related hypnotic effects that progress from light sleep to unconsciousness. This anesthetic is useful in patients with compromised cardiopulmonary function due to the minimal hemodynamic effects and decreased respiratory depressant effects relative to other IV anesthetics such as barbiturates and propofol.

Dosage:
- For both typical adult and pediatric patients, the introduction of anesthesia by IV should be 0.2-0.6mg/kg with an average of 0.3mg/kg from a 0.2% solution. For maintenance of etomidate by IV, smaller increments than the original dose should be used; typically doses of 0.05-0.1mg/kg are used as needed with an average total dosage of up to 0.26mg/kg.
- For geriatric patients, the dosage should be lower than younger patients due to their pharmacokinetic differences.

Major interactions:
- Isocarboxazid, phenelzine, selegiline, or tranylcypromine may significantly affect blood pressure if used alongside etomidate.
- Sodium oxybate may increase side effects such as dizziness, lightheadedness, drowsiness, confusion, low blood pressure, shallow breathing, depression, or impairment in thinking, judgement, and/or motor coordination. Severe reactions may occur in rarer cases that include coma or death.

Side effects: Common side effects of etomidate include, but are not limited to postoperative nausea or vomiting, pain at injection site, and skeletal muscle movements. Some rare problems that may occur with etomidate use include adrenocortical suppression – dose dependent inhibition of the enzyme 11-B-Hydroxylase that converts cholesterol to cortisol – for 4-8 hours and lowers post-operative cortisol levels in healthy patients. No outcome differences have been noted for major procedures.

Name Brand (1): Amidate

Ketamine [32,53-61] (ketamine systemic) – an injectable anesthetic solution used in surgeries and to prevent pain. While the mechanism of action of ketamine requires further investigation, it appears to inhibit biogenic amine uptake, binding to opioid receptors, and inhibition of NMDA receptors.

Usage: Ketamine is used preoperatively and during surgeries as well as being widely used to prevent pain and discomfort during certain medical procedures.

Dosage:
- In adults, induction should be 1.0-4.5mg/kg IV with an average of 1.5mg/kg or 1.0-2.0mg/kg IV at a rate of 0.5mg/kg/min.
- If by IM, induction should be 6.5-13.0mg/kg, where 9-13mg/kg is used; typically doses of 0.05-0.1mg/kg are used as needed with an average total dosage of up to 0.26mg/kg.

Common side effects of etomidate include, but are not limited to coughing, nausea, chills, dizziness, increased saliva, drowsiness, headaches, or vomiting.

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Dosage:
- For both typical adult and pediatric patients, the introduction of anesthesia by IV should be 0.2-0.6mg/kg with an average of 0.3mg/kg from a 0.2% solution. For maintenance of etomidate by IV, smaller increments than the original dose should be used; typically doses of 0.05-0.1mg/kg are used as needed with an average total dosage of up to 0.26mg/kg.
- For geriatric patients, the dosage should be lower than younger patients due to their pharmacokinetic differences.

Major interactions:
- Isocarboxazid, phenelzine, selegiline, or tranylcypromine may significantly affect blood pressure if used alongside etomidate.
- Sodium oxybate may increase side effects such as dizziness, lightheadedness, drowsiness, confusion, low blood pressure, shallow breathing, depression, or impairment in thinking, judgement, and/or motor coordination. Severe reactions may occur in rarer cases that include coma or death.

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Usage: Ketamine is used preoperatively and during surgeries as well as being widely used to prevent pain and discomfort during certain medical procedures.

Dosage:
- In adults, induction should be 1.0-4.5mg/kg IV with an average of 1.5mg/kg or 1.0-2.0mg/kg IV at a rate of 0.5mg/kg/min.
- If by IM, induction should be 6.5-13.0mg/kg, where 9-13mg/kg IM provides 12-25 minutes of surgical anesthesia. For maintenance, dosage should be adjusted according to the patient’s anesthetic needs.

