Intravenous Medications in the Intensive Care Unit
Paul Juang, Pharm.D., BCPS
Assistant Professor of Pharmacy Practice
St. Louis College of Pharmacy
April 16, 2011
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

Sterile IV Techniques
• USP 797 Sterile Compounding
  — Clean Room
  — Critical Sites
  — Environment Control
  — Personnel
• Increase patient safety!

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

What are some of these procedures?
Fluids

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

- **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 vasodilatation
- Stimulation of α₁ receptors
  - Increase arterial vasoconstriction

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

**Vasopressors**
- Dopamine
  - Stimulation of DA, β, α₁ receptors
- Norepinephrine
  - Stimulation of α₁, β receptors
- Phenylephrine
  - Stimulation of α₁ receptors
- Epinephrine
  - Stimulation of β, α₁ receptors

**Vasopressin**
- Synthetic antidiuretic hormone
- Stimulation of VP₁ receptors
  - Peripheral vascular constriction
- Stimulation of VP₂ receptors
  - Sodium and water retention in kidneys
- Stimulation of VP₃ 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
  - ↑ 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**

- **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

**Protein Synthesis Inhibitors**
- Inhibit protein synthesis
- Examples
  - Tetracyclines
  - Aminoglycosides
  - Lincosamides
  - Oxazolidinones
  - Streptogramins

**Nucleic Acid Inhibitors**
- Antifolates
  - Inhibits purine metabolism
  - Trimethoprim/Sulfamethoxazole
- Topoisomerase Inhibitors
  - Inhibits DNA replication
    - Fluoroquinolones
      - Ciprofloxacin
      - Levofloxacin (Levaquin®)
      - Moxifloxacin (Avelox®)
- DNA Inhibitor
  - Nitroimidazole
    - Metronidazole (Flagyl®)
Cell Membrane Inhibitors

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

Fungal Cell Wall Inhibitors

- Polyenes
  - Amphotericin B
  - Amphotericin B lipids 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?

Heparins

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

ANTICOAGULANTS
Heparins

- Role
  - Blood clots
    - Prevention
    - Treatment

Anticoagulants

- Direct Thrombin Inhibitors
  - Agents
    - Argatroban
    - Lepirudin (Refudan®)
    - Bivalrudin (AngiMax®)
  - 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®)
  - Eptifibatide (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
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