

Intravenous Medications in the Intensive Care Unit

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The speaker has no conflict to disclose.



Objectives

- Describe the pharmacology of common intravenous medications used in the Intensive Care Unit (ICU).
- Explain the potential uses of common intravenous medications used within the ICU.
- Describe the potential role of pharmacy technicians in the safe medication use process within an ICU.



FLUIDS



Fluids

- Crystalloids
 - Normal Saline
 - Lactated Ringer's
 - Dextrose 5%
- Colloids
 - Albumin 5%
 - Hetastarch 6%
 - Hextend® (in lactated electrolyte solution)
 - Hespan®, Voluven® (in NS)
- Blood Products
- Others



How many of you have sterile compounding technique procedures at your institution?

What are some of these procedures?





Sterile IV Techniques

- USP 797 Sterile Compounding
 - Clean Room
 - Critical Sites
 - Environment Control
 - Personnel
- Increase patient safety!





Fluids

- Crystalloids
 - Advantages
 - Low cost
 - Widely available
 - Disadvantages
 - Only ~ 25-33% remain in blood vessels



Fluids

- Colloids
 - Advantages
 - Range from ~80-100% remain in blood vessels
 - Disadvantages
 - Very expensive
 - May not be readily available



Blood Products

- Blood Products
- Whole Blood
- Packed Red Blood Cell (PRBC)
- Platelets
- Fresh Frozen Plasma (FFP)
- Cryoprecipitate


Oxygen Therapeutic Agents

- Hemoglobin-based oxygen carriers
 - Polyheme® (human glutaraldehyde polymerized)
 - Hemopure® (hemoglobin glutamer-250[bovine])
- Perfluorocarbons





Fluids

- Role
 - Crystalloids and Colloids
 - Maintain adequate hydration
 - Maintain adequate blood pressure
 - Maintain perfusion of tissues and organs
 - Blood and Blood Products
 - Maintain adequate oxygen delivery to tissues and organs
 - Maintain adequate ability to coagulate



VASOACTIVE AGENTS



Vasoactive Agents

Vasopressors

- Dopamine
- Norepinephrine
- Epinephrine
- Phenylephrine
- Vasopressin

Inotropes

- Dopamine
- Dobutamine
- Milrinone



Vasopressor Pharmacology

- Stimulation of DA receptors
 - Increase kidney and GI tract blood flow
 - Inhibition of kidney sodium reabsorption
- Stimulation of β receptors
 - Increase heart contraction and rate
 - Small increase in arterial vasodilation
- Stimulation of α_1 receptors
 - Increase arterial vasoconstriction



Vasopressors

- Dopamine
 - Stimulation of DA, β , α_1 receptors
- Norepinephrine
 - Stimulation of α_1 , β receptors
- Phenylephrine
 - Stimulation of α_1 receptors
- Epinephrine
 - Stimulation of β , α_1 receptors



With the norepinephrine shortage, what vasoactive agent are you using in your institution?



Vasopressin

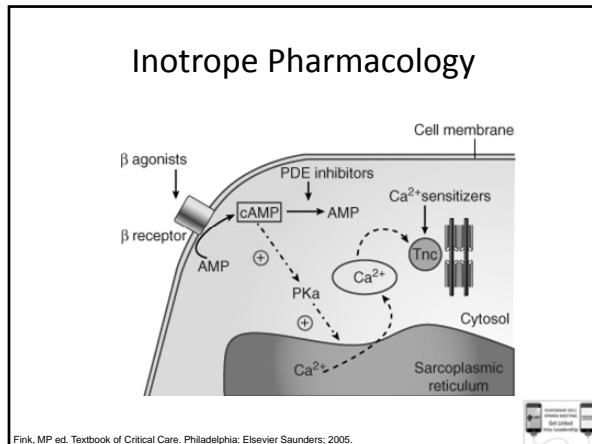
- Synthetic antidiuretic hormone
- Stimulation of VP_1 receptors
 - Peripheral vascular constriction
- Stimulation of VP_2 receptors
 - Sodium and water retention in kidneys
- Stimulation of VP_3 receptors
 - Increase ACTH and cortisol production



Vasopressors

- Role
 - Maintain adequate blood pressure
 - Maintain perfusion of tissues and organs





Inotrope Pharmacology

- **Dobutamine**
 - Stimulation of β receptors
- **Milrinone**
 - Phosphodiesterase type 3 (PDE₃) inhibitor
 - Inhibits breakdown of cAMP in myocardium and vasculature
 - \uparrow heart contraction and arterial vasodilatation

Inotropes

- **Role**
 - Maintain adequate cardiac function
 - Maintain adequate blood pressure (indirectly)
 - Maintain perfusion of tissues and organs

