UNIT TERMINAL OBJECTIVE

1-6 At the completion of this unit, the paramedic student will be able to apply the general concepts of pathophysiology for the assessment and management of emergency patients.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

1-6.1 Discuss cellular adaptation. (C-1)
1-6.2 Describe cellular injury and cellular death. (C-1)
1-6.3 Describe the factors that precipitate disease in the human body. (C-1)
1-6.4 Describe the cellular environment. (C-1)
1-6.5 Discuss analyzing disease risk. (C-1)
1-6.6 Describe environmental risk factors. (C-1)
1-6.7 Discuss combined effects and interaction among risk factors. (C-1)
1-6.8 Describe aging as a risk factor for disease. (C-1)
1-6.9 Discuss familial diseases and associated risk factors. (C-1)
1-6.10 Discuss hypoperfusion. (C-1)
1-6.11 Define cardiogenic, hypovolemic, neurogenic, anaphylactic and septic shock. (C-1)
1-6.12 Describe multiple organ dysfunction syndrome. (C-1)
1-6.13 Define the characteristics of the immune response. (C-1)
1-6.14 Discuss induction of the immune system. (C-1)
1-6.15 Discuss fetal and neonatal immune function. (C-1)
1-6.16 Discuss aging and the immune function in the elderly. (C-1)
1-6.17 Describe the inflammation response. (C-1)
1-6.18 Discuss the role of mast cells as part of the inflammation response. (C-1)
1-6.19 Describe the plasma protein system. (C-1)
1-6.20 Discuss the cellular components of inflammation. (C-1)
1-6.21 Describe the systemic manifestations of the inflammation response. (C-1)
1-6.22 Describe the resolution and repair from inflammation. (C-1)
1-6.23 Discuss the effect of aging on the mechanisms of self-defense. (C-1)
1-6.24 Discuss hypersensitivity. (C-1)
1-6.25 Describe deficiencies in immunity and inflammation. (C-1)
1-6.26 Describe homeostasis as a dynamic steady state. (C-1)
1-6.27 List types of tissue. (C-1)
1-6.28 Describe the systemic manifestations that result from cellular injury. (C-1)
1-6.29 Describe neuroendocrine regulation. (C-1)
1-6.30 Discuss the inter-relationships between stress, coping, and illness. (C-1)

AFFECTIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

1-6.31 Advocate the need to understand and apply the knowledge of pathophysiology to patient assessment and treatment. (A-2)

PSYCHOMOTOR OBJECTIVES

None identified for this unit.

DECLARATIVE

I. Introduction
- A. Correlation of pathophysiology with disease process
  - 1. Cells appear similar to multicellular "social" organism
  - 2. Cells communicate electrochemically - when interrupted disease processes can initiate and advance
  - 3. Knowledge of coordination of specific bodily functions leads to better understanding of the disease process
    - a. Endocrine
    - b. Exocrine
    - c. Other coordinating receptors
      - (1) Chemoreceptors
      - (2) Baroreceptors
      - (3) Adrenergic
      - (4) Others
- B. Correlation of disease process with care provided to patients by paramedics
  - 1. Understanding disease process is important for paramedics to better understand, anticipate, correct, and provide appropriate care
    - a. Once knowledge of physical laws and principles have been gained paramedics can apply these to the mechanisms and complications of disease
    - b. Cells of the immune system and inflammatory responses are found with every type of trauma or disease process

II. Basic cellular review
- A. Major classes of cells - living cells divided into two major divisions
- B. Chief cellular functions
  - 1. Cells become specialized through process of differentiation, or maturation
  - 2. Eventually perform one function or act in concert with other cells to perform a more complex task
- C. Cellular components
  - 1. Structure & function
  - 2. Three main components
- D. Tissue types
  - 1. Epithelial tissue
  - 2. Connective tissue
  - 3. Muscle tissue
  - 4. Nervous tissue

III. Alterations in cells and tissues
- A. Cellular adaptation - cells adapt to their environment to avoid and protect themselves from injury; adapted cells are neither normal or injured (they are somewhere between these two states)
  - 1. Cellular adaptations are common and a central part of many disease states
    - a. Early stages of a successful adaptation response may enhance the cell's function
    - b. Difficult to determine pathological responses versus an extreme adaptation to an excessive functional demand
  - 2. Atrophy
  - 3. Hypertrophy
  - 4. Hyperplasia

5. Dysplasia
6. Metaplasia

B. Cellular injury
   1. Hypoxic injury
      a. Most common cause of cellular injury
      b. May result from
         (1) Decreased amounts of oxygen in the air
         (2) Loss of hemoglobin or hemoglobin function
         (3) Decreased number of red blood cells
         (4) Disease in respiratory or cardiovascular system
         (5) Loss of cytochromes
   2. Chemical injury
      a. Chemical agents causing cellular injury
         (1) Poisons
         (2) Lead
         (3) Carbon monoxide
         (4) Ethanol
         (5) Pharmacological
   3. Infectious injury
      a. Virulence or pathogenicity of microorganisms depends on their ability to survive and reproduce in the human body, where they injure cells and tissues
         (1) Disease producing potential depends upon its ability to
            (a) Invade and destroy cells
            (b) Produce toxins
            (c) Produce hypersensitivity reactions
      b. Bacteria
         (1) Survival and growth depend upon the effectiveness of the body's defense mechanisms and the bacteria's ability to resist the mechanisms
            (a) Coating protects the bacterium from ingestion and destruction by phagocytes and capsules may also function as exotoxins
            (b) Not all virulent extracellular pathogens are encapsulated - mycobacterium tuberculosis can survive and be transported by phagocytes
         (2) Bacteria also produce substances such as enzymes or toxins which can injure or destroy cells
            (a) Toxins are produced by many microorganisms
               i) Exotoxins
               ii) Endotoxins
            (b) Fever is caused by the release of endogenous pyrogens from macrophages or circulating white blood cells that are attracted to the injury site
            (c) Inflammation is one of the body's responses to the presence of bacteria
            (d) Ability to produce hypersensitivity reactions is an important pathogenic mechanism of bacteria toxins
            (e) Bacteremia or septicemia is proliferation of microorganisms in the blood
      c. Viruses
         (1) Viral disease are among the most common afflictions seen in humans
         (2) Intracellular parasites that take over the control of metabolic machinery of host cells for use to replicate the virus

(3) Protein coat (capsid) encapsulating most viruses allows them to resist phagocytosis
(4) Viral replication occurs within the host cell
(5) Having no organelles, viruses are incapable of metabolism
(6) Causes decreased synthesis of macromolecules vital to the host cell
(7) Viruses do not produce exotoxins or endotoxins
(8) There may be a symbiotic relationships between viruses and normal cells resulting in a persistent unapparent infection
(9) Viruses can evoke a strong immune response but can rapidly produce irreversible and lethal injury in highly susceptible cells (as in AIDS)

4. Immunologic and inflammatory injury
   a. Cellular membranes are injured by direct contact with cellular and chemical components of the immune or inflammatory process as in phagocytes (lymphocytes and macrophages) and others such as histamine, antibodies, lymphokines
   b. Membrane alterations are associated with rapid leakage of potassium out of the cell and an influx of water
5. Injurious genetic factors
6. Injurious nutritional imbalances
7. Injurious physical agents

C. Manifestations of cellular injury
   1. Cellular manifestations
   2. Systemic manifestations
D. Cellular death/ necrosis

IV. The cellular environment
A. Distribution of body fluids
   1. Intracellular fluid (ICF)
   2. Extracellular fluid (ECF)
      a. Interstitial fluid
      b. Intravascular fluid
      c. Other
   3. Total body water (TBW)
B. Aging and distribution of body fluids
   1. Birth
   2. Infancy
   3. Childhood
   4. Adulthood
   5. Elderly
C. Water movement between ICF and ECF
   1. Osmotic forces
   2. Role of sodium and potassium
D. Water movement between plasma and interstitial fluid
   1. Osmotic forces within capillary bed
   2. Starling's hypothesis
   3. Role of capillary and membrane permeability
E. Alterations in water movement
   1. Edema
      a. Pathophysiology
         (1) Increased capillary permeability
         (2) Decreased oncotic pressure
         (3) Increased capillary hydrostatic pressure

(4) Hydrostatic pressure
(5) Lymphatic vessel obstruction
b. Clinical manifestations
(1) Local
(2) Generalized
c. Evaluation and treatment

