

Anesthetic drugs: a comprehensive overview for pediatrics

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Keypoints

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 in pediatric anesthesia.

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 pediatric healthcare professionals.

Keywords

Anesthesia Drugs, Drug-Drug Interactions, Pediatrics, Dosage, SideEffects, 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 pediatric healthcare professionals 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 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.

TOPICAL ANESTHETICS (3)

- **Benzocaine** [1][2][3][95] (benzocaine topical) - a local anesthetic that works by binding to sodium channels which decreases permeability of sodium ions, stabilizing the neuronal membrane, blocking initiation, and conduction of nerve impulses in the body.
- Usage: The benzocaine cream or spray numbs the skin or surfaces within the mouth and gums and is used for temporary pain relief, often caused by dentures and/or orthodontic appliances or injury. The cream should not be used on infants or any person under 2 years of age.
- Dosage: The correct dosage is often considered the smallest amount needed to numb the area and/or to relieve pain.
- Major Interactions:

- Usage with other sodium channel blockers increases the risk of methemoglobinemia.
- Nitrite usage may increase an individual’s risk of methemoglobinemia.
- Side Effects:
- Methemoglobinemia, common signs and symptoms of methemoglobinemia, which may occur within minutes to 2 hours after oral use, may include headaches, tiredness, confusion, tachycardia, light-headedness, shortness of breath, and pale, blue, or grey appearance of the skin, lips, and/or fingernails.
- Other common side effects include mild stinging, burning, or itching at the site of application, skin redness and/or tenderness, or dry, white flakes at the site of application.
- Name Brands (9): Benzodent, Omedia, Oticaine, Americaine Otic, Otocain, Dermoplast, Orajel, Anbesol, and Cepacol Ultra
- **Lidocaine / Prilocaine** [4][5][6][96] (lidocaine / prilocaine topical) – a combination medicine of local anesthetics that works by binding to voltage-gated sodium channels, inhibiting ionic fluxes that trigger nerve signals in the body.
- Usage: This topical medication is used to numb the skin and/or surfaces of the penis or vagina in preparation for surgery in those regions.
- Dosage: By using the smallest amount needed for numbing, it should be used exactly as it is described on the prescription label up to 4 hours before a surgery or procedure. Dosing instructions on the prescription label will differ for children as lidocaine / prilocaine topical doses are based on weight in children.
- Major Interactions:
- Acetaminophen and Aminosalicic acid, other sodium channel blockers, nitrates, antiepileptic drugs, and sulfa drugs may all increase the risk of methemoglobinemia when used concurrently.

- This anesthetic is not recommended for teething infants and young children as it could be potentially hazardous or even fatal. Ingestion of the drug has resulted in severe brain injury, seizures, and heart problems in children.
- As lidocaine is rapidly and extensively metabolized by the liver, patients with liver disease or any form of hepatic dysfunction should be administered this drug cautiously and dosing should be modified for patients with compromised hepatic function.
- Lidocaine is primarily eliminated by the kidneys where two active metabolites, MEGX and GX, exhibit antiarrhythmic and convulsant properties. A serum concentration of these metabolites with lidocaine are increased and the half-life is prolonged in patients with renal impairment, and therefore lidocaine should be administered cautiously in patients with impaired or compromised renal function.
- Seizures could potentially occur as a result of an accumulation of active metabolites, and thus, lidocaine should be applied cautiously on patients with a past medical history of or a predisposition for seizures.
- Side Effects: Major side effects may include mild burning on application site, itching, rash, or changes in skin color on application site. Although uncommon, some signs of an allergic reaction may occur such as hives, swelling of the face, lips, tongue, or throat, or respiratory depression.
- Name Brands (25): AgonEaze, Anodyne LPT, DermacinRX Empricaine, DermacinRX Prikaan, DermacinRX Prizopak, Dolotranz, Elma, Leva Set, Lidopril, Lidopril XR, Livixil Pak, Nuvakaan II, Ora-qix, Prikaan, Prilolid, Prilovix, Prilovix Lite, Prilovix Plus, Prilovix Lite Plus, Prilovix Ultralite, Prilovix Ultralite Plus, Prilovixil Plus, Relador Pak Plus, SkyaDerm-LP, and Venipuncture CPI
- **Lidocaine** [7][8][9][10][97] (lidocaine topical) – a topical anesthetic that absorbed into the mucous membrane where it stabilizes the neuronal membrane by inhibiting the ionic fluxes, preventing the initiation and conduction of nerve impulses.
- Usage: Lidocaine topical is used to reduce discomfort or pain caused by skin irritations such as poison oak, poison ivy, poison sumac, insect bites, sunburns, burns, or scratches. Lidocaine topical is also known to treat rectal discomfort that is caused by hemorrhoids.
- Dosage: Lidocaine topical may come in a variety of forms such as lotion, ointment, spray, gel, cream, skin patch, or liquid, so it is important to use as directed on the label and by using the smallest amount possible needed to numb the skin or to relieve pain.
- Major Interactions:
- Sodium Channel Blockers and Nitrates increase the risk of methemoglobinemia.
- Lidocaine topical is not recommended for use in young children or teething infants as ingestion could potentially be fatal or cause seizures, severe brain injury, or heart problems.
- At higher plasma levels, caused by local anesthetic toxicity, this drug could cause hypotension, bradycardia, or cardiovascular collapse and should be administered cautiously.
- Lidocaine topical should be administered cautiously to patients with impaired or compromised hepatic function.
- Serum concentrations of lidocaine and active metabolites in the kidneys are increased in patients with renal impairment, and thus, should be administered cautiously to any patient with impaired or compromised renal function.
- This drug should not be applied in high doses to any patient with a history of or a predisposition to seizures.
- Side Effects: Common side effects of lidocaine topical usage may include allergic reactions, mild irritation, and/or numbness where the medication has been applied.