Major interactions: Medication such as ketamine could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 197 major interactions and 173 moderate interactions should be reviewed fully before prescribing. More common interactants may include, but are not limited to any drugs that cause sleepiness or slow breathing such as opioids, sleeping pills, muscle relaxers, or medication for anxiety or seizures.

Side effects: As there are many side effects that could potentially occur from ketamine, some may include confusion, hallucinations, unusual thoughts, extreme fear, painful or increased urination, incontinence, blood in urine, lightheadedness, bradycardia, shallow breathing, lucidity, blurred or double vision, nausea, loss of appetite, insomnia, or vomiting. For patients that hallucinate with ketamine, benzodiazepines, vitamin V, or barbiturates/propofol can all be used. However, if using barbiturates or propofol, it is important to note that ketamine is sometimes used for patients that cannot tolerate barbiturates or propofol.

Name Brand (1): Ketalar

Induction for a typical adult should be 1.0-1.5mg/kg of a 1% solution IV at a rate of 1ml/5 seconds, which usually lasts 5-7 minutes. If needed, intermittent IV injections of 20-40mg of the 1% solution every 4-7 minutes or administration of 3ml of 0.2% solution IV every minute may be used.

For pediatric patients one month or older, induction should be IM 6.6-10mg/kg with a 5% solution or rectal 25mg/kg using a 1% solution.

**Major interactions:**
- Methohexital can reduce the blood levels of anisindione, dicumarol, or warfarin, which may make the medication less effective in preventing blood clots.
- Ethanol, when mixed with this anesthetic, can add to certain side effects such as dizziness or drowsiness.
- Hemin is known to potentially become less effective when mixed with methohexital.
- Isocarboxazid, phenelzine, selegiline, or tranylcypromine may significantly affect blood pressure when taken with isoflurane.
- Sodium oxybate may increase side effects such as dizziness, lightheadedness, drowsiness, confusion, low blood pressure, shallow breathing, depression, or impairment in thinking, judgement, and/or motor coordination. Severe reactions may occur in rarer cases that include coma or death.

**Side effects:** Some side effects of methohexital may include, but are not limited to severe burning or welting at injection site, airway irritability, tachycardia, numbness, lightheadedness, shallow breathing, confusion or anxiety, drowsiness, chills, nausea, coughing, hiccups, muscle twitching, skin rashes, or vomiting. Myoclonus, hiccoughs, and seizures can occur at low doses, although in high doses, methohexital is used to treat seizures.

**Name Brand (1):** Brevital Sodium

**Propofol** [32,68-79] (propofol systemic) – an anesthetic drug used to slow the activity of the brain and nervous system by decreasing the rate of dissociation of the GABA from the receptor, resulting in hyperpolarization of cell membranes.

**Usage:** Propofol is used preoperatively to place patients into a mechanical ventilator.

**Dosage:**
- The induction dosage for a typical adult less than 55-years-old should be 2-2.5mg/kg IV, titrated at roughly 40mg/10 seconds until onset of induction.

**For cardiac anesthesia or neurosurgical patients, 20mg/10 seconds should be used. For maintenance of a typical adult less than 55-years-old, 100-200mcg/kg/min IV with 60-70% nitrous oxide should be used.**

**The induction for a pediatric patient between the ages of 3-16 should be 2.5-3.5mg/kg over 20-30 seconds. To maintain, 200-300mcg/kg/min should immediately follow the induction dose, where the first 30 minutes of maintenance should have an infusion rate of 125-150mcg/kg/min.**

**Major interactions:**
- Isocarboxazid, phenelzine, selegiline, or tranylcypromine may significantly affect blood pressure when taken with isoflurane.
- Sodium oxybate may increase side effects such as dizziness, lightheadedness, drowsiness, confusion, low blood pressure, shallow breathing, depression, or impairment in thinking, judgement, and/or motor coordination. Severe reactions may occur in rarer cases that include coma or death.
- Oliceridine or remimazolam, when used with any other medications that cause central nervous system depression, can lead to respiratory distress, coma, or death.
- Ozanimod or papaverine can increase the risk of an irregular heart rhythm that may be serious or potentially life-threatening, although rare, when used with isoflurane. Individuals with congenital long QT syndrome or other cardiac diseases, conduction abnormalities, or electrolyte disturbances may be more susceptible.

