

**SYLLABUS**  
**ANES 403**

**By**  
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## **TEXTBOOKS and other RESOURCES**

### **Textbooks**

**REQUIRED: Primary all-class textbook (used as a “guide text”):**  
**“Clinical Anesthesiology”, Morgan, Mikhail, and Murray, 4th edition**  
**2005, McGraw Hill-Lange, ISBN = 0-07-142358-3 (ref MMM 4)**

**REQUIRED: Primary text for ANES 403 Blood gasses: “All you really**  
**need to know to interpret arterial blood gasses” L. Martin 2<sup>nd</sup> edition**  
**Lippincott, 1999, ISBN 0-683-30604-9**

**Highly Recommended: “Basics of Anesthesia” RobertK. Stoelting and**  
**Ronald D. Miller, 5<sup>th</sup> Edition, Churchill – Livingstone ISBN: 13: 978-0-**  
**443-06801-0, 2007. [Sometimes called “Baby Miller”] Reference = (SM)**

**Anesthesiology reference text: Two volumes, EXCELLENT, expensive!,**  
**Miller 5<sup>th</sup> Ed (MI5) Reference for ANES 440 Volume #1, Chapters 28-37**

**Primary Pathophysiology support text (Excellent): “Pathophysiology –**  
**Clinical concepts of disease processes” Price and Wilson 6<sup>th</sup> Ed., Mosby**  
**(PW)**

**Primary Physiology support text: “Textbook of Medical Physiology”**  
**Guyton and Hall (11<sup>th</sup> Ed), Saunders. (GH)**

**Primary Molecular biology, advanced physiology support text : “Review of**  
**Medical Physiology” Ganong, (18-19<sup>th</sup> Ed), Appleton-Lange (GA)**



## **ANES 403**

# **COMPLEX SYSTEMS PHYSIOLOGY: QUANTITATIVE APPROACHES TO SIGNIFICANT ISSUES ANESTHESIA**

ANES 403 will follow the structure, but not necessarily the content, of various texts as outlined below. Supplemental material will be added as required.

### **Objectives**

Objectives for the student:

1. To master the basic science, including mathematics, associated with a variety of important topics that have historically required special attention in practical clinical applications
2. To develop the bridging (reasoning) skills necessary to make correct clinical decisions in situations where calculation is necessary and where pathology can substantially alter management decisions.
3. To become comfortable and confident during analysis of clinical situations.

### **Methods**

These goals can be accomplished by text-directed study, answering written questions, and in-class analysis of responses to questions. Novel situations are posed by the instructor, or the students, are analyzed in class (problem-oriented instruction).

**Note: UNITS** represent lectures usually supported by PowerPoint (PPT) slides and are **APPROXIMATELY** equivalent to lecture sessions. You will always know what is “coming next”.

# **BLOOD, FLUID, and ELECTROLYTE DISTRIBUTION and PATHOLOGICAL STATES REQUIRING ATTENTION DURING ANESTHESIA.**

**GUIDE TEXT : MMM4 Chapters 28 and 29**

**EXCELLENT SUPPLEMENTARY TEXT: Price and Wilson (PW) “Pathophysiology”, 6<sup>th</sup> Edition Chapters 20-21-22 .**

Goals: To become familiar with normal body water distribution and elimination rates and routes. To predict the effects of surgery and common anesthesia practices on fluid distribution. To predict adverse effects of excess fluid loss or retention and how to reverse the effects.

## **UNIT 1**

**GUIDE TEXT : MMM4 Chapters 28 and 29**

**EXCELLENT SUPPLEMENTARY TEXT: Price and Wilson (PW) “Pathophysiology”, 6<sup>th</sup> Edition Chapters 20-21-22 . **SM Chapters 22,23,24****

### **Basic Fluid and Electrolyte Physiology**

Body Fluid Compartments

Electrolyte distribution

Measuring solute concentrations (e.g. osmolality , osmolarity)

Movement of solutes among compartments

Movement of fluid among compartments

Starling forces (origin and “balance equation”)

Erythrocyte responses to changes on osmolarity

Movement of water between plasma and ISF

Movement of Water between ECF, ICF and losses to environment

Basic concepts of regulation of key electrolytes

Sodium

Potassium

Ca<sup>++</sup> and PO<sub>4</sub> - - -

Hydrogen

Clinical assessment of fluid imbalances

- Laboratory tests
  - Osmolarity
  - Critical electrolyte and organic species “normal;” values
- Clinical evaluation of intravascular volume
- Hemodynamic measurements
- Intravenous fluids
  - Crystalloids
  - Colloids