F. Water balance and the role of electrolytes
1. Water balance
a. Role of antidiuretic hormone (ADH)
b. Receptors
(1) Osmoreceptors
(2) Volume sensitive receptors
(3) Baroreceptors
2. Sodium and chloride balance
a. Role and function of sodium as a cation
b. Role and function of chloride as an anion
c. Hormone regulation by aldosterone and natriuretic hormone
d. Role of renin-angiotensin system
3. Alterations in sodium, chloride, and water balance
a. Isotonic alterations
(1) Isotonic volume depletions
(2) Isotonic volume excesses
b0 Hypertonic alterations
(1) Hypernatremia
(2) Water deficit
(3) Hyperchloremia
c0 Hypotonic alterations
(1) Hyponatremia
(2) Water excess
(3) Hypochloremia
4 Alterations in potassium, calcium, phosphate, and magnesium balance
a0 Potassium
(1) Hypokalemia
(2) Hyperkalemia
b0 Calcium and phosphate
(1) Hypocalcemia
(2) Hypercalcemia
(3) Hypophosphatemia
(4) Hyperphosphatemia
c0 Magnesium
(1) Hypomagnesemia
(2) Hypermagnesemia

G0 Acid - base balances
1 Hydrogen ion and pH
2 Buffer systems
a0 Carbonic acid-bicarbonate buffering
b0 Protein buffering
c0 Renal buffering
d0 Other buffers

- 3 Acid-base imbalances
  - a0 Metabolic acidosis
    - (1) Pathophysiology
    - (2) Clinical presentation
    - (3) Evaluation and treatment
  - b0 Metabolic alkalosis (rare)
    - (1) Pathophysiology
    - (2) Clinical presentation
    - (3) Evaluation and treatment
  - c0 Respiratory acidosis
    - (1) Pathophysiology
    - (2) Clinical presentation
    - (3) Evaluation and treatment
  - d0 Respiratory alkalosis
    - (1) Pathophysiology
    - (2) Clinical presentation
    - (3) Evaluation and treatment

V Genetics and familial diseases

- A0 Factors causing disease
  - 1 Genetic
  - 2 Environmental
    - a0 Microoganisms and immunologic exposures
    - b0 Personal habits and life-style
    - c0 Chemical substances
    - d0 Physical environment
    - e0 Psychosocial environment
  - 3 Age and gender
    - a0 Accumulative affects of both genetic and environmental factors
    - b0 Life-style, anatomic, or hormonal differences
- B0 Analyzing disease risk
  - 1 Disease rates
    - a0 Incidence rate
    - b0 Prevalence rate
    - c0 Mortality rate
  - 2 Risk factor analysis
    - a0 Causal risk factors
    - b0 Noncausal risk factors
- C0 Combined effects and interaction among risk factors
  - 1 Familial disease tendency
  - 2 Aging and age-related disorders
- D0 Common familial disease and associated risk factors
  - 1 Immunologic disorders
    - a0 Allergies
    - b0 Asthma
    - c0 Rheumatic fever
  - 2 Cancer
    - a0 Breast cancer
    - b0 Colorectal cancer
    - c0 Lung cancer

- 3 Endocrine disorders
  - a0 Diabetes mellitus
    - (1) Insulin-dependent diabetes mellitus
    - (2) Non-insulin dependent diabetes mellitus
- 4 Hematologic disorders
  - a0 Drug-induced hemolytic anemia
  - b0 Hemophilia
  - c0 Hematochromatosis
- 5 Cardiovascular disorders
  - a0 Long QT syndrome (autosomal dominant disorder)
  - b0 Cardiac myopathies
  - c0 Mitral valve prolapse
  - d0 Coronary heart disease
    - (1) Family history and CHD risk
    - (2) Genetic factors and predisposition
  - e0 Hypertension and stroke
- 6 Renal disorders
  - a0 Gout (uric acid accumulation)
  - b0 Kidney stones
- 7 Gastrointestinal disorders
  - a0 Malabsorption disorders
    - (1) Lactose intolerance
    - (2) Ulcerative colitis
    - (3) Crohn's disease
  - b0 Peptic ulcers
  - c0 Gallstones
  - d0 Obesity
    - (1) Associated disease processes
    - (2) Causal risk factors
- 8 Neuromuscular disorders
  - a0 Huntington disease
  - b0 Muscular dystrophy
  - c0 Multiple sclerosis
  - d0 Alzheimer disease
- 9 Psychiatric disorders
  - a0 Schizophrenia
  - b0 Manic-depressive

VI Hypoperfusion

- A0 Pathogenesis
  - 1 Decreased cardiac output
  - 2 Compensatory mechanisms
    - a0 Catecholamine release
      - (1) Epinephrine and norepinephrine
      - (2) Increase in systemic vascular resistance
    - b0 Role of aldosterone renin-angiotensin, and ADH
      - (1) Adequate or increased blood volume
      - (2) Vasoconstriction increases systemic blood pressure
    - c0 Shift of interstitial fluid
    - d0 Splenic discharge

- 3 Increased preload, stroke volume, and heart rate
  - a0 Increased myocardial oxygen demand
  - b0 Systemic and pulmonary edema
    - (1) Dyspnea
    - (2) Dusky skin color
    - (3) Low blood pressure
    - (4) Oliguria
    - (5) Impaired mentation
  - c0 Decreased cardiac output and ejection fraction
    - (1) Decreased blood pressure
    - (2) Decreased tissue perfusion
    - (3) Impaired cellular metabolism

B0 Types of Shock

- 1 Cardiogenic shock
  - a0 Defined
  - b0 Pathophysiology
  - c0 Evaluation and treatment
- 2 Hypovolemic shock
  - a0 Defined
  - b0 Pathophysiology
  - c0 Evaluation and treatment
- 3 Neurogenic shock
  - a0 Defined
  - b0 Pathophysiology
  - c0 Evaluation and treatment
- 4 Anaphylactic shock
  - a0 Defined
  - b0 Pathophysiology
  - c0 Evaluation and treatment
- 5 Septic Shock
  - a0 Defined
  - b0 Pathophysiology
  - c0 Evaluation and treatment

C0 Multiple organ dysfunction syndrome (MODS)

- 1 Defined
  - a0 Progressive failure of two or more organ systems
  - b0 Occurs after severe illness or injury
  - c0 New diagnosis first described in 1975
  - d0 Mortality rate of 60% - 90%
  - e0 Major cause of death following septic, traumatic, and burn injuries
- 2 Pathophysiology
  - a0 Injury or endotoxin release
  - b0 Vascular endothelial damage, neuroendocrine response, and release of inflammatory mediators
  - c0 Activation of complement, coagulation, and kallikrein/ kinin systems
  - d0 Massive systemic immune/ inflammatory and coagulation responses
  - e0 Vascular changes
    - (1) Vasodilation
    - (2) Increase in capillary permeability
    - (3) Selective vasoconstriction
    - (4) Microvascular thrombi

- f0 Maldistribution of systemic and organ blood flow
- g0 Hypermetabolism
- h0 Oxygen supply/ demand imbalance
- i0 Tissue hypoxia
  - (1) Tissue hypoperfusion
  - (2) Exhaustion of fuel supply (i.e. ATP, glucose, etc)
  - (3) Metabolic failure
  - (4) Lysosome breakdown
  - (5) Anaerobic metabolism
  - (6) Acidosis and impaired cellular function
- j0 Organ dysfunction
  - (1) Decreased cardiac function and myocardial depression
  - (2) Renal failure
  - (3) Failure of smooth muscle of vascular system
    - (a) Release of capillary sphincters
    - (b) Vasodilation

3 Clinical presentation - 24 hours after initial resuscitation
- a0 Low-grade fever due to inflammatory responses
- b0 Tachycardia
- c0 Dyspnea and adult respiratory distress syndrome (ARDS)
- d0 Altered mental status
- e0 Hyperdynamic state
- f0 Hypermetabolic states
- g0 Renal and liver failure (14 - 21 days)
- h0 Gastrointestinal and immune collapse (14 - 21 days)
- i0 Cardiovascular collapse and death (21 - 28 days)

D0 Cellular metabolism impairment

1 Oxygen impairment
- a0 Anaerobic metabolism
- b0 Increased lactate
- c0 Metabolic acidosis
- d0 Decreased oxygen affinity for hemoglobin
- e0 Decreased ATP
- f0 Changes in cellular electrolytes
- g0 Cellular edema
- h0 Release of lysosomal enzymes