Vasoactive Agents

- **Role**
 - Septic Shock (overwhelming infection)
 - Norepinephrine
 - Dopamine
 - Phenylephrine
 - Vasopressin
 - Dobutamine
 - Cardiogenic Shock (heart failure, heart attack)
 - Dopamine
 - Dobutamine
 - Milrinone

Vasodilators

- **Venodilator**
 - Nitroglycerin
- **Vasodilator**
 - Sodium nitroprusside
- **Adrenergic Blockers**
 - Labetolol
 - Esomolol (Brevibloc®)
- **Calcium Channel Blockers**
 - Nicardipine (Cardene®)
 - Clevidipine (Cleviprex®)

Vasodilators

- **Role**
 - Decrease blood pressure
 - Prevention of heart attack, stroke and aneurysms
 - Decrease heart rate
 - Prevention of heart attack

Vasodilators

- Prostaglandins
 - Epoprostenol (Flolan®)
 - Role
 - Pulmonary hypertension
 - Improve oxygenation in patients on mechanical ventilation

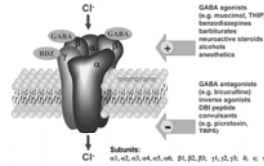


SEDATIVES, PARALYTICS AND ANALGESICS



Sedatives

- Benzodiazepines
 - Midazolam
 - Lorazepam
 - Diazepam
- Propofol
- Dexmedetomidine (Precedex®)



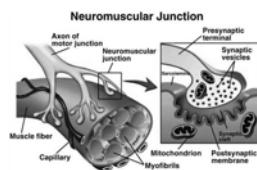
Sedatives

- Roles
 - Maintain adequate mental status
 - Prevent agitation



Neuromuscular Blockers

- Depolarizing
 - Succinylcholine
- Non-depolarizing
 - Atracurium
 - Cisatracurium (Nimbex®)
 - Mivacurium
 - Pancuronium
 - Pipecuronium
 - Rocuronium (Zemuron®)
 - Vecuronium



What neuromuscular blocking agent(s) do you have in your RSI kit?



Neuromuscular Blockers

- Role
 - Maintain paralysis
 - Improve ventilation
 - Allow intubation
 - Rapid Sequence Intubation
 - » Midazolam / Propofol
 - » Succinylcholine / Rocuronium
 - Improve outcome in patients with elevated intracranial pressure



Analgesics

- Opiates
 - Fentanyl
 - Hydromorphone
 - Morphine



Analgesics

- Role
 - Maintain adequate pain control
 - Maintain adequate mental status



Analgesics

- Patient Controlled Analgesics (PCA)
 - Computerized Ambulatory Drug Delivery (CADD) Pump
 - Safety Mechanism
 - Continuous infusion
 - Patient controlled demand
 - Lock-out mechanism



Antipsychotics

- Butyrophenone
 - Haloperidol (Haldol®)
- Atypical Antipsychotics
 - Aripiprazole (Abilify®)
 - Olanzapine (Zyprexa®)
 - Ziprasidone (Geodon®)



Antipsychotics

- Role
 - Maintain adequate mental status
 - Alleviate delirium



ANTIMICROBIALS

Cell Wall Inhibitors

- Inhibits bacterial growth via elongation of peptidoglycan on bacterial cell wall
- Examples
 - Beta-Lactams
 - Glycopeptides

Cell Wall Inhibitors

- Penicillins
 - Penicillin G
 - Ampicillin
 - Ampicillin/sulbactam (Unasyn®)
 - Oxacillin, Nafcillin
 - Piperacillin/tazobactam (Zosyn®)
 - Ticarcillin/clavulanate (Timentin®)
- Carbapenems
 - Imipenem/cilastatin (Primaxin®)
 - Meropenem (Merrem®)
 - Doripenem (Doribax®)
 - Ertapenem (Invanz®)
- Cephalosporins
 - Cefazolin
 - Cefuroxime
 - Cefotetan, Cefoxitin
 - Cefotaxime, Ceftriaxone (Rocephin®)
 - Ceftazidime (Fortaz®)
 - Cefepime (Maxipime®)
 - Ceftaroline (Teflaro®)
- Monobactams
 - Aztreonam (Azactam®)
- Glycopeptides
 - Vancomycin
 - Telavancin (Vibativ®)

Protein Synthesis Inhibitors

- Inhibit protein synthesis
- Examples
 - Tetracyclines
 - Macrolides
 - Aminoglycosides
 - Lincosamides
 - Oxazolidinones
 - Streptogramins

Sohmen, D. Cell. 2009; 139:212.