- Name Brands (19): Anestacon, CidalEaze, Derma Numb, DermacinRX Lido V Pak, Eha Lotion, Lid-aMantle, Lidocaine Viscous, Lidopac, Lidopin, Lidovex, Lidozol, LMX 4, LMX 5, Lydexa, Medi-Quik Spray, Regenecare HA Spray, Xylocaine Jelly, Xylocaine Topical, and Ziondil

OPIOID ANESTHETICS (8)

- **Alfentanil** [11][12][13][14][98] (alfentanil systemic) – an intravenous anesthetic injection solution that exposes users to risk of addiction, abuse, and misuse. Mechanism of action involved binding to a G-protein coupled receptor (the mu-opioid receptor) that induces anti-nociception responses through the release of various neurotransmitters, including GABA, dopamine, acetylcholine, and noradrenaline.
- Usage: This drug is typically given to assist in relieving pain during surgery that is also used as a primary anesthesia for patients undergoing general surgery. As alfentanil systemic is an opioid, the drug is only to be given by or under direct supervision of a physician.
- Dosage:
 - For anesthetic induction, the proper dosage should be 130-245mcg/kg, whereas the maintenance of anesthesia should be 0.5-1.5mcg/kg/min.
 - Induction of MAC should be 3-8mcg/kg and the maintenance should be 3-5mcg/kg over 5-20 minutes or 0.25-1.0mcg/kg/min with a total dose of 3-50mcg/kg.
 - The concentration of inhalation agents should be reduced by 30-50% for the initial hour.
 - The total dosage is dependent on the duration of procedure.
 - Children under the age of 12 should not be given Alfentanil.
 - 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 Brand (1): Alfenta
- **Butorphanol** [15][16][17][99] (butorphanol systemic) – An opioid injection used to treat moderate to severe pain by acting as a mu-opioid receptor agonist, as well as a kappa-opioid receptor agonist.
- Usage: butorphanol systemic is used as part of anesthetic for surgery or during early labor if childbirth is expected to be more than 4 hours away.
- Dosage:
 - The recommended initial dosage for injection is 1mg IV or 2mg IM with repeated doses every 3-4 hours as necessary.
 - The standard preoperative dosage is 2mg IM given 60-90 minutes before surgery or 2mg IV shortly before induction and the maintenance in balanced anesthesia should be an incremental dose of 0.5-1.0mg IV and up to 0.06mg/kg (4mg/70kg), depending on previous sedative, analgesic, and hypnotic drugs administered.
 - Rarely should a patient be given less than 4mg or more than 12.5mg, or roughly 0.06-0.18mg/kg.
 - Butorphanol is not recommended for patients under the age of 18.
 - 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 Brand (1):** Stadol (no longer available in the US)
 - **Fentanyl** [18][19][20][21][100] (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.
 - In children greater than 12-years-old, 0.5-1.0mcg/kg/dose IV should be given every 1-2 hours as needed.
 - In children 1-12-years-old, a dose of 1-4mcg/kg/dose IV should be given every 2-4 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, respiratory depression, headaches, nervousness, sweating, or unusual tiredness or weakness.
 - **Name Brands (6):** Duragesic, Fentanyl Transdermal System, Sublimaze, Ionsys, Lazanda, and Fentora
- **Nalbuphine** [22][23][24][25][26][101] (nalbuphine systemic) – an opioid pain medication used to treat moderate to severe pain, although the full mechanism of action of this drug is still not fully understood, it is believed that the drug binds to the kappa receptors of the CNS, which inhibits the neurotransmitters that mediate pain.
 - **Usage:** Generally, nalbuphine is a widely used anesthetic drug that is used to treat many different types of pain, including treating pain just after surgery or childbirth.
 - **Dosage:**
 - For a typical child greater than 1-year-old, 0.1-0.2mg/kg IV/IM/SC, where an individual dose should not exceed 20mg or to exceed 160mg/day.
 - **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 Brand (1):** Nubain
 - **Remifentanil** [27][28][29][30][31][32][33][34][35][36][37][102] (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:**