2 Impaired glucose use
- a0 Increase serum glucose
- b0 Catecholamines, cortisol, growth hormone release
- c0 Increased gluconeogenesis, gluconeolysis, and lipolysis

VII Self-defense mechanisms

A0 Introduction - lines of defense
- 1 Anatomic barriers
- 2 Inflammatory response
- 3 Immune response

B0 Characteristics of the immune response

1 Natural versus acquired immunity
- a0 Natural or native immunity
- b0 Acquired immunity

(1) Active acquired immunity
(2) Passive acquired immunity
2 Primary versus secondary immunity
a0 Primary or initial immune response
b0 Secondary or anamnestic immune response
3 Humoral versus cell-mediated immunity
a0 B-cell lymphocyte
b0 T-cell lymphocyte
C0 Induction of the immune response
1 Antigens and immunogens
a0 Antigens
b0 Immunogen
c0 Tolerance
d0 Molecular size
(1) Larger - proteins, polysaccharides, and nucleic acids
(2) Smaller - amino acids, monosaccharides, and fatty acids
(3) Haptens - smaller molecules which become immunogenic
2 Histocompatibility antigens (HLA antigens)
a0 HLA complexes or major histocompatibility complexes (MHC)
b0 Role of HLA antigens
3 Blood group antigens
a0 Rh system
b0 ABO system
D0 Humoral immune response
1 B-cell lymphocytes
a0 Formation
(1) Lymphoid stem cell
(2) Generation of clonal diversity
(3) Clonal selection
(4) Activated B-cell
(a) Immunoglobulin-secreting plasma cells found in blood and secondary lymphoid organs
(b) Memory cells - responsible for long term immunity
2 Immunoglobulins
a0 Differences between immunoglobulins and antibodies
b0 Structure of immunoglobulin molecules
c0 Function of antibodies
(1) Agglutination
(2) Precipitation
(3) Neutralization
(a) Bacterial toxins
(b) Viruses
(c) Opsonization of bacteria
(d) Activation of inflammatory processes
(e) Classes of immunoglobulins
(f) Antibodies as antigens
(4) Isotypic antigens
(5) Allotypic antigens
(6) Idiotypic antigenic determinants
d0 Monoclonal antibodies

- 3 Secretory immune system
  - a0 Mucosal-associated lymphoid tissue
    - (1) Lacrimal glands
    - (2) Salivary glands
    - (3) Bronchial-associated lymphoid tissue
    - (4) Mammary-associated lymphoid tissue
    - (5) Gut-associated lymphoid tissue
    - (6) Genital-associated lymphoid tissue
  - b0 Circulates independently of other lymphocytes
    - (1) Mucosal-associated lymphoid tissue
    - (2) Regional lymph nodes
    - (3) Thoracic duct
    - (4) Blood
  - c0 One of body's first lines of defense
  - d0 Occurs locally rather than systemically

E0 Cell-mediated immune response

- 1 T-cells
  - a0 Five types of mature T-cells
    - (1) Memory cells
    - (2) Td cells or lymphokine-producing cells
    - (3) Tc cells or cytotoxic cells
    - (4) Th cells or helper T-cells
    - (5) Ts cells or suppressor T-cells
  - b0 Proliferation and differentiation
- 2 Major effects of cell-mediated immune response
  - a0 Cytotoxicity
  - b0 Delayed hypersensitivity
  - c0 Memory
  - d0 Control

F0 Cellular interactions in the immune response

- 1 Cytokines
  - a0 Lymphokines
  - b0 Monokines
- 2 Antigen processing, presentation, and recognition
  - a0 Antigen degradation
  - b0 Classes of histocompatible antigens (HLA)
  - c0 T-cell receptors
  - d0 Interleukin - 1 (IL-1)
- 3 T-cell and B-cell differentiation
  - a0 T-cell differentiation
  - b0 B-cell differentiation
  - c0 Control of B and T-cell development

G0 Fetal and neonatal immune function

- 1 Fetal immunological capabilities
  - a0 Immunologic responses
  - b0 Antibody capabilities
- 2 Antibody levels
  - a0 Umbilical cord blood
  - b0 Neonatal circulation
- 3 Trophoblasts

H0 Aging and the immune response in elderly
- 1 T-cell function
- 2 Antibody production

VIII Inflammation
- A0 The acute inflammatory response
  - 1 Triggers
    - a0 Lethal cellular injury
    - b0 Non-lethal cellular injury
    - c0 Other microorganisms
  - 2 Response
    - a0 Vascular responses to inflammation
    - b0 Cellular responses to inflammation
- B0 Mast cells
  - 1 Degranulation of vasoactive amines and chemotactic factors
    - a0 Stimulation of degranulation
      - (1) Physical injury
      - (2) Chemical agents
      - (3) Immunological (IgE-mediated hypersensitivity)
    - b0 Vasoactive amines
      - (1) Histamine
      - (2) Serotonin
    - c0 Chemotactic factors
      - (1) Neutrophil
      - (2) Eosinophil
  - 2 Synthesis of leukotrienes and prostaglandins
    - a0 Leukotrienes or slow-reacting substances of anaphylaxis (SRS-A)
      - (1) Composition
      - (2) Function
    - b0 Prostaglandins
      - (1) Composition
      - (2) Function
- C0 Plasma protein systems
  - 1 Complement system
    - a0 Structure and function
    - b0 Activation
      - (1) Classic pathway
      - (2) Alternative pathway
  - 2 Clotting system
    - a0 Structure and function
    - b0 Activation
      - (1) Extrinsic pathway
      - (2) Intrinsic pathway
  - 3 Kinin system
    - a0 Structure and function
    - b0 Activation
      - (1) Plasma kinin cascade
  - 4 Control and interaction of the plasma protein system
    - a0 Reason for control
    - b0 Types of control
      - (1) Antagonists

(2) Histamine control
(3) Interaction of control processes

D0 Cellular components of inflammation
1 Functions of phagocytes
a0 Margination
b0 Diapedesis
c0 Exudation into inflamed tissue
d0 Process of phagocytosis
2 Polymorphonuclear neutrophils
a0 Predominance in early inflammatory response
b0 Role
3 Monocytes and macrophages
a0 Monocyte - young macrophage
(1) Structure
(2 Role
b. Macrophages
(1 Structure
(2 Role
4. Eosinophils
a. Structure
b. Role

E. Cellular products
1. Interleukins (ILs)
a. Interleukin - 1
b. Interleukin - 2
2. Lymphokines
a. Production
b. Types and effects
(1 Migration-inhibitory factor
(2 Macrophage-activating factor
3. Interferon
a. Structure
b. Actions and effects

F. Systemic responses of acute inflammation
1. Fever
a. Activation
b. Effects
2. Leukocytosis
a. Activation
b. Effects
3. Increase in circulating plasma proteins or acute-phase reactants
a. Activation
b. Effects

G. Chronic inflammation responses
1. Causes
a. Unsuccessful acute inflammatory response due to foreign body
b. Persistence of infection or antigen
2. Characteristics
a. Persistence of acute inflammation response
b. Neutrophil degranulation and death
c. Lymphocyte activation

d. Fibroblast activation
e. Infiltration (pus)
f. Tissue repair (scar)

H. Local inflammation responses
1. Vascular changes
a. Vasodilation
b. Increased capillary permeability
2. Exudation
a. Functions
b. Compositions

I. Phases of resolution and repair
1. Definitions
a. Regeneration
b. Repair
c. Debridement
d. Primary intention
e. Secondary intention
2. Reconstruction phase
a. Initial wound response
b. Granulation
c. Epithelialization
3. Maturation Phase
a. Completion of contraction, differentiation, and remodeling of scar tissue
b. Disappearance of capillaries from scar tissue
4. Dysfunctional wound healing
a. Dysfunction during the inflammatory response
b. Dysfunction during the reconstruction phase
(1 Impaired collagen synthesis
(2 Impaired epithelialization
(3 Wound disruption
(4 Impaired contraction