**Side effects:** Common propofol side effects may include, but are not limited to lightheadedness, shallow breathing, severe pain, burning, or stinging at the injection site, tachycardia, bradycardia, or a mild rash. Long-term use of propofol could potentially lead to propofol infusion syndrome, which can result in death. Some rare problems with propofol in critically ill adults with head injuries receiving long-term, high dose infusions include lipidemia, fatty infiltrates of the liver, enlarged liver, metabolic acidosis, rhabdomyolysis, or myoglobinuria.

**Name Brands (2):** Diprivan and Propoven

**Neuromuscular Blocking Agent (Regional Anesthetics (4))**

**Cisatracurium** [80-92] (cisatracurium systemic) – an anesthetic used to relax muscles by blocking cholinergic receptors leading to the blockage of neuromuscular transmission.

**Usage:** Cisatracurium is typically given before general anesthesia in preparing a patient for surgery as to keep them still during the procedure. This anesthetic also relaxes the throat for the breathing tube to be placed easier before the surgery begins. Cisatracurium should only be used by trained providers and should only be used on patients with a secured airway.

**Dosage:**
- For adults and children older than 12-years-old, induction dose should be 0.15-0.2 mg/kg IV with additional maintenance dosage of 0.03 mg/kg to be used after 40-65 minutes.
- Continuous infusion should be 1-3 mcg/kg/min. In pediatric patients one month or older, induction should be IM 6.6-10mg/kg with a 5% solution or rectal 25mg/kg using a 1% solution.
patients 2-12-years-old, induction dose should be 0.1-0.15 mg/kg IV with continuous infusion of 1-3 mcg/kg/min.

- In pediatric patients 1-23-months-old, induction dose should be 0.15 mg/kg.

**Major interactions:** More common interactants may include, but are not limited to lithium, antibiotics, or seizure medications. Medication such as cisatracurium could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 17 major interactions and 127 moderate interactions should be reviewed fully before prescribing.

**Side effects:** Common side effects of cisatracurium may include, but are not limited to paralysis, respiratory arrest, bradycardia, dizziness, redness, warmth, or tingling sensations.

**Name Brand (1):** Nimbex

**Rocuronium** [32,93-107] (rocuronium systemic) – an anesthetic used to relax muscles by blocking the signals through the action as an aminosteroid non-depolarizing neuromuscular blocker.

**Usage:** Rocuronium is typically given before general anesthesia in preparing a patient for surgery as to keep them still during the procedure. This anesthetic also relaxes the throat for the breathing tube to be placed easier before the surgery begins. Rocuronium should only be used by trained providers and should only be used on patients with a secured airway.

**Dosage:**

- For an adult patient, the initial dosage prior to intubation should be 0.6mg/kg IV with maintenance doses of 0.1, 0.15, and 0.2mg/kg.
- Continuous infusion should be at a rate of 10-12mcg/kg/min. For a pediatric patient, the initial dosage prior to intubation should be 0.45-0.6mg/kg IV.

**Major Interactions:** More common interactants may include, but are not limited to lithium, quinidine, procainamide, antibiotics, or seizure medications. Medication such as cisatracurium could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 17 major interactions and 128 moderate interactions should be reviewed fully before prescribing.

**Side effects:** Common side effects of rocuronium may include, but are not limited to paralysis, respiratory arrest, bradycardia, hypertension, hypotension, flushing, rash, excessive salivation, or increased intragastric pressure. Succinylcholine's increase in potassium levels of patients can lead to arrhythmias and/or cardiac arrest.