- For a child 1-12 years of age, the initial dose should be 1mcg/kg IV over 30-60 seconds, where maintenance dosing should be 1mcg/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: blurred vision, confusion, chest pain or discomfort, dizziness, faintness, or lightheadedness, respiratory depression, headaches, nervousness, sweating, or unusual tiredness or weakness.
- Name Brand (1): Ultiva
- **Sufentanil** [38][39][40][41][42][103] (sufentanil systemic) – an injection that is used to relieve pain during and after surgery or other medical procedures. This drug inhibits pain through the mechanism of action as acting as a mu-opioid receptor agonist.
- Usage: Sufentanil is widely used as a pain reliever for patients who require or have recently undergone surgery or another medical procedure such as childbirth.
- Dosage:
 - For pediatric patients needing anesthesia for 1-2 hours, an initial dosage of 1-2mcg/kg IV should be administered, and maintenance doses should be 10-25mcg IV as needed.
 - For pediatric patients needing anesthesia for 2-8 hours, an initial dosage of 2-8mcg/kg IV should be administered, and maintenance doses should be 10-50mcg IV 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, respiratory depression, headaches, nervousness, sweating, or unusual tiredness or weakness.
- Name Brand (1): Sufenta
- **Morphine** [104][119][120][121] (morphine systemic) – a short-acting or extended-release opioid medication used to treat pain by binding to specific opiate receptors, delta, mu, and kappa.
- Usage: Short-acting formulations of morphine are used to treat moderate to severe pain whereas extended-release morphine is used as an around-the-clock treatment for pain management.
- Dosage:
 - Post-op pain dose is typically 5-20mg IV titrated.
 - In pediatric patients 6 months or older, weighing 45kg or more, an initial dose of 15-30mg should be given orally every 4 hours as needed.
 - In pediatric patients 6 months or older, weighing 45kg or less, an initial dose of 0.1mg/kg IV or 0.3mg/kg orally should be given every 4-6 hours as needed.
 - For pediatric patients less than 6 months, an initial dose of 0.025-0.03mg/kg IV or 0.075-0.09mg/kg orally should be given every 4-6 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, respiratory depression, headaches, nervousness, sweating, or unusual tiredness or weakness.

- Name Brands (11): Astramorph PF, AVINza, Duramorph, Infumorph, Kadian, Kadian ER, Morphabond, MS Contin, Oramorph SR, Roxanol, and Roxanol-T.
- **Hydromorphone**
[105][122][123][124][125][126][127][128] (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:
 - In pediatric patients, the typical dosing is 0.03-0.08mg/kg/dose orally every 4-6 hours or 0.01mg/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

ANTICHOLINERGIC ANESTHETICS (3)

- **Glycopyrrolate**
[64][65][66][67][68][69][70][71][72][73][74][75][76][77][106] (glycopyrrolate systemic) – ANTISPASMODIC
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& BRONCHODILATOR – an anticholinergic that works by relaxing muscles in the airway to improve breathing. This drug competitively binds to muscarinic receptors and inhibits cholinergic transmission, producing relaxation in smooth muscles.

- Usage: Glycopyrrolate is an inhaled medication that is used to prevent airflow obstruction or bronchospasm in individuals with COPD such as emphysema and bronchitis.
- Dosage:
 - When used in an inhalation device, one capsule, twice daily, should be used.
 - The capsule should go into the device, the mouthpiece should be clicked closed, and the buttons on the side should be pushed and released to pierce the capsule to release the medicine into the inhalation chamber.
- Major Interactions:
 - Potassium chloride or potassium citrate may increase the irritant effects of potassium on the stomach and upper intestine. Although rare, this could potentially result in ulcers, bleeding, or other gastrointestinal injuries.
 - Topiramate and zonisamide can both cause increased body temperature with decreased sweating, which may be worsened if combined with glycopyrrolate. Heat stroke and hospitalization may occur in some people, specifically in children, and may be more likely in warm weather or during exercise.
 - Cold or allergy medications that contain an antihistamine, medicine to treat Parkinson's disease, medicine to treat excess stomach acid, ulcers, motion sickness, or irritable bowel syndrome, bladder or urinary medicines, or other bronchodilators can all potentially have a negative effect when taken with glycopyrrolate.
- Side Effects: Side effects of glycopyrrolate may include, but are not limited to wheezing, choking, or any other breathing problems, blurred vision, eye

pain, nausea, painful or difficult urination, congestion, sneezing, sore throat, or vomiting.