J. Aging and self-defense mechanisms
1. Newborn
2. Elderly

IX. Variances in immunity and inflammation
A. Hypersensitivity: allergy, autoimmunity, and isoimmunity
1. Definitions
a. Hypersensitivity
b. Allergy
c. Autoimmunity
d. Isoimmunity
2. Mechanisms of hypersensitivity
a. Immediate versus delayed reactions
b. IgE reactions
(1 Role of IgE
(2 Mechanism of IgE
(3 Clinical indications
(4 Genetic predisposition
(5 IgE-mediated hypersensitivity tests
(6 Desensitization

c. Tissue-specific reactions
(1 Tissue-specific antigens
(2 Mechanisms
d. Immune-complex mediated injury
(1 Mechanisms
(2 Immune-complex disease
e. Cell-mediated tissue destruction
(1 Mechanisms
(2 Clinical instances
3. Targets of hypersensitivity
a. Allergy
(1 Allergens
(2 Neoantigen
b. Autoimmunity
(1 Breakdown of tolerance
(2 Original insult
(3 Genetic factors
c. Isoimmunity
(1 Transient neonatal diseases
(2 Transplant rejections and transfusion reactions
4. Autoimmune and isoimmune diseases
a. Grave's disease
b. Rheumatoid arthritis
c. Myasthenia gravis
d. Immune thrombocytopenic purpura
e. Isoimmune neutropenia
f. Systemic lupus erythematosus (SLE)
g. Rh and ABO isoimmunization

B. Immunity and inflammation deficiencies
1. Congenital immune deficiencies
2. Acquired deficiencies
a. Nutritional deficiencies
b. Iatrogenic deficiencies
c. Deficiencies caused by trauma
d. Deficiencies caused by stress
e. AIDS
3. Replacement therapies for immune deficiencies
a. Gamma globulin therapy
b. Transplantation and transfusion
c. Gene therapy

X. Stress and disease
A. Concepts of stress
1. Triad of manifestations
2. General adaptation syndrome (Selye)
a. Alarm stage
b. Resistance or adaptation stage
c. Exhaustion stage
d. Definition of physiological stress

3. Psychologic mediators and specificity
   a. Psychologic factors effects on physiological responses to stress
   b. Pituitary gland and adrenal cortex sensitivity to emotional, psychologic and social influences
4. Homeostasis as a dynamic steady state
   a. Definitions
      (1 Dynamic steady state
      (2 Turnover
   b. Reaction of body to stressors

B. Stress responses
1. Psychoneuroimmunologic response
   a. Interaction of consciousness, brain and central nervous system, and the body's defense mechanisms
   b. Stress response
2. Neuroendocrine regulation
   a. Catecholamines
      (1 Components
         (a Epinephrine
         (b Norepinephrine
      (2 Physiologic actions of alpha and beta receptors
         (a $Alpha_1$
         (b $Alpha_2$
         (c $Beta_1$
         (d $Beta_2$
      (3 Physiologic effects of catecholamines
         (a Brain
         (b Cardiovascular
         (c Pulmonary
         (d Muscle
         (e Liver
         (f Adipose Tissue
         (g Skin
         (h Skeleton
         (i G.I. and G.U. systems
         (j Lymphoid tissue
   b. Cortisol
      (1 Source
      (2 Primary effects of cortisol
         (a Stimulation of glucogenesis
         (b Formation of glycogen
         (c Cortisol effects on cell-mediated immunity
      (3 Other physiologic effects of cortisol
         (a Protein metabolism
         (b Digestive function
         (c Urinary function
         (d Connective tissue function
         (e Muscle function
         (f Bone function
         (g Vascular system and myocardial function
         (h Central nervous system function

c. Other hormones
(1 Endorphins
(2 Growth hormone
(3 Prolactin
(4 Testosterone

d. Role of the immune system
(1 Interaction of immune, nervous, and endocrine systems during a stress response
(2 Influence of stress response on immune system
(3 Relationship between stress and immune-related conditions and diseases
(a Cardiovascular
(b Muscles
(c Connective tissue
(d Pulmonary system
(e Immune system
(f G.I. system
(g G.U. system
(h Skin
(i Endocrine system
(j Central nervous system

C. Stress, coping, and illness interrelationships
1. Stress as interdependent processes
a. Definition of physiologic stress and psychologic distress
b. Effects of psychologic distress
c. Relationship between distress and immune dysfunction
2. Potential stress effects on
a. Healthy individuals
(1 Ineffective coping
(2 Effective coping
b. Symptomatic individuals
(1 Ineffective coping
(2 Effective coping
c. Medical interventions
(1 Ineffective coping
(2 Effective coping

REFERENCE

McCance, K.L., Heuther, S.E., (1994). *Pathophysiology: The Biological Basis for Disease in Adults and Children* (2nd ed.) St. Louis: Mosby-Yearbook.

UNIT TERMINAL OBJECTIVE

2-1 At the completion of this unit, the paramedic student will be able to establish and/ or maintain a patent airway, oxygenate, and ventilate a patient.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

2-1.1 Explain the primary objective of airway maintenance. (C-1)
2-1.2 Identify commonly neglected prehospital skills related to airway. (C-1)
2-1.3 Identify the anatomy of the upper and lower airway. (C-1)
2-1.4 Describe the functions of the upper and lower airway. (C-1)
2-1.5 Explain the differences between adult and pediatric airway anatomy. (C-1)
2-1.6 Define gag reflex. (C-1)
2-1.7 Explain the relationship between pulmonary circulation and respiration. (C-3)
2-1.8 List the concentration of gases that comprise atmospheric air. (C-1)
2-1.9 Describe the measurement of oxygen in the blood. (C-1)
2-1.10 Describe the measurement of carbon dioxide in the blood. (C-1)
2-1.11 Describe peak expiratory flow. (C-1)
2-1.12 List factors that cause decreased oxygen concentrations in the blood. (C-1)
2-1.13 List the factors that increase and decrease carbon dioxide production in the body. (C-1)
2-1.14 Define atelectasis. (C-1)
2-1.15 Define FiO_2. (C-1)
2-1.16 Define and differentiate between hypoxia and hypoxemia. (C-1)
2-1.17 Describe the voluntary and involuntary regulation of respiration. (C-1)
2-1.18 Describe the modified forms of respiration. (C-1)
2-1.19 Define normal respiratory rates and tidal volumes for the adult, child, and infant. (C-1)
2-1.20 List the factors that affect respiratory rate and depth. (C-1)
2-1.21 Explain the risk of infection to EMS providers associated with ventilation. (C-3)
2-1.22 Define pulsus paradoxes. (C-1)
2-1.23 Define and explain the implications of partial airway obstruction with good and poor air exchange. (C-1)
2-1.24 Define complete airway obstruction. (C-1)
2-1.25 Describe causes of upper airway obstruction. (C-1)
2-1.26 Describe causes of respiratory distress. (C-1)
2-1.27 Describe manual airway maneuvers. (C-1)
2-1.28 Describe the Sellick (cricoid pressure) maneuver. (C-1)
2-1.29 Describe complete airway obstruction maneuvers. (C-1)
2-1.30 Explain the purpose for suctioning the upper airway. (C-1)
2-1.31 Identify types of suction equipment. (C-1)
2-1.32 Describe the indications for suctioning the upper airway. (C-3)
2-1.33 Identify types of suction catheters, including hard or rigid catheters and soft catheters. (C-1)
2-1.34 Identify techniques of suctioning the upper airway. (C-1)
2-1.35 Identify special considerations of suctioning the upper airway. (C-1)
2-1.36 Describe the indications, contraindications, advantages, disadvantages, complications, equipment and technique of tracheobronchial suctioning in the intubated patient. (C-3)
2-1.37 Describe the use of an oral and nasal airway. (C-1)
2-1.38 Identify special considerations of tracheobronchial suctioning in the intubated patient. (C-1)
2-1.39 Define gastric distention. (C-1)
2-1.40 Describe the indications, contraindications, advantages, disadvantages, complications, equipment and technique for inserting a nasogastric tube and orogastric tube. (C-1)
2-1.41 Identify special considerations of gastric decompression. (C-1)

2-1.42 Describe the indications, contraindications, advantages, disadvantages, complications, and technique for inserting an oropharyngeal and nasopharyngeal airway (C-1)
2-1.43 Describe the indications, contraindications, advantages, disadvantages, complications, and technique for ventilating a patient by: (C-1)
1. Mouth-to-mouth
2. Mouth-to-nose
3. Mouth-to-mask
4. One person bag-valve-mask
5. Two person bag-valve-mask
6. Three person bag-valve-mask
7. Flow-restricted, oxygen-powered ventilation device