**Name Brands (2):** Anectine and Quelicin

**Vecuronium** [119-126] (vecuronium systemic) – an anesthetic which relaxes muscles by competitively binding to the nicotinic acetylcholine receptor at the neuromuscular junction, preventing acetylcholine to bind and resulting in muscle relaxation.

**Usage:** Vecuronium is used for skeletal muscle relaxation for short durations during medical procedures after general anesthesia has been induced. Additionally, it is used for the facilitation of intubation to relax the muscles in the throat. Vecuronium should only be used by trained providers and should only be used on patients with a secured airway.

**Dosage:**

- For adult patients, the initial dose should be 0.08-0.1mg/kg IV, where the maintenance dose during prolonged surgical procedures should be 0.01-0.015mg/kg for 25-40 minutes after and as frequent as every 12-15 minutes.
- For continuous infusion in an adult patient, an intubating dose should be 80-100mcg/kg followed by 20-40 minutes later with 1mcg/kg/min.

**Major interactions:** Medication such as vecuronium could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 17 major interactions and 145 moderate interactions should be reviewed fully before prescribing.

**Side effects:** More common side effects of vecuronium may include, but are not limited to paralysis, respiratory arrest, muscle weakness, loss of bodily movements, or shallow breathing.
For light sedation in a typical adult under 60 years, 0.07-
If administering midazolam by IV, the recommended dose for
For sedation in a typical adult patient, the initial dose should
Major Interactants
For light anesthesia in a premedicated typical adult patient,
If administering midazolam intranasally, the recommended
Adult Dosing
In pediatric patients, the recommended oral dose should be
Minor surgeries, dental work, or other specific medical procedures.
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Summary

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<td>MAC for 25-45-year-olds ranges</td>
<td>• Droperidol</td>
<td>• Dizziness</td>
</tr>
<tr>
<td>Systemic</td>
<td>from 7.3-6%, respectively. Loss of</td>
<td>• Epinephrine or norepinephrine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>awareness and amnesia is 2.4%.</td>
<td>• Isoxcarboxazid, phenelzine,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surgical levels are achieved at 2.5-</td>
<td>• selegline, or tranylcypromine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.5% with or without nitrous oxide.</td>
<td>• Sodium oxybate</td>
<td></td>
</tr>
<tr>
<td>Etomidate</td>
<td>Induction, 0.3mg/kg from a 0.2%</td>
<td>• Isocarboxazid, phenelzine,</td>
<td>• Blush lips or skin</td>
</tr>
<tr>
<td>Systemic</td>
<td>solution. Maintenance by IV, average</td>
<td>• selegline, or tranylcypromine</td>
<td>• Respiratory depression</td>
</tr>
<tr>
<td></td>
<td>doses of 0.26mg/kg used.</td>
<td>• Sodium oxybate</td>
<td>• Difficulty swallowing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Tightness of the chest</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>0.5-2mcg/kg/dose IV should be used.</td>
<td>Any drugs that cause sleepiness or slow</td>
<td>Respiratory depression</td>
</tr>
<tr>
<td>Systemic</td>
<td>Major surgeries, 2-20mcg/kg/dose.</td>
<td>breathing</td>
<td>Blurred vision</td>
</tr>
<tr>
<td></td>
<td>Maintenance is 1-2mcg/kg/hr IV.</td>
<td></td>
<td>Chest pain</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unusual tiredness or weakness</td>
</tr>
<tr>
<td>Hydromorphone</td>
<td>Oral solution, 2.5-10ml every 3-6</td>
<td>Any drugs that cause sleepiness or slow</td>
<td>Respiratory depression</td>
</tr>
<tr>
<td>Systemic</td>
<td>hours as needed.</td>
<td>breathing</td>
<td>Blurred vision</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chest pain</td>
</tr>
<tr>
<td>Isoflurane</td>
<td>1.5-3.0% for surgical anesthesia</td>
<td>Any drugs that cause sleepiness or slow</td>
<td>Signs of high potassium levels</td>
</tr>
<tr>
<td>Systemic</td>
<td>within 7-10 mins. Maintenance, 1.0-</td>
<td>breathing</td>
<td>• Malignant hyperthermia</td>
</tr>
<tr>
<td></td>
<td>2.5% with nitrous oxide. When using</td>
<td></td>
<td>• Tachycardia</td>
</tr>
<tr>
<td></td>
<td>oxygen alone, 0.5-1.0%.</td>
<td></td>
<td>• Shortness of breath</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Respiratory depression</td>
</tr>
</tbody>
</table>