Protein Synthesis Inhibitors


- Tetracyclines
 - Doxycycline
 - Minocycline
- Glycylcycline
 - Tigecycline (Tygacil®)
- Macrolides
 - Clarithromycin
 - Azithromycin
- Aminoglycosides
 - Gentamicin
 - Tobramycin
 - Amikacin
- Lincosamides
 - Clindamycin
- Oxazolidinones
 - Linezolid (Zyvox®)
- Streptogramins
 - Quinupristin/Dalfopristin (Synercid®)

Nucleic Acid Inhibitors

- Antifolates
 - Inhibits purine metabolism
 - Trimethoprim/Sulfamethoxazole
- Topoisomerase Inhibitors
 - Inhibits DNA replication
 - Fluoroquinolones
 - Ciprofloxacin
 - Levofloxacin (Levaquin®)
 - Moxifloxacin (Avelox®)
- DNA Inhibitor
 - Nitro-imidazole
 - Metronidazole (Flagyl®)



Cell Membrane Inhibitors

- Lipopeptide
 - Daptomycin (Cubicin®)
- Polymyxin
 - Colistin, colistimethate




Fungal Cell Wall Inhibitors

- Polyenes
 - Amphotericin B
 - Amphotericin B deoxycholate
 - Amphotericin B Lipid Complex (Abelcet®)
 - Liposomal Amphotericin B (AmBisome®)
- Imidazoles / Triazoles
 - Fluconazole (Diflucan®)
 - Voriconazole (Vfend®)
- Echinocandins
 - Caspofungin (Cancidas®)
 - Micafungin (Mycamine®)
 - Anidulafungin (Eraxis®)





Antimicrobials


- Role
 - Treatment of suspected infections
 - Best outcome when started early
 - Quick delivery of antimicrobials



What antimicrobials have you been preparing or delivering more often?




ANTICOAGULANTS



Heparins

- Unfractionated Heparin (UFH)
- Low Molecular Weight Heparin (LMWH)
 - Enoxaparin (Lovenox®)
 - Dalteparin (Fragmin®)
 - Tinzaparin (Innohep®)
- Pentasaccharide
 - Fondaparinux (Arixtra®)



Heparins

- Role
 - Blood clots
 - Prevention
 - Treatment



Anticoagulants

- Direct Thrombin Inhibitors
 - Agents
 - Argatroban
 - Lepirudin (Refludan®)
 - Bivalirudin (Angiomax®)
 - Role
 - Treatment of blood clots in patients allergic to heparins



Anticoagulants

- Activated Protein C
 - Drotrecogin alfa (Xigris®)
 - Used in patients with sepsis



Fibrinolytics

- Agents
 - Alteplase (Activase®)
 - Reteplase (Retavase®)
 - Tenecteplase (TNKase®)
 - Urokinase (Kinlytic®)
- Role
 - Patients with heart attack or stroke
 - Unclogging IV catheter



Glycoprotein IIb/IIIa Inhibitors

- Agents
 - Abciximab (ReoPro®)
 - Eptifibatid (Integrilin®)
 - Tirofiban (Aggrastat®)
- Role
 - Patients with heart attack going for stent placement



Smart Pump

- Smart Pumps
 - Drug libraries with standardized concentrations for commonly used drugs
 - Feedback for dosing
 - Especially for high risk medications
 - Insulin
 - Heparin
 - Propofol
 - Vasoactive agents



ICHP/MSHP 2011 Spring Meeting
Technician Session - Intravenous Medications in the Intensive Care Unit
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Post Test Questions:

1. Which of the following is a potential benefit of crystalloids versus colloids?
 - a. Expensive
 - b. Stays in the blood vessels
 - c. Widely available
 - d. Frequent shortages

2. Which of the following is a potential use of vasopressors?
 - a. Help blood coagulate?
 - b. Help maintain adequate blood pressure
 - c. Help maintain adequate heart function
 - d. Help decrease heart rate

3. Which of the following can technicians help in the safe use of analgesics?
 - a. Ensure sterile preparation of fentanyl solution
 - b. Ensure correct preparation of morphine solution via compounding log
 - c. Ensure appropriate loading of CADD cassettes
 - d. All of the above

4. Which of the following is an agent that works by inhibiting cell wall production of resistance bacteria like methicillin-resistant *Staphylococcus aureus* (MRSA)?
 - a. Vancomycin
 - b. Levofloxacin
 - c. Azithromycin
 - d. Gentamicin

5. Which of the following is a potential use of heparin?
 - a. Treat bacterial infections
 - b. Prevent agitation
 - c. Treat blood clots
 - d. Maintain blood pressure