2-1.44 Explain the advantage of the two person method when ventilating with the bag-valve-mask. (C-1)
2-1.45 Compare the ventilation techniques used for an adult patient to those used for pediatric patients. (C-3)
2-1.46 Describe indications, contraindications, advantages, disadvantages, complications, and technique for ventilating a patient with an automatic transport ventilator (ATV). (C-1)
2-1.47 Explain safety considerations of oxygen storage and delivery. (C-1)
2-1.48 Identify types of oxygen cylinders and pressure regulators (including a high-pressure regulator and a therapy regulator). (C-1)
2-1.49 List the steps for delivering oxygen from a cylinder and regulator. (C-1)
2-1.50 Describe the use, advantages and disadvantages of an oxygen humidifier. (C-1)
2-1.51 Describe the indications, contraindications, advantages, disadvantages, complications, liter flow range, and concentration of delivered oxygen for supplemental oxygen delivery devices. (C-3)
2-1.52 Define, identify and describe a tracheostomy, stoma, and tracheostomy tube. (C-1)
2-1.53 Define, identify, and describe a laryngectomy. (C-1)
2-1.54 Define how to ventilate with a patient with a stoma, including mouth-to-stoma and bag-valve-mask-to-stoma ventilation. (C-1)
2-1.55 Describe the special considerations in airway management and ventilation for patients with facial injuries. (C-1)
2-1.56 Describe the special considerations in airway management and ventilation for the pediatric patient. (C-1)
2-1.57 Differentiate endotracheal intubation from other methods of advanced airway management. (C-3)
2-1.58 Describe the indications, contraindications, advantages, disadvantages and complications of endotracheal intubation. (C-1)
2-1.59 Describe laryngoscopy for the removal of a foreign body airway obstruction. (C-1)
2-1.60 Describe the indications, contraindications, advantages, disadvantages, complications, equipment, and technique for direct laryngoscopy. (C-1)
2-1.61 Describe visual landmarks for direct laryngoscopy. (C-1)
2-1.62 Describe use of cricoid pressure during intubation. (C-1)
2-1.63 Describe indications, contraindications, advantages, disadvantages, complications, equipment and technique for digital endotracheal intubation. (C-1)
2-1.64 Describe the indications, contraindications, advantages, disadvantages, complications, equipment and technique for using a dual lumen airway. (C-3)
2-1.65 Describe the indications, contraindications, advantages, disadvantages, complications and equipment for rapid sequence intubation with neuromuscular blockade. (C-1)
2-1.66 Identify neuromuscular blocking drugs and other agents used in rapid sequence intubation. (C-1)
2-1.67 Describe the indications, contraindications, advantages, disadvantages, complications and equipment for sedation during intubation. (C-1)
2-1.68 Identify sedative agents used in airway management. (C-1)
2-1.69 Describe the indications, contraindications, advantages, disadvantages, complications, equipment and technique for nasotracheal intubation. (C-1)

2-1.70 Describe the indications, contraindications, advantages, disadvantages and complications for performing an open crichothyrotomy. (C-3)
2-1.71 Describe the equipment and technique for performing an open cricothyrotomy. (C-1)
2-1.72 Describe the indications, contraindications, advantages, disadvantages, complications, equipment and technique for transtlaryngeal catheter ventilation (needle cricothyrotomy). (C-3)
2-1.73 Describe methods of assessment for confirming correct placement of an endotracheal tube. (C-1)
2-1.74 Describe methods for securing an endotracheal tube. (C-1)
2-1.75 Describe the indications, contraindications, advantages, disadvantages, complications, equipment and technique for extubation. (C-1)
2-1.76 Describe methods of endotracheal intubation in the pediatric patient. (C-1)

AFFECTIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

2-1.77 Defend the need to oxygenate and ventilate a patient. (A-1)
2-1.78 Defend the necessity of establishing and/ or maintaining patency of a patient's airway. (A-1)
2-1.79 Comply with standard precautions to defend against infectious and communicable diseases. (A-1)

PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

2-1.80 Perform body substance isolation (BSI) procedures during basic airway management, advanced airway management, and ventilation. (P-2)
2-1.81 Perform pulse oximetry. (P-2)
2-1.82 Perform end-tidal CO_2 detection. (P-2)
2-1.83 Perform peak expiratory flow testing. (P-2)
2-1.84 Perform manual airway maneuvers, including: (P-2)
- a. Opening the mouth
- b. Head-tilt/ chin-lift maneuver
- c. Jaw-thrust without head-tilt maneuver
- d. Modified jaw-thrust maneuver

2-1.85 Perform manual airway maneuvers for pediatric patients, including: (P-2)
- a. Opening the mouth
- b. Head-tilt/ chin-lift maneuver
- c. Jaw-thrust without head-tilt maneuver
- d. Modified jaw-thrust maneuver

2-1.86 Perform the Sellick maneuver (cricoid pressure). (P-2)
2-1.87 Perform complete airway obstruction maneuvers, including: (P-2)
- a. Heimlich maneuver
- 2. Finger sweep
- 3. Chest thrusts
- 4. Removal with Magill forceps

2-1.88 Demonstrate suctioning the upper airway by selecting a suction device, catheter and technique. (P-2)
2-1.89 Perform tracheobronchial suctioning in the intubated patient by selecting a suction device, catheter and technique. (P-2)
2-1.90 Demonstrate insertion of a nasogastric tube. (P-2)
2-1.91 Demonstrate insertion of an orogastric tube. (P-2)
2-1.92 Perform gastric decompression by selecting a suction device, catheter and technique. (P-2)
2-1.93 Demonstrate insertion of an oropharyngeal airway. (P-2)
2-1.94 Demonstrate insertion of a nasopharyngeal airway. (P-2)
2-1.95 Demonstrate ventilating a patient by the following techniques: (P-2)

a. Mouth-to-mask ventilation
2. One person bag-valve-mask
3. Two person bag-valve-mask
4. Three person bag-valve-mask
5. Flow-restricted, oxygen-powered ventilation device
6. Automatic transport ventilator
7. Mouth-to-stoma
8. Bag-valve-mask-to-stoma ventilation

2-1.96 Ventilate a pediatric patient using the one and two person techniques. (P-2)
2-1.97 Perform ventilation with a bag-valve-mask with an in-line small-volume nebulizer. (P-2)
2-1.98 Perform oxygen delivery from a cylinder and regulator with an oxygen delivery device. (P-2)
2-1.99 Perform oxygen delivery with an oxygen humidifier. (P-2)
2-1.100 Deliver supplemental oxygen to a breathing patient using the following devices: nasal cannula, simple face mask, partial rebreather mask, non-rebreather mask, and venturi mask (P-2)
2-1.101 Perform stoma suctioning. (P-2)
2-1.102 Perform retrieval of foreign bodies from the upper airway. (P-2)
2-1.103 Perform assessment to confirm correct placement of the endotracheal tube. (P-2)
2-1.104 Intubate the trachea by the following methods: (P-2)
a. Orotracheal intubation
b. Nasotracheal intubation
c. Multi-lumen airways
9. Digital intubation
d. Transillumination
e. Open cricothyrotomy
2-1.105 Adequately secure an endotracheal tube. (P-1)
2-1.106 Perform endotracheal intubation in the pediatric patient. (P-2)
2-1.107 Perform transtracheal catheter ventilation (needle cricothyrotomy). (P-2)
2-1.108 Perform extubation. (P-2)
2-1.109 Perform replacement of a tracheostomy tube through a stoma. (P-2)

DECLARATIVE

I. Introduction
1. The body's need for oxygen
2. Primary objective of emergency care
    a. Ensure optimal ventilation
        (1) Delivery of oxygen
        (2) Elimination of CO_2
3. Brain death occurs within 6 to 10 minutes
4. Major prehospital causes of preventable death
    a. Early detection
    b. Early intervention
    c. Lay-person BLS education
5. Most often neglected of prehospital skills
    a. Basics taken for granted
    b. Poor techniques
        (1) BVM seal
        (2) Improper positioning
        (3) Failure to reassess