Name Brands (2): Vecuronium Bromide and Norcuron

Benzodiazepine Anesthetics (1)

Midazolam [32,127-132] (midazolam systemic) – an oral
anesthetic medication used for sedation that is five times more
potent than diazepam. This drug achieves these characteristics by
binding to the GABA receptor-chloride ionophore complex in the
CNS, opening chloride channels, and increases the inhibitory effect
of GABA on the CNS.

Usage: Midazolam is used to sedate patients who are having
minor surgeries, dental work, or other specific medical procedures.

Side effects:
• In pediatric patients, the recommended oral dose should be
0.25-0.5mg/kg/dose as needed with a maximum dose of 20mg.
• If administering midazolam by IV, the recommended dose for
a pediatric patient should be 0.025-0.1mg/kg/dose as needed
with a maximum dose of 2mg.
• If administering midazolam intranasally, the recommended
pediatric dose is 0.2-0.3mg/kg/dose as needed with a maximum
dose of 10mg.

Major interactions: Medication such as midazolam could
potentially interact with many other drugs and cause dangerous side
effects, or even death. A total list consisting of 34 major interactions
and 391 moderate interactions should be reviewed fully before
prescribing. More common interactants may include, but are not
limited to any drugs that cause sleepiness or slow breathing such as
opioids, sleeping pills, muscle relaxers, or medication for anxiety or
seizures.

Side effects: Some side effects of midazolam may include, but
are not limited to depressed airway reflexes and decreased ability to
swallow (especially at higher doses), blurred vision, dizziness, irregular
heartbeat, nausea, sweating, body aches, chills, fever, congestion,
sore throat, insomnia, disorientation, pale or blue lips, fingernails,
or skin, mood changes, shakiness, or vomiting. Midazolam can
potentially cause apnea in any patient regardless of dose.