- **Name Brand (1):** Glyrx-PF – ANTISPASMODIC
- **Atropine** [87][88][89][90][91][92][93][94][107] (atropine systemic) – ANTISPASMODIC & BRONCHODILATOR – a drug given during anesthesia to help keep the heartbeat normal during surgery. This drug works by acting as a sympathetic, competitive antagonist of the muscarinic cholinergic receptors, reducing the effects of the parasympathetic stimulation.
- **Usage:** Atropine is used to treat the symptoms of bradycardia as well as to decrease salivation and bronchial secretions before and during surgery. It is also used as an antidote for overdose of cholinergic drugs or mushroom poisoning.
- **Dosage:**
- For pediatric patients, the proper dosage should be 0.01-0.03mg/kg IV every 3-5 minutes, where the minimum dose is 0.1mg. In a child, the maximum dose is 0.5mg and in an adolescent, the maximum dose is 1.0mg. The maximum cumulative dose is 1.0mg in a child and 2.0mg in an adolescent.
- For rapid sequence intubation pretreatment, the proper pediatric dosage should be 0.02mg/kg IV, where the minimum dosage should be 0.1mg. This is not recommended as a routine treatment option.
- **Major Interactions:**
- Potassium chloride or potassium citrate may increase the irritant effects of potassium on the stomach and upper intestine. Although rare, this could potentially result in ulcers, bleeding, or other gastrointestinal injuries.
- Topiramate and zonisamide can both cause increased body temperature with decreased sweating, which may be worsened if combined with glycopyrrolate. Heat stroke and hospitalization may occur in some people, specifically in children, and may be more likely in warm weather or during exercise.

- **Side Effects:** Atropine may potentially cause various side effects that include, but are not limited to hypersensitivity reactions, sinus tachycardia, blepharitis, decreased visual acuity, decreased food absorption, lethargy, chest pain, insomnia, dehydration, paranoia, anxiety, atrial fibrillation, headaches, dizziness, blurred vision, vertigo, nausea, or vomiting.
- **Name Brands (3):** AtroPen, Atreza, and Sal-Tropine
- **Hyoscyamine** [78][79][80][81][82][83][84][85][86][108] (hyoscyamine systemic) – ANTISPASMODIC – an antispasmodic medication that comes in many forms such as oral liquid, solution, and tablet to treat many different medical conditions. This drug is a non-selective competitive antagonist of the muscarinic receptors that leads to the inhibition of the parasympathetic activities of acetylcholine.
- **Usage:** Hyoscyamine is used to treat many different intestinal and stomach disorders such as peptic ulcers, irritable bowel syndrome as well as to control muscle spasms in the digestive tract, kidneys, and bladder. Hyoscyamine is also used to reduce stomach acid, reduce tremors and rigid muscles, and as a drying agent to control excessive salivation, runny nose, or excessive sweating.
- **Dosage:**
- Pre-anesthetic dose for pediatric patients should be 0.005mg/kg IM, IV, or subcutaneous injection 30-60 minutes prior to anticipated start time of anesthesia or at the same time preanesthetic narcotic/sedatives are given.
- During surgery, a dose of 0.125mg IV once and repeated in increments of 0.125mg as needed to reduce drug-induced bradycardia.
- **Major Interactions:**
- Potassium chloride or potassium citrate may increase the irritant effects of potassium on the stomach and upper intestine and could potentially result in ulcers, bleeding, or other gastrointestinal injuries.

- Topiramate and zonisamide can both cause increased body temperature with decreased sweating, which may be worsened if combined with glycopyrrolate. Heat stroke and hospitalization may occur in some people, specifically in children, and may be more likely in warm weather or during exercise.
- Other medications that may potentially interact with hyoscyamine include but are not limited to antidepressants or any medicine to treat mental illnesses, cold or allergy medication, antinausea medications, or an MAO inhibitor.
- Side Effects: Hyoscyamine may potentially cause various side effects that include, but are not limited to anxiety, hallucinations, confusion, slurred speech, memory problems, diarrhea, dizziness, rash, dry mouth, decreased sense of taste, nausea, bloating, constipation, headache, insomnia, impotence, vomiting, or blurred vision.
- Name Brands (15): Anazpaz, Colidrops, Ed-Spaz, HyoMax, HyoMax DT, HyoMax FT, HyoMax SL, HyoMax SR, Hyosyne, Levbid, Levsin, Levsin SL, Oscimin, Symax Duotab, Symax SL, and Symax SR

LOCAL INJECTABLE ANESTHETICS (6)

- **Articaine / Epinephrine** [56][57][58][59][60][61][62][63][109] (articaine / epinephrine systemic) – a combination anesthetic that works by blocking nerve signals in the body through the binding to sodium channels they will reduce sodium influx and threshold cannot be met for neuronal firing.
- Usage: Articaine/epinephrine is most commonly used as a numbing agent for the mouth during dental procedures by injection into the gum area.
- Dosage:
- In typical patients 4-10 years of age, the maximum dose should not exceed 7mg/kg.
- In typical patients 4-16 years of age, the maximum dose should not exceed 5.65mg/kg.