II. Anatomy of upper airway
1. Function of the upper airway
    a. Warm
    b. Filter
    c. Humidify
2. Pharynx
    a. Nasopharynx
        (1) Formed by the union of facial bones
        (2) Orientation of nasal floor is towards the ear not the eye
        (3) Separated by septum
        (4) Lined with
            (a) Mucous membranes
            (b) Cilia
        (5) Turbinate
            (a) Parallel to nasal floor
            (b) Provide increased surface area for air
                i) Filtration
                ii) Humidifying
                iii) Warming
        (6) Sinuses
            (a) Cavities formed by cranial bones
            (b) Appear to further trap bacteria and act as tributaries for fluid to and from Eustachian tubes and tear ducts
                i) Commonly become infected
                ii) Fracture of certain sinus bones may cause cerebrospinal fluid (CSF) leak
        (7) Tissues extremely delicate and vascular
            (a) Improper or overly aggressive placement of tubes or airways will cause significant bleeding which may not be controlled by direct pressure

b. Oropharynx
   (1) Teeth
      (a) 32 adult
      (b) Requires significant force to dislodge
      (c) May fracture or avulse causing obstruction
   (2) Tongue
      (a) Large muscle attached at the mandible and hyoid bones
      (b) Most common airway obstruction
   (3) Palate
      (a) Roof of mouth separates oro/ nasopharynx
         i) Anterior is hard palate
         ii) Posterior (beyond the teeth) is soft palate
   (4) Adenoids
      (a) Lymph tissue located in the mouth and nose that filters bacteria
      (b) Frequently infected and swollen
   (5) Posterior tongue
   (6) Epiglottis
   (7) Vallecula
      (a) "Pocket" formed by the base of the tongue and epiglottis
      (b) Important landmark for endotracheal intubation

3. Larynx
   a. Attached to hyoid bone
      (1) "Horseshoe-shaped" bone between the chin and mandibular angle
      (2) Supports trachea
      (3) Made of cartilage
   b. Thyroid cartilage
      (1) First tracheal cartilage
      (2) "Shield-shaped"
         (a) Cartilage anterior
         (b) Smooth muscle posterior
      (3) Laryngeal prominence
         (a) "Adam's Apple" anterior prominence of thyroid cartilage
         (b) Glottic opening directly behind
   c. Glottic opening
      (1) Narrowest part of adult trachea
      (2) Patency heavily dependent on muscle tone
      (3) Contain vocal bands
         (a) White bands of cartilage
         (b) Produce voice
   d. Arytenoid cartilage
      (1) "Pyramid-like" posterior attachment of vocal bands
      (2) Important landmark for endotracheal intubation
   e. Pyriform fossae
      (1) “Hollow pockets” along the lateral borders of the larynx
   f. Cricoid ring
      (1) First tracheal ring
      (2) Completely cartilaginous
      (3) Compression occludes esophagus (Sellick maneuver)
   g. Cricothyroid membrane
      (1) Fibrous membrane between cricoid and thyroid cartilage
      (2) Site for surgical and alternative airway placement

h. Associated structures
(1) Thyroid gland
(a) Located below cricoid cartilage
(b) Lies across trachea and up both sides
(2) Carotid arteries
(a) Branches cross and lie closely alongside trachea
(3) Jugular veins
(a) Branch across and lie close to trachea

III. Anatomy of lower airway
1. Function of the lower airway
a. Exchange of O_2 and CO_2
2. Location of the lower airway
a. From fourth cervical vertebrae to xiphoid process
b. From glottic opening to pulmonary capillary membrane
3. Structures of the lower airway
a. Trachea
(1) Trachea bifurcates at carina into
(a) Right and left mainstem bronchi
(b) Right mainstem has lesser angle
i) Foreign bodies, ET tubes commonly displace here
(2) Lined with
(a) Mucous cells
(b) Beta 2 receptors - dilate bronchioles
b. Bronchi
(1) Mainstem bronchi enter lungs at hilum
(2) Branch into narrowing secondary and tertiary bronchi that branch into bronchioles
c. Bronchioles
(1) Branch into alveolar ducts that end at alveolar sacs
d. Alveoli
(1) "Balloon-like" clusters
(2) Site of gas exchange
(3) Lined with surfactant
(a) Decreases surface tension of alveoli which facilitates ease of expansion
(b) Alveoli become thinner as they expand which makes diffusion of O_2/ CO_2 easier
(c) If surfactant is decreased or alveoli are not inflated, alveoli collapse (atelectasis)
e. Lungs
(1) Right lung
(a) 3 lobes
(2) Left lung
(a) 2 lobes
(3) Lobes made of parenchymal tissue
(4) Membranous outer lining called pleura
(5) Lung capacity

IV. Differences in pediatric airway
1 Pharynx
a0 A proportionately smaller jaw causes the tongue to encroach upon the airway
b0 Omega shaped, floppy epiglottis
c0 Absent or very delicate dentition
2 Trachea

a0 Airway is smaller and narrower at all levels
b0 Larynx lies more superior
c0 Larynx is "funnel-shaped" due to narrow, undeveloped cricoid cartilage
d0 Narrowest point is at cricoid ring before 10 years of age
e0 Further narrowing of the airway by tissue swelling of foreign body results in major increase in airway resistance

3 Chest wall
a0 Ribs and cartilage are softer
b0 Cannot optimally contribute to lung expansion
c0 Infants and children tend to depend more heavily on the diaphragm for breathing

V Lung/ respiratory volumes
1 Total lung volume
a0 Adult male, 6 liters
b0 Not all inspired air enters alveoli
c0 Minor diffusion of O_2 takes place in alveolar ducts and terminal bronchioles
2 Tidal volume
a0 Volume of gas inhaled or exhaled during a single respiratory cycle
b0 5-7cc/ kg (500 cc normally)
3 Dead space air
a0 Air remaining in air passageways, unavailable for gas exchange (approximately 150cc)
b0 Anatomic dead space
(1) Trachea
(2) Bronchi
c0 Physiologic dead space
(1) Dead space formed by factors like disease or obstruction
(a) COPD
(b) Atelectasis
4 Minute volume
a0 Amount of gas moved in and out of the respiratory tract per minute
b0 Determined by
(1) Tidal volume - dead space volume times respiratory rate
5 Functional reserve capacity
a0 After optimal inspiration: optimum amount of air that can be forced from the lungs in a single exhalation
6 Residual volume
a0 Volume of air remaining in lungs at the end of maximal expiration
7 Alveolar air
a0 Air reaching the alveoli for gas exchange (alveolar volume)
b0 Approximately 350 cc
8 Inspiratory reserve
a0 Amount of gas that can be inspired in addition to tidal volume
9 Expiratory reserve
a0 Amount of gas that can be expired after a passive (relaxed) expiration
10 FiO_2
a0 Percentage of oxygen in inspired air (increases with supplemental oxygen)
(1) Commonly documented as a decimal (e.g., FiO_2 = .85)

VI Ventilation
1 Definition - movement of air into and out of the lungs
2 Phases

a0 Inspiration
- (1) Stimulus to breathe from respiratory center
- (2) Impulse transmitted to diaphragm via phrenic nerve
  - (a) Diaphragm - "muscle of respiration"
  - (b) Separates thoracic from abdominal cavity
- (3) Diaphragm contracts - "flattens"
  - (a) Causes intrapulmonic pressure to fall slightly below atmospheric pressure
- (4) Intercostal muscles contract
- (5) Ribs elevate and expand
- (6) Air is drawn into lungs like a vacuum
- (7) Alveoli Inflate
- (8) O_2/ CO_2 are able to diffuse across membrane

b0 Expiration
- (1) Stretch receptors in lungs signal respiratory center via vagus nerve to inhibit inspiration (Hering-Breuer Reflex)
- (2) Natural elasticity (recoil) of the lungs passively expires air

VII Respiration

1 Definition
- a0 Exchange of gases between a living organism and its environment
- b0 The major gases of respiration are oxygen and carbon dioxide

2 Types
- a0 External respiration - exchange of gasses between the lungs and the blood cells
- b0 Internal respiration - exchange of gases between the blood cells and tissues