## **UNIT 2**

**GUIDE TEXT : MMM4 Chapters 28 and 29**

**EXCELLENT SUPPLEMENTARY TEXT: Price and Wilson (PW)  
“Pathophysiology”, 6<sup>th</sup> Edition Chapters 20-21-22 . **SM Chapters  
22,23,24****

### **Fluid and Electrolyte Pathophysiology**

- Volume Imbalances
  - ECF Volume deficits
    - Etiology
    - Renal losses
    - Extra-renal losses
    - Clinical signs – impact on anesthesia
    - Review of IV fluid requirements and replacement therapy
  - ECF Volume Overload
    - Etiology
    - Clinical signs - impact on anesthesia
- Osmolality Imbalances
  - Hypo- and Hyper- natremia (Na<sup>+</sup>)
    - Etiology
    - Clinical signs – impact on anesthesia
  
  - Hypo- and Hyper- kalemia (K<sup>+</sup>)
    - Etiology
    - Clinical signs – impact on anesthesia
  
  - Hypo- and Hyper- calcemia (Ca<sup>++</sup>)
    - Etiology
    - Clinical signs – impact on anesthesia
  
  - Hypo- and Hyper- phosphatemia (PO<sub>4</sub><sup>--</sup>)

Etiology  
Clinical signs – impact on anesthesia

Hypo- and Hyper- magnesemia (Mg<sup>++</sup>)  
Etiology  
Clinical signs – impact on anesthesia

## **UNIT 3**

**MMM4 Chapter 29 pp 694-707 SM Chapter 24**

### **Transfusion and Blood Products in Anesthesia**

Fluid therapy review including blood replacement

NPO deficit

Insensible (3-rd space losses)

EBL (estimated blood loss)

ABL (allowable blood loss)

Blood products (introduction)

Blood groups

Matching

PRBC's

FFP

Cryoprecipitate

Platelets

## **KEY ELEMENTS IN HEMATOLOGY and BLOOD CLOTTING: IMPLICATIONS IN ANESTHESIA**

Goals: To understand normal hematology, clotting mechanisms and immunological function and how commonly used anesthesia-related agents alter normal functioning of these systems. How to recognize adverse reactions, how to avoid them and what to do if a reaction occurs.

**Excellent Supplemental Text:** Price and Wilson (PW) 6<sup>th</sup> Edition, Chapters 5, 6, 9, 10, 15, 16, 18

**Supplemental text** = Morgan, Mikhail and Murray (MMM4) Chapter 29

**HEMATOLOGY:** (PW Ch 16 to 18) **SM Chapters 24**

Note: MMM4 does not have concentrated material on hematology or immunology - rely on PW for basic science.

### **UNIT 4:**

#### **Blood components**

#### **Erythropoiesis**

##### Sources

Bone marrow

75% leukopoietic

25% erythropoietic

liver (F + adults in disease)

spleen (F + adults in disease)

Cellularity-vs-age (various bones)

Lab values and definitions (PW 194)

##### Pathologies

anemias

count abnormalities

Drugs and cell damage (PW 201)

#### **Leukopoiesis (PW Ch 18)**

Macrophages

Lymphocytes

T-lymphocytes

B-lymphocytes

Normal numbers in peripheral blood

Pathologies and chemotherapy (PW 212)

## **UNIT 5:**

### **Blood Clotting (PW Ch 19) SM Chapter 22**

Review of the "cascade"

intrinsic path

extrinsic path

common path

Lab values (PW 230)

DIC and other pathology (PW 230)

Hepatic disease and (MM 629)

Renal disease and (MM 594)

Pregnancy and (MM 694)

### **Components used in Bypass operations a Dialysis**

Heparin

Warfarin

Protamine

e-aminocaproic acid

Tranexamic acid

Aprotonin (?)

## **UNIT 6**

### **Receptor Physiology SM Chapters 5, 7**

Goals: To appreciate the variety of receptors that are involved in homeostasis and how anesthesia alters homeostatic functions.