- Major Interactions: More common interactants may include, but are not limited to antidepressants, anti-psychotic medications, or an MAO inhibitor. Medication such as an articaine/epinephrine combination could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 38 major interactions and 191 moderate interactions should be reviewed fully before prescribing.
- Side Effects: Common side effects of the articaine/epinephrine combination anesthetic include, but are not limited to tongue pain or swelling, headache, mild swelling in the face, shallow breathing, blurred vision, anxiety, bradycardia, confusion, numbness, or a tingling sensation.
- Name Brands (6): Articadent, Orabloc, Septocaine, Ultacan, Ultacan Forte, and Zorcaine
- **Lidocaine** [7][8][9][10][110] (lidocaine systemic) – GROUP 1 ANTIARRHYTHMICS – an anesthetic that causes numbness to the specific area of the body where injected to reduce pain or discomfort by stabilizing the neuronal membrane by binding to and inhibiting voltage-gated sodium channels.
- Usage: Injectable forms of lidocaine are often used as a numbing agent to aid in reducing pain or discomfort caused by invasive medical procedures. Additionally, this form of lidocaine is used to treat irregular heart rhythms that may signal a possible heart attack as well as acting as an epidural to reduce the discomforts of contractions during labor.
- Dosage:
- For pediatric patients, the initial dose should be 1mg/kg/dose IV with a maintenance dose of 20-50mcg/kg/min and should not exceed 20mcg/kg/min in patients with shock, hepatic disease, cardiac arrest, or congestive heart failure.
- Major Interactions: More common interactants may include, but are not limited to nefazodone, antibiotics, St John's wort, antiviral medicine to treat hepatitis or HIV/AIDS, seizure medications, tuberculosis

medications, or heart or blood pressure medications. Medication such as lidocaine could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 14 major interactions and 149 moderate interactions should be reviewed fully before prescribing.

- **Side Effects:** Some common side effects of lidocaine may include, but are not limited to shallow breathing, feeling faint, muscle stiffness, bradycardia, nausea, dizziness, anxiety, confusion, blue appearance of the skin, or vomiting.
- **Name Brands (3):** DentiPatch, Xylocaine HCl, and Xylocaine-MPF
- **Tetracaine** [51][52][53][54][55][111] (tetracaine systemic) – a local anesthetic that works by reversibly binds voltage-gated sodium ion channels in neuronal cell membranes, preventing the initiation and conduction of nerve impulses.
- **Usage:** Tetracaine is most often given as an epidural injection to produce numbness during labor, surgery, or other medical procedures.
- **Dosage:**
- For adult patients, the maximum single dose should be 1-3mg/kg without a vasoconstrictor or 1.5mg/kg with a vasoconstrictor.
- For pediatric patients, the safety and efficacy have not yet been established and is therefore not recommended for use in pediatric patients.
- **Major Interactions:**
- Bupivacaine liposome could potentially alter the release rate if exposed to another local anesthetic solution such as tetracaine. If injected into the same area around the same time, bupivacaine liposome could potentially cause a rapid release of the active medication and alter the safety and efficiency of each other. Additional use of local anesthetics should be generally avoided within 96 hours following administration of bupivacaine liposome.
- Sodium nitrite usage may increase an individual's risk of methemoglobinemia.

- Other medicines such as sulfa drugs may potentially cause adverse effects when used alongside tetracaine.
- **Side Effects:** Some potential side effects of tetracaine may include, but are not limited to lightheadedness, headaches, shallow breathing, dizziness, chills, tingling sensations, blurred vision, tremors, nausea, ringing in the ears, or vomiting.
- **Name Brands (3):** Pontocaine, Democaine, and Vi-ractin
- **Ropivacaine** [112][129][130][131][132][133] (ropivacaine systemic) – an injectable anesthetic solution that binds to voltage-gated sodium ion channels in the neuronal membrane.
- **Usage:** Ropivacaine is used as a local anesthetic for a spinal block, or an epidural, to provide anesthesia during a surgery or C-section, or to ease labor pains.
- **Dosage:**
- For children, the recommended single-injection caudal block dose is 1ml/kg IV of a 0.2% solution.
- In infants, an infusion of a 0.1% solution at 0.2mg/kg/hour is recommended.
- In older children, an infusion of a 0.1% solution at 0.4mg/kg/hour, lasting no longer than 48 hours is recommended.
- **Major Interactions:**
- Bupivacaine liposome could potentially alter the release rate if exposed to another sodium channel block. If injected into the same area around the same time, bupivacaine liposome could potentially cause a rapid release of the active medication and alter the safety and efficiency of each other. Additional use of local anesthetics should be generally avoided within 96 hours following administration of bupivacaine liposome.
- Sodium Channel blocker usage may increase an individual's risk of methemoglobinemia.
- **Side Effects:** Potentially dangerous side effects may include, but are not limited to anxiousness, confusion, issues with speech or vision, ringing in the ears,

metallic taste, seizures, bradycardia or tachycardia, problems with urination or sexual function, back pain, nausea, or vomiting.