Name Brands (3): Nayzilam, Seizalam, and Versed.
<table>
<thead>
<tr>
<th>Anesthetic Drug Systemic</th>
<th>Administration</th>
<th>Adverse Effects</th>
<th>Interactants to Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketamine Systemic</td>
<td>Induction average of 1.5mg/kg or 1.0-2.0mg/kg IV at a rate of 0.5mg/kg/min.</td>
<td>Blood in urine, Painful urination, Insomnia, Nausea/vomiting, Incontinence, Bradycardia, Extreme fear</td>
<td>Total list of 197 interactants should be reviewed, Any drugs that cause sleepiness or slow breathing</td>
</tr>
<tr>
<td>Methohexital Systemic</td>
<td>Induction, 1.0-1.5mg/kg of a 1% solution IV at a rate of 1ml/5 seconds. Maintenance, 20-40mg every 4-7 mins.</td>
<td>Tachycardia, Shallow breathing, Anxiety, Nausea/vomiting, Chills, Lightheadedness, Muscle twitching, Hiccups</td>
<td>Anisindione, dicumarol, or warfarin, Ethanol, Hemin, Isoxcarbazid, phenelzine, selegiline, or tranylcypromine, Sodium oxybate</td>
</tr>
<tr>
<td>Midazolam Systemic</td>
<td>Induction, 0.01-0.05mg/kg IV over several minutes and repeated every 10-15 mins. Maintenance, 0.1-0.2mg/kg IV per hour.</td>
<td>Decreased ability to swallow, Insomnia, Nausea/vomiting, Pale/blue lips, skin, or fingernails, Irregular heartbeat, Shakiness</td>
<td>Total list of 34 major interactants should be reviewed, Any drugs that cause sleepiness or slow breathing</td>
</tr>
<tr>
<td>Propofol Systemic</td>
<td>Induction, 2-2.5mg/kg IV, titrated at roughly 40mg/10 seconds.</td>
<td>Respiratory depression, Blurred vision, Chest pain, Unusual tiredness or weakness</td>
<td>Isocarbazid, phenelzine, selegiline, or tranylcypromine, Sodium oxybate, Oliceridine or remimazolam, Ozanimod or papaverine</td>
</tr>
<tr>
<td>Remifentanil Systemic</td>
<td>Induction, 0.5-1mcg/kg/minute by continuous IV. With nitrous oxide at 66%, maintenance should be continuous IV at 0.4mcg/kg/min.</td>
<td>Paralysis, Respiratory arrest, Hypertension, Anxiety, Blurred vision</td>
<td>Any drugs that cause sleepiness or slow breathing</td>
</tr>
<tr>
<td>Rocuronium Systemic</td>
<td>Induction, 0.6mg/kg IV. Maintenance, 0.1, 0.15, and 0.2mg/kg.</td>
<td>Headaches, Nausea/vomiting, Drowsiness, Increased saliva, Chills, Coughing</td>
<td>Lithium, Quinidine, Procainamide, Antibiotics, Seizure medications, Paralysis medications</td>
</tr>
<tr>
<td>Sevoflurane Systemic</td>
<td>MAC for surgical anesthesia with oxygen is 2.6%, 2.1%, and 1.7% for 25/40/60-year-olds, respectively. MAC for surgical anesthesia with nitrous oxide is 1.4%, 1.1%, and 0.9% for 25/40/60-year-olds, respectively.</td>
<td>Paralysis, Respiratory arrest, Hypertension, Anxiety, Blurred vision, Hyperkalemia</td>
<td>Total list of 63 major interactants should be reviewed, Any drugs that cause sleepiness or slow breathing</td>
</tr>
<tr>
<td>Succinylcholine Systemic</td>
<td>Short surgical procedures, 0.3-1.1mg/kg IV. Long surgical procedures, 2.5-4.3mg/min IV.</td>
<td>Paralysis, Respiratory arrest, Hypertension, Hypotension</td>
<td>Oxytocin, Lithium, MAO inhibitors, Corticosteroids, Procaine</td>
</tr>
<tr>
<td>Vecuronium Systemic</td>
<td>Induction, 0.08-0.1mg/kg IV. Maintenance during prolonged surgical procedures, 0.01-0.015mg/kg for 25-40 mins after and every 12-15 minutes.</td>
<td>Paralysis, Respiratory arrest, Muscle weakness, Loss of bodily movements, Shallow breathing</td>
<td>Total list of 17 major interactants should be reviewed, Any drugs that cause sleepiness or slow breathing</td>
</tr>
</tbody>
</table>

Conclusion

The purpose of this paper is to provide a clear and easy means to navigate a document on the use of different anesthetic drugs and the key clinical pearls for ensuring patient safety. Through gathering this key information into a singular document, this paper can be utilized as a convenient guide in work rooms for residents and medical school trainees. This paper is designed around the idea that the practice of medicine and the understanding of how to utilize the currently available medications should be easy to access, therefore, it is simply a summary of what is known at the time of writing. With this in mind, the paper was designed to be a potential living document - which could be added to and modified based on the current literature and amended as newer drugs are discovered and available. This would allow for further reviewers and/or authors to be added as contributors in the future as more is learned about the utilization of these drugs.

Disclosures

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Cheney E. Merhavy – Conception, documentation, & critical revision.

Thomas C. Varkey – Conception, documentation, & critical revision.

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