3 The transportation of oxygen and carbon dioxide in the human body
- a0 Diffusion - passage of solution from area of higher concentration to lower concentration
  - (1) O_2/ CO_2 dissolve in water and pass through alveolar membrane by diffusion
- b0 Oxygen content of blood
  - (1) Dissolved O_2 crosses pulmonary capillary membrane and binds to hemoglobin (Hgb) of red blood cell
  - (2) Oxygen is carried
    - (a) Bound to hemoglobin
    - (b) Dissolved in plasma
  - (3) Approximately 97% of total O_2 is bound to hemoglobin
  - (4) O_2 saturation
    - (a) % of hemoglobin saturated
    - (b) Normally greater than 98%
- c0 Oxygen in the blood
  - (1) Bound to hemoglobin
    - (a) SaO_2
  - (2) Dissolved in plasma
    - (a) PaO_2
- d0 Carbon dioxide content of the blood
  - (1) CO_2 is a byproduct of cellular work (cellular respiration)
  - (2) CO_2 is transported in blood as bicarbonate ion
  - (3) About 33% is bound to hemoglobin
  - (4) As O_2 crosses into blood, CO_2 diffuses into alveoli
  - (5) Carbon dioxide in the blood
    - (a) $PaCO_2$
- e0 Diagnostic testing
  - (1) Pulse oximetry

(2) Peak expiratory flow testing
(3) End-tidal CO_2 monitoring
(4) Other equipment

VIII Causes of decreased oxygen concentrations in the blood
1 Lower partial pressure of atmospheric O_2
2 Lower hemoglobin levels in blood
3 Trauma
a0 Less surface area for gas exchange
(1) Pneumothorax
(2) Hemothorax
(3) Combination of pneumothorax and hemothorax
b0 Decreased mechanical effort
(1) Pain
(2) Traumatic suffocation
(3) Hypoventilation
4 Medical
a0 Physiological barriers
(1) Pneumonia
(2) Pulmonary edema
(3) COPD

IX Carbon dioxide in blood
1 Increases
a0 Hypoventilation
2 Decreases
a0 Hyperventilation

X The measurement of gases
1 Total pressure
a0 The combined pressure of all atmospheric gases
b0 100% or 760 torr at sea level
2 Partial pressure
a0 The pressure exerted by a specific atmospheric gas
3 Concentration of gases in the atmosphere
a0 Nitrogen 597.0 torr (78.62%)
b0 Oxygen 159.0 torr (20.84%)
c0 CO_2 0.3 torr (0.04%)
d0 Water 3.7 torr (0.5%)
4 Water vapor pressure
5 Alveolar gas concentration
a0 Nitrogen 569.0 torr (74.9%)
b0 Oxygen 104.0 torr (13.7%)
c0 CO_2 40.0 torr (5.2%)
d0 Water 47.0 torr (6.2%)

XI Respiratory rate
1 Definition - the number of times a person breathes in one minute
2 Neural control
a0 Primary control from the medulla and pons
b0 Medulla

(1) Primary involuntary respiratory center
(2) Connected to respiratory muscles by vagus nerve

c0 Pons
(1) Apneustic center - secondary control center if medulla fails to initiate respiration
(2) Pneumotaxic center - controls expiration

3 Chemical stimuli
a0 Receptors for O_2/ CO_2 balance
(1) Cerebrospinal fluid pH
(2) Carotid bodies (sinus)
(3) Aortic arch
b0 Hypoxic drive - respiratory stimulus dependent on O_2 rather than CO_2 in the blood

4 Control of respiration by other factors
a0 Body temperature - respirations increase with fever
b0 Drug and medications - may increase or decrease respirations depending on their physiologic action
c0 Pain - increases respirations
d0 Emotion - increases respirations
e0 Hypoxia - increases respirations
f0 Acidosis - respirations increase as compensatory response to increased CO_2 production
g0 Sleep - respirations decrease

XII Pathophysiology
1 Obstruction
a0 Tongue
(1) Most common airway obstruction
(2) Snoring respirations
(3) Corrected with positioning
b0 Foreign body
(1) May cause partial or full obstruction
(2) Symptoms include
(a) Choking
(b) Gagging
(c) Stridor
(d) Dyspnea
(e) Aphonia (unable to speak)
(f) Dysphonia (difficulty speaking)
c0 Laryngeal spasm and edema
(1) Spasm
(a) Spasmotic closure of vocal cords
(b) Most frequently caused by
i Trauma from over aggressive technique during intubation
ii Immediately upon extubation especially when patient is semiconscious
(2) Edema
(a) Glottic opening becomes extremely narrow or totally obstructed
(b) Most frequently caused by
i Epiglottitis (a bacterial infection of the epiglottis)
ii Anaphylaxis (severe allergic reaction)
iii Relieved by
(c) Aggressive ventilation
(d) Forceful upward pull of the jaw
(e) Muscle relaxants

d0 Fractured larynx
(1) Airway patency dependent upon muscle tone
(2) Fractured laryngeal tissue
(a) Increases airway resistance by decreasing airway size through
i Decreasing muscle tone
ii Laryngeal edema
iii Ventilatory effort

e0 Aspiration
(1) Significantly increases mortality
(a) Obstructs airway
(b) Destroys delicate bronchiolar tissue
(c) Introduces pathogens
(d) Decreases ability to ventilate

XIII Airway evaluation

1 Essential parameters

a0 Rate
(1) Normal resting rate in adults - 12-24

b0 Regularity
(1) Steady pattern
(2) Irregular respiratory patterns are significant until proven otherwise

c0 Effort
(1) Breathing at rest should be effortless
(2) Effort changes may be subtle in rate or regularity
(3) Patients often compensate by preferential positioning
i Upright sniffing
ii Semifowlers
iii Frequently avoid supine

2 Recognition of airway problems

a0 Respiratory distress
(1) Upper and lower airway obstruction
(2) Inadequate ventilation
(3) Impairment of the respiratory muscles
(4) Impairment of the nervous system

b0 Difficulty in rate, regularity, or effort is defined as dyspnea

c0 Dyspnea may be result of or result in hypoxia
(1) Hypoxia - lack of oxygen
(2) Hypoxia - lack of oxygen to tissues
(3) Anoxia - total absence of oxygen

d0 Recognition and treatment of dyspnea is crucial to patient survival
(1) Expert assessment and management is essential
(a) The brain can survive only a few minutes of anoxia
(b) All therapies fail if airway is inadequate

e0 Visual techniques
(1) Position
(a) Tripod positioning
(b) Orthopnea
(2) Rise and fall of chest
(3) Gasping
(4) Color of skin
(5) Flaring of nares

- (6) Pursed lips
- (7) Retraction
  - (a) Intercostal
  - (b) Suprasternal notch
  - (c) Supraclavicular fossa
  - (d) Subcostal

f0 Auscultation techniques
- (1) Air movement at mouth and nose
- (2) Bilateral lung fields equal

g0 Palpation Techniques
- (1) Air movement at mouth and nose
- (2) Chest wall
  - (a) Paradoxical motion
  - (b) Retractions

h0 Bag-valve-mask
- (1) Resistance or changing compliance with bag-valve-mask ventilations

i0 Pulsus paradoxus
- (1) Systolic blood pressure drops greater than 10mm Hg with inspiration
  - (a) Change in pulse quality maybe detected
  - (b) Seen in COPD, pericardial tamponade
  - (c) Possible increase in intrathoracic pressure

j0 History
- (1) Evolution
  - (a) Sudden
  - (b) Gradual over time
  - (c) Known cause or "trigger"
- (2) Duration
  - (a) Constant
  - (b) Recurrent
- (3) Ease - what makes it better?
- (4) Exacerbate - what makes it worse?
- (5) Associate
  - (a) Other symptoms (productive cough, chest pain, fever, etc...)
- (6) Interventions
  - (a) Evaluations/ admissions to hospital
  - (b) Medications (include compliance)
  - (c) Ever intubated

k0 Modified forms of respiration
- (1) Protective reflexes
  - (a) Cough
    - i Forceful, spastic exhalation
    - ii Aids in clearing bronchi and bronchioles
  - (b) Sneeze - clears nasopharynx
  - (c) Gag reflex - spastic pharyngeal and esophageal reflex from stimulus of the posterior pharynx
- (2) Sighing
  - (a) Involuntary deep breath that increases opening of alveoli
  - (b) Normally sigh about once per minute
- (3) Hiccough - intermittent spastic closure of glottis

l0 Respiratory pattern changes
- (1) Cheyne-Stokes

(a) Gradually increasing rate and tidal volume followed by gradual decrease
(b) Associated with brain stem insult
(2) Kussmaul's breathing
(a) Deep, gasping respirations
(b) Common in diabetic coma
(3) Biot's respirations
(a) Irregular pattern, rate, and volume with intermittent periods of apnea
(b) Increased intracranial pressure
(4) Central neurogenic hyperventilation
(a) Deep rapid respirations similar to Kussmall's
(b) Increased intracranial pressure
(5) Agonal
(a) Slow, shallow, irregular respirations
(b) Resulting from brain anoxia

m0 Inadequate ventilation
(1) Occurs when body cannot compensate for increased O_2 demand or maintain O_2/ CO_2 balance
(2) Many causes
(a) Infection
(b) Trauma
(c) Brainstem insult
(d) Noxious or hypoxic atmosphere
(e) Renal failure
(3) Multiple symptoms
(a) Altered response
(b) Respiratory rate changes (up or down)