- **Name Brands (4):** Naropin, Naropin Polyamp, Naropin SDV, and Naropin Novaplus
- **Bupivacaine** [113][134][135][136] (bupivacaine systemic) – an injectable local anesthetic solution with many practical medical uses due to its ability to reversibly bind to specific sodium ion channels in the neuronal membrane, reducing the permeability of sodium ions and resulting in the loss of sensation.
- **Usage:** Bupivacaine is given as an epidural injection into the spinal column to produce numbness during labor, surgery, or other certain medical or dental procedures.
- **Dosage:**
- For pediatric patients 12 years or older, the recommended dose is a 0.25% concentrated solution with a maximum dose of 175mg.
- For a complete motor block, a 0.75% solution of 75-150mg should be administered.
- For a moderate to complete motor block, a 0.5% solution of 50-100mg should be administered.
- For a partial to moderate motor block, a 0.25% solution of 25-50mg should be administered.
- **Major Interactions:**
- Bupivacaine liposome could potentially alter the release rate if exposed to another local anesthetic solution such as bupivacaine. If injected into the same area around the same time, bupivacaine liposome could potentially cause a rapid release of the active medication and alter the safety and efficiency of each other. Additional use of local anesthetics should be generally avoided within 96 hours following administration of bupivacaine liposome.
- Prilocaine usage may increase an individual's risk of methemoglobinemia.
- **Side Effects:** Potentially dangerous side effects may include, but are not limited to anxiousness,

confusion, issues with speech or vision, ringing in the ears, metallic taste, seizures, bradycardia or tachycardia, problems with urination or sexual function, back pain, nausea, or vomiting.

- **Name Brands (5):** Marcaine HCl, Marcaine Spinal, Sensorcaine, Sensorcaine-MPF, and Sensorcaine-MPF Spinal
- **Chloroprocaine** [114][137][138][139][140] (chloroprocaine systemic) – a fast-onset injectable local anesthetic solution to produce local anesthesia by infiltration and peripheral nerve block. This drug acts by increasing the threshold required for electrical excitation of nerves.
- **Usage:** Chloroprocaine is used most commonly to establish adequate epidural anesthesia as well as for peripheral nerve block in a patient undergoing short ambulatory surgery that is not anticipated to produce significant postoperative pain.
- **Dosage:**
- In typical pediatric patients over 3 years of age, the recommended maximum dose should not exceed 11mg/kg of a 0.5-1.0% concentrated solution, or 1.0-1.5% for a nerve block.
- **Major Interactions:**
- Bupivacaine liposome could potentially alter the release rate if exposed to another sodium channel blockers. If injected into the same area around the same time, bupivacaine liposome could potentially cause a rapid release of the active medication and alter the safety and efficiency of each other. Additional use of local anesthetics should be generally avoided within 96 hours following administration of bupivacaine liposome.
- Nitrite usage may increase an individual's risk of methemoglobinemia.
- **Side Effects:** Dangerous side effects of chloroprocaine may include, but are not limited to hyperhidrosis, severe anxiety, lightheadedness, confusion, headaches, change in speech, tremors, dizziness, blurred vision, seizures, bradycardia or tachycardia,

chest pain, leaking of urine or stool, back pain, or sexual dysfunction.

- Name Brands (2): Nesacaine and Nesacaine-MPF

BENZODIAZEPINE ANESTHETICS (4)

- **Remimazolam**

[43][44][45][46][47][48][49][50][115] (remimazolam systemic) – an injectable anesthetic and sedative that binds to brain benzodiazepine receptors with high affinity, which facilitates the opening of GABA activated chloride channels and leads to the decrease in neuron firing and produces an inhibitory response.

- Usage: Remimazolam is most often used as a means for maintaining relaxation or sleep in patients undergoing medical procedures that last 30 minutes or less.

- Dosage:

- For adult patients, the induction dose should be 5mg IV over one minute, while maintenance dosages should be 2.5mg IV over 15 seconds.

- For pediatric patients, the safety and effectiveness have not yet been established and is therefore not recommended for use in pediatric patients.

- Major Interactions: Medication such as remimazolam could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 31 major interactions and 272 moderate interactions should be reviewed fully before prescribing.

- Side Effects: Remimazolam has many potential side effects which include, but are not limited to 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.

- Name Brand (1): Byfavo

- **Diazepam** [116][141][142][143][144][145] (diazepam systemic) – an oral anesthetic medication that works by enhancing the activity of certain neurotransmitters in the brain through the binding of

GABA receptors found in the limbic system and hypothalamus.

- Usage: Diazepam is used to treat anxiety disorders, alcohol withdrawal symptoms, or muscle spasms. Diazepam is sometimes also used with other medications to treat seizures.

- Dosage:

- The recommended pediatric dose should be 0.12-0.8mg/kg/day every 6-8 hours, orally with a maximum dose of 10mg/dose.

- If given by IV, the recommended dose for pediatric patients is 0.04-0.3mg/kg/dose every 6-12 hours.

- Major Interactions: Medication such as diazepam could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 30 major interactions and 379 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 depression or seizures.

- Side Effects: Diazepam has many potential side effects which include, but are not limited to 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.