### **General principles and theory**

Classification

Structures

G-proteins

Signaling cascades

PK's

2<sup>nd</sup> messengers

C-AMP

C-GMP

PDE's

Drugs used in anesthesia

### Applications in the OR

Specific receptors with drug-targeted pharmacology and clinical applications in the OR including agonists, antagonists, blocking agents and reuptake inhibitors

- Alpha class

- Beta class

- Cholinergic class (M and N)

- Dopaminergic class

- V-type (ADH)

- Adenosine

- Opioid class

- DHP and Ryanodyne

- ATr's (and ARBS)

- GABA

- Others of importance in anesthesia

Range of targets

- Nerve and muscle cell activation/depression

- Ubiquitous effects on biochemistry/molecular biology of body cells

## UNIT 7

### Ubiquitous chemical “exchange couples” in anesthesia practice.

Goals: To appreciate how drugs used in anesthesia alter normal trans-membrane transport mechanisms with beneficial and deleterious effects.

Defining couples

- Gradients

- Passive couples

- Carrier mediation

  - Facilitated

  - Active transport

- Interactive gradient control

  - Altering the gradient of X in order to transport Y

- Coupling of vastly different species

  - Potassium and glucose – clinical application

  - Hydrogen and Potassium – clinical application

  - Sodium and amino acids – clinical application

Applications in anesthesia:

Electrolyte imbalance

Diuretics

Cardioactive drugs (digoxin)

Aldosterone

## **UNIT 8**

### **Important Biochemical Pathways in anesthesia**

The arachidonic acid pathway

Triggers

Enzymes (COX and LOX)

The products

Pro-inflammatory substances

Leukotrienes

Prostaglandins

Pharmacological control of the pathway

Implications in anesthesia

The use of NSAIDs and steroids

Second messenger-based pathways

Adenylate/guanylate cyclase

G-protein coupling

Phosphodiesterase (PDE) and PDE inhibitors

Implications in anesthesia

The use of xanthines and PDEi's

Reactive oxygen species (ROS) – importance in anesthesia

O<sub>2</sub>·, OH·, H<sub>2</sub>O<sub>2</sub>, peroxynitrate

Effects on blood vessels

Lung

Kidney

Quenching

Se

Vitamin E

Vitamin C

Catalase

Superoxide dismutase (SOD)

Possible beneficial effects of

Anesthetic preconditioning

Ischemic preconditioning

Possible prophylactic use of Beta-blockers in surgery

Caution with unopposed beta-blockage s/ alpha-blockade.

Renin-angiotensin-aldosterone system

Applications in anesthesia

## UNIT 9

# BLOOD GAS THEORY, MEASUREMENT AND ANALYSIS

**GUIDE TEXT => Lawrence Martin (LM), “All you really need to know to interpret arterial blood gasses” Chapters 1 to 6 inclusive. Return and review Pages xvii to xxxiii at the END of this module. SM Chapter 6**

**EXCELLENT PARALLEL TEXT=>Price and Wilson 6<sup>th</sup> Edition Chapters 35 and 36**

**PARALLEL TEXT =>MMM4 Chapter 22**

Goals: To become familiar with the physiological principles of gas diffusion and distribution to organs and tissues in the body. To be able to predict the consequences of changes in “normal values” and what to do to correct problems. To be able to analyze blood gas lab reports. NOTE: This module is NOT INTENDED to cover all of respiratory physiology, details are presented elsewhere.

### **Preliminaries (Chapter 1)**

Measurements made on a blood sample  
Requirements for interpreting ABG's

### **Three physiological processes and 4 equations (Chapter 2)**

PCO<sub>2</sub>  
Alveolar Gas  
Oxygen content  
Henderson-Hasselbach

### **Focus on PaCO<sub>2</sub> in relation to alveolar ventilation (Chapter 3)**

Clinical assessment  
Capnography overview  
End-tidal CO<sub>2</sub>  
Problems  
Clinical applications

Relationship between PaCO<sub>2</sub>, Oxygenation and Acid-base balance

**Focus on PaO<sub>2</sub> and (A-a)O<sub>2</sub> (Chapter 4)**

Alveolar gas equation and shunting

The (A-a)O<sub>2</sub> function

Clinical applications

Detecting hypoxemia

**Focus on PaO<sub>2</sub>, SaO<sub>2</sub> and CaO<sub>2</sub> (Chapter 5)**

Definitions

HgB saturation

Difference between SaO<sub>2</sub>, PaO<sub>2</sub> and CaO<sub>2</sub>

Hypoxia –vs- hypoxemia

**Focus on SaO<sub>2</sub> and pulse oximetry (Chapter 6)**

Contributions to SaO<sub>2</sub> readings

Pitfalls in calculating SaO<sub>2</sub>

P50 and HgB curve shifts

CO and the HgB saturation curve

Pulse oximetry in clinical practice

**Clinical Problem Solution (Martin clinical problems)**

## UNIT 10

### ACID/BASE BALANCE and BUFFERING

**GUIDE TEXT:** Lawrence Martin (LM). Chapters 7 – 8. Chapter 9 (case analysis)

**SM Chapters 21, 28**

**PARALLEL TEXT => MMM4 Chapter 30 (overview of therapies only. May be too advanced for novice)**

**EXCELLENT PARALLEL TEXT => Price and Wilson. Chapter 22 (clear and concise – good for novice)**

Goals:

To become familiar with the physiological principles which govern the regulation of blood and tissue pH, CO<sub>2</sub> distribution and metabolic acid handling. To predict the results of disturbances to normal mechanisms and to fix problems.

Clinical challenges will be the order of the day.

#### **Focus on pH, PaCO<sub>2</sub>, electrolytes and Acid-base status (Chapter 7)**

The Henderson\_Hasselbach equation and pH  
Measuring pH and defining acidemia and alkalemia  
The value of venous CO<sub>2</sub>  
Electrolytes and the anion gap (AG)  
The bicarbonate gap  
Diagnostic flow chart  
Base Excess/Deficit

#### **Focus on Primary and mixed acid-base disorders (Chapter 8)**

Basic definitions  
    Respiratory and metabolic acidosis  
    Respiratory and metabolic alkalosis  
Compensations  
Mixed disorders

## Diagnostic flow chart

## UNIT 11

# ALLERGIC AND ADVERSE REACTIONS.

(PW Ch 5, 9, 10, MMM4 Ch 46)

Goal: To appreciate the fundamentals and complexity of the immune system and be able to classify various kinds of "allergic" reactions and to know triggers and cautions. To appreciate the importance blood typing and matching.

**The Hypersensitivity reaction** – the root of many problems

Mast cells

- found largely in connective tissue
- have IgE receptors

Immune system

- fast
- exquisitely specific
- adaptable
- memory

B-cell (HUMORAL)

The Ig's

- E - body surface atopia (masts- histamine)
- G - extravascular - antibacterial, antitoxin

Blocking Ig-x by cromalyn

Releases

- histamine (masts 70% all histamine)
- leukotrienes (neg inotropes)
- chemotaxins (attract EOS, neutrophils => inflammation)

TYPE I - anaphylaxis, extrinsic asthma, allergic rhinitis

TYPE II - cytotoxic - ABO incompatibilities, immune hemolytic anemia, heparin-induced thrombocytopenia

TYPE III - immune complex - serum sickness (snake antisera), nephritis due to immune complex formation

T-cell (CELL MEDIATED)

TYPE IV - delayed hypersensitivity. - graft rejection, contact dermatitis (poison ivy), tuberculin immunity.

### Anaphylaxis (means “excessive protection”)

- \* females:males = 3:1 ==> OB expects more rxn's
- \* spinal cord deformity LATEX =>incr risk ==> ped neuro expect more. 12% in other individuals
- \* 52% of all life threatening reactions (LTR) under anes due to anaphylaxis and this is 1:3500 cases
- \* 80% of LTR occur at induction
- \* Large regional differences (Minnesota 1:1100, vs Texas 28:967
- \* due to MR's(70% of all LTRs), sedatives, hypnotics, antibiotics (give 1H PREOP! not intraop)

### Anaphylactoid reactions

- \* very frequent
- \* chemically mediated (histamine)
- \* non-immunologic
- \* Tracrium (direct histamine), propofol (1:60K),
- \* opiates "xis" rare, "oid" common - GI and cutaneous
- \* fentanyl no histamine but 0.76% "xis"

### Major types

- non-IgE complement
- non-IgE histamine

### How to recognize (see MMM4 Chapter 46) (PW Chapter 9)

- systems - signs - symptoms reviewed
- causal agents (leukotrienes, prostaglandins, kinins )
- list of allergens

### Treatment of untoward “reactions” (MMM4)

### Blood Transfusion Reactions (MMM4 Chapter 29 pp 700)

ABO mismatch

Other agglutinogens

Rh factor

Complications revisited (Renal transplant example PW 746 to 752)

**UDH: 02.07.2002rc, 04.07.2003rc, 03.21.2004rc, 08.17.2005rc,  
06.15.2007rc, 06.10.2008rc, 07.16.2008 rc, 04.20.2009rc 06.24.2009rc  
07.27.2009rc**