- Name Brands (4): Diastat, Diastat AcuDial, Valium, and Valtoco

- **Midazolam** [117][146][147][148][149][150] (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.
- **Dosage:**
- 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 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.
- **Name Brands (3):** Nayzilam, Seizalam, and Versed
- **Lorazepam** [118][151][152][153][154] (lorazepam systemic) – an oral anesthetic medication designed to produce a calming effect that is five times more potent than midazolam. This drug enhances the effect of the inhibitory neurotransmitter gamma-aminobutyric acid on the GABA receptors by binding to a site that is distinct from the GABA binding site in the CNS.
- **Usage:** Lorazepam is most commonly used to treat anxiety in patients to help them relax before an operation or other medical or dental treatment.
- **Dosage:**
- For pediatric patients, the recommended dose is 0.025-0.1mg/kg/dose IV or orally with a maximum dosage of 2mg every 4-6 hours.
- **Major Interactions:** Medication such as diazepam could potentially interact with many other drugs and cause dangerous side effects, or even death. A total list consisting of 29 major interactions and 296 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 depression or seizures.
- **Side Effects:** Potential side effects of lorazepam may include, but are not limited to severe drowsiness, unusual changes in mood or behavior, confusion, insomnia, changes in vision, dark urine, drowsiness, feeling unsteady, dizziness, or jaundice.
- **Name Brands (2):** Ativan and Lorazepam Intensol

The following Table 1 shows the drugs summary.

Drug Name	Pediatric Dosing	Major Interactants	Major Side Effects
Alfentanil Systemic	Induction, 130-245mcg/kg. Maintenance, 0.5-1.5mcg/kg/min. Alfentanil is not recommended for children under the age of 12.	<ul style="list-style-type: none"> Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> Respiratory depression Blurred vision Chest pain
Articaine / Epinephrine Systemic	4-10 years of age: max dose of 7mg/kg. 4-16 years of age: max dose of 5.65mg/kg.	<ul style="list-style-type: none"> Antidepressants Antipsychotics MAO inhibitor 	<ul style="list-style-type: none"> Tongue pain Swelling of the face Bradycardia
Atropine Systemic	0.01-0.03mg/kg IV every 3-5 minutes with a minimum of 0.1mg and a maximum of 1.0mg.	<ul style="list-style-type: none"> Potassium chloride or potassium citrate Topiramate and zonisamide 	<ul style="list-style-type: none"> Atrial fibrillation Decreased food absorption Decreased visual acuity Blepharitis Sinus tachycardia
Benzocaine Topical	The smallest amount needed to relieve pain.	<ul style="list-style-type: none"> Other sodium channel blockers Nitrite 	<ul style="list-style-type: none"> Methemoglobinemia Mild stinging, burning, or itching at the site of application
Bupivacaine Systemic	Complete motor block, 0.75% solution of 75-150mg. Moderate to complete block, 0.5% solution of 50-100mg. Partial to moderate block, 0.25% solution of 25-50mg.	<ul style="list-style-type: none"> Bupivacaine liposome Prilocaine 	<ul style="list-style-type: none"> Seizures ringing in the ears Metallic taste Urination problems Sexual dysfunction Nausea/vomiting Back pain
Butorphanol Systemic	Butorphanol is not recommended for patients under the age of 18.	<ul style="list-style-type: none"> Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> Respiratory depression Blurred vision Chest pain
Chlorprocaine Systemic	Max dose is 11mg/kg of a 0.5-1.0% solution, or 1.0-1.5% solution for a nerve block.	<ul style="list-style-type: none"> Bupivacaine liposome Nitrites 	<ul style="list-style-type: none"> Seizures Tremors Hyperhidrosis
Diazepam Systemic	Orally: 0.12-0.8mg/kg/day every 6-8 hours with max dose of 10mg/dose. IV: 0.04-0.3mg/kg/dose every 6-12 hours.	<ul style="list-style-type: none"> Total list of 30 major interactants should be reviewed Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> Insomnia Nausea/vomiting Pale/blue lips, skin, or fingernails Irregular heartbeat Shakiness Mood changes Disorientation
Fentanyl Systemic	1-12: 1-4mcg/kg/dose IV every 2-4 hours as needed. 12+: 0.5-1.0mcg/kg/dose IV every 1-2 hours as needed.	<ul style="list-style-type: none"> Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> Respiratory depression Blurred vision Chest pain Unusual tiredness or weakness
Glycopyrrolate Systemic	In an inhalation device, one capsule, twice daily.	<ul style="list-style-type: none"> Potassium chloride or potassium citrate Topiramate and zonisamide Cold or allergy medications that contain an antihistamine 	<ul style="list-style-type: none"> Choking Breathing problems Eye pain Nausea/vomiting Painful urination Blurred vision Sneezing
Hydromorphone Systemic	0.03-0.08mg/kg/dose orally every 4-6 hours, or 0.01mg/kg/dose IV every 4-6 hours.	<ul style="list-style-type: none"> Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> Respiratory depression Blurred vision Chest pain
Hyoscyamine Systemic	30-60min before surgery, 0.005mg/kg IM, IV, or subcutaneous injection. During surgery, 0.125mg IV once and repeated in identical increments as needed.	<ul style="list-style-type: none"> Potassium chloride or potassium citrate Topiramate and zonisamide Antidepressants Cold or allergy medication 	<ul style="list-style-type: none"> Insomnia Impotence Nausea/vomiting Decreased taste Constipation Diarrhea Slurred speech
Lidocaine Systemic	Initial dose, 1mg/kg/dose IV with a maintenance dose of 20-50mcg/kg/min. Maintenance dose should not exceed 20mcg/kg/min in patients with shock, hepatic disease, cardiac arrest, or congestive heart failure.	<ul style="list-style-type: none"> Nefazodone Antibiotics Antivirals for hepatitis or HIV/AIDS St John's wort Seizure medications Tuberculosis medications Heart/blood pressure medications 	<ul style="list-style-type: none"> Shallow breathing Bradycardia Nausea/vomiting Blue appearance of the skin Anxiety Muscle stiffness Confusion Dizziness Feeling faint
Lidocaine Topical	The smallest amount needed to relieve pain.	<ul style="list-style-type: none"> Sodium channel blockers Nitrates 	<ul style="list-style-type: none"> Mild stinging, burning, or itching at the site of application
Lidocaine / Prilocaine Topical	The smallest amount needed to relieve pain, based on patient weight.	<ul style="list-style-type: none"> Acetaminophen Aminosalicylic acid Other sodium channel blockers Nitrates Antiepileptic drugs Sulfa drugs 	<ul style="list-style-type: none"> Mild stinging, burning, or itching at the site of application
Lorazepam Systemic	0.025-0.1mg/kg/dose IV or oral with a maximum dose of 2mg every 4-6 hours.	<ul style="list-style-type: none"> Total list of 29 major interactants should be reviewed Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> Jaundice Dark urine Mood changes Feeling unsteady Changes in vision Drowsiness Confusion
Midazolam Systemic	Oral: 0.25-0.5mg/kg/dose as needed with a max of 20mg. IV: 0.025-0.1mg/kg/dose as needed with a max of 2mg. Intranasal: 0.2-0.3mg/kg/dose as needed with a max of 10mg.	<ul style="list-style-type: none"> Total list of 34 major interactants should be reviewed Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> Insomnia Nausea/vomiting Pale/blue lips, skin, or fingernails Irregular heartbeat Shakiness Mood changes

			<ul style="list-style-type: none"> • Disorientation
Morphine Systemic	6 months and greater than 45kg, initial dose of 15-30mg orally every 4 hours as needed.	<ul style="list-style-type: none"> • Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> • Respiratory depression • Blurred vision • Chest pain
Nalbuphine Systemic	Greater than 1-year-old, 0.1-0.2mg/kg IV/IM/SC. Individual dose should not exceed 20mg or 160mg/day.	<ul style="list-style-type: none"> • Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> • Respiratory depression • Blurred vision • Chest pain
Remifentanyl Systemic	Initial dose for 1-12-year-olds, 1mcg/kg IV over 30-60 seconds. Maintenance, 1mcg/kg every 2-5 minutes.	<ul style="list-style-type: none"> • Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> • Respiratory depression • Blurred vision • Chest pain • Unusual tiredness or weakness
Remimazolam Systemic	The safety and effectiveness have not yet been established and is therefore not recommended for use.	<ul style="list-style-type: none"> • Total list of 31 major interactants should be reviewed 	<ul style="list-style-type: none"> • Insomnia • Nausea/vomiting • Pale/blue lips, skin, or fingernails
Ropivacaine Systemic	In infants, a 0.1% solution at 0.2mg/kg/hour. In older children, a 0.1% solution at 0.4mg/kg/hour, lasting no longer than 48 hours.	<ul style="list-style-type: none"> • Bupivacaine liposome • Sodium channel blockers 	<ul style="list-style-type: none"> • Urination problems • Sexual dysfunction • Ringing in the ears • Nausea/vomiting • Back pain • Seizures • Metallic taste
Sufentanil Systemic	1-2 hours: Induction, 1-2mcg/kg IV with maintenance of 10-25mcg IV as needed. 2-8 hours: Induction, 2-8mcg/kg IV with maintenance of 10-50mcg IV as needed.	<ul style="list-style-type: none"> • Any drugs that cause sleepiness or slow breathing 	<ul style="list-style-type: none"> • Respiratory depression • Blurred vision • Chest pain • Unusual tiredness or weakness
Tetracaine Systemic	Safety and efficacy have not yet been established and is therefore not recommended for use in pediatric patients.	<ul style="list-style-type: none"> • Bupivacaine liposome • Sodium nitrite • Sulfa drugs 	<ul style="list-style-type: none"> • Ringing in the ears • Tremors • Nausea/vomiting • Shallow breathing

Table 1. Summary

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.

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