XIV Supplemental oxygen therapy
1 Rationale
a0 Enriched O_2 atmosphere increases oxygen to cells
b0 Increasing available O_2 increases patient's ability to compensate
c0 O_2 delivery method must be reassessed to determine adequacy and efficiency
2 Oxygen source
a0 Compressed gas
(1) Oxygen compressed in gas form in an aluminum or steel tank
(2) Common sizes and volumes
(a) D 400L
(b) E 660L
(c) M 3450L
(3) O_2 delivery measured in liters/ min (LPM)
(4) Calculating tank life
(a) Tank pressure (psi) x 0.28 = volume
(b) Volume/ LPM = tank life in minutes
b0 Liquid oxygen
(1) O_2 cooled to its aqueous state
(a) Converts to gaseous state when warmed
(2) Advantage
(a) Much larger volume of gaseous O_2 can be stored in aqueous state
(3) Disadvantage
(a) Units generally require upright storage
(b) Special requirements for large volume storage and cylinder transfer

3 Regulators
- a0 High-pressure
  - (1) Attached to cylinder stem delivers cylinder gas under high pressure
  - (2) Used to transfer cylinder gas from tank to tank
- b0 Therapy regulators
  - (1) Attached to cylinder stem
  - (2) 50psi escape pressure is "stepped down" through regulator mechanism
  - (3) Subsequent delivery to patient is adjustable low pressure

4 Delivery devices
- a0 Nasal cannula
  - (1) Nasally placed O_2 catheter for oxygen enrichment
  - (2) Optimal delivery: 40% at 6 L/ min
  - (3) Indications
    - (a) Low to moderate O_2 enrichment
    - (b) Long term O_2 maintenance therapy
  - (4) Contraindications
    - (a) Poor respiratory effort
    - (b) Severe hypoxia
    - (c) Apnea
    - (d) Mouth breathing
  - (5) Advantages
    - (a) Well tolerated
  - (6) Disadvantages
    - (a) Does not deliver high volume/ high concentration
- b0 Simple face mask
  - (1) Full airway enclosure with open side ports
    - (a) Room air is drawn through side ports on inspiration
    - (b) Diluting O_2 concentration
  - (2 Indications
    - (a Delivery of moderate to high O_2 concentrations
    - (b Range - 40-60% at 10 L/ min
  - (3 Advantages
    - (a Higher O_2 concentrations
  - (4 Disadvantages
    - (a Delivery of volumes beyond 10 L/ min does not enhance O_2 concentration
  - (5 Special considerations
    - (a Mask leak around face decreases O_2 concentration
- c. Partial rebreather
  - (1 Mask vent ports covered by one-way disc
    - (a Residual expired air mixed in mask and rebreathed
    - (b Room air not entrained with inspiration
  - (2 Indications
  - (3 Contraindications
    - (a Apnea
    - (b Poor respiratory effort
  - (4 Advantages
    - (a Inspired gas not mixed with room air
      - i) Higher O_2 concentrations attainable
    - (b Disadvantages
      - i) Delivery of volumes beyond 10 L/ min does not enhance O_2 concentration

(c Special considerations
i) Mask leak around face decreases O_2 concentration

d. Non-rebreather mask
(1 Mask side ports covered by one-way disc
(2 Reservoir bag attached
(3 Range: 80-95+% at 15 L/ min
(4 Indications
(a Delivery of highest O_2 concentration
(5 Contraindications
(a Apnea
(b Poor respiratory effort
(6 Advantages
(a Highest O_2 concentration
(b Delivers high volume/ high O_2 enrichment
(c Patient inhales enriched O_2 from reservoir bag rather than residual air
(7 Disadvantages

e. Venturi mask
(1 Mask with interchangeable adapters
(a Adapters have port holes that entrain room air as O_2 passes
(b Patient receives a highly specific concentration of O_2
(c Air is entrained by venturi principle

f. Small volume nebulizer
(1 Delivers aerosolized medication
(2 O_2 enters an aerosol chamber containing 3-5 ccs of fluid
(3 Pressurized O_2 mists fluid

5. Oxygen humidifiers
a. Sterile water reservoir for humidifying O_2
b. Good for long term O_2 administration
c. Desirable for croup/ Epiglottitis/ bronchiolitis

6. Tracheostomy, stoma, and tracheostomy tubes
a. Tracheostomy
(1 Surgical opening into trachea
(a Done in operating room under controlled conditions
(b A stoma located just superior to the suprasternal notch

b. Stoma
(1 Resultant orifice connecting trachea to outside air
(2 Patient now breathes through this surgical opening

c. Tracheostomy tube
(1 Plastic tube placed within tracheostomy site
(2 15 mm connector for ventilator acceptance

XV. Ventilation

1. Mouth-to-mouth
a. Most basic form of ventilation
b. Indications
(1 Apnea from any mechanism when other ventilation devices are not available
c. Contraindications
(1 Awake patients
(2 Communicable disease risk limitations
d. Advantages
(1 No special equipment required

(2 Delivers excellent tidal volume
(3 Delivers adequate oxygen

e. Disadvantages
(1 Psychological barriers from
(a Sanitary issues
(b Communicable disease issues
i) Direct blood/ body fluid contact
ii) Unknown communicable disease risks at time of event

f. Complications
(1 Hyperinflation of patient's lungs
(2 Gastric distension
(3 Blood/ body fluid contact manifestation
(4 Hyperventilation of rescuer

2. Mouth-to-nose
a. Ventilating through nose rather than mouth
b. Indications
(1 Apnea from any mechanism
c. Contraindications
(1 Awake patients
d. Advantages
(1 No special equipment required
e. Disadvantages
(1 Direct blood/ body fluid contact
(2 Psychological limitations of rescuer
f. Complications
(1 Hyperinflation of patient's lungs
(2 Gastric distension
(3 Blood/ body fluid manifestation
(4 Hyperventilation of rescuer

3. Mouth-to-mask
a. Adjunct to mouth-to-mouth ventilation
b. Indications
(1 Apnea from any mechanism
c. Contraindications
(1 Awake patients
d. Advantages
(1 Physical barrier between rescuer and patient blood/ body fluids
(2 One-way valve to prevent blood/ body fluid splash to rescuer
(3 May be easier to obtain face seal
e. Disadvantages
(1 Useful only if readily available
f. Complications
(1 Hyperinflation of patient's lungs
(2 Hyperventilation of rescuer
(3 Gastric distention
g. Method for use
(1 Position head by appropriate method
(2 Position and seal mask over mouth and nose
(3 Ventilate as appropriate

4. One person bag-valve-mask
a. Fixed volume self inflating bag can deliver adequate tidal volumes and O_2 enrichment

b. Indications
   (1 Apnea from any mechanism
   (2 Unsatisfactory respiratory effort
c. Contraindications
   (1 Awake, intolerant patients
d. Advantages
   (1 Excellent blood/ body fluid barrier
   (2 Good tidal volumes
   (3 Oxygen enrichment
   (4 Rescuer can ventilate for extended periods without fatigue
e. Disadvantages
   (1 Difficult skill to master
   (2 Mask seal may be difficult to obtain and maintain
   (3 Tidal volume delivered is dependent on mask seal integrity
f. Complications
   (1 Inadequate tidal volume delivery with
      (a Poor technique
      (b Poor mask seal
      (c Gastric distention
g. Method for use
   (1 Position appropriately
   (2 Choose proper mask size - seats from bridge of nose to chin
   (3 Position, spread/ mold/ seal mask
   (4 Hold mask in place
   (5 Squeeze bag completely over 1.5 to 2 seconds for adults
   (6 Avoid overinflation
   (7 Reinflate completely over several seconds
h. Special considerations
   (1 Medical
      (a Observe for
         i) Gastric distension
         ii) Changes in compliance of bag with ventilation
         iii) Improvement or deterioration of ventilation status (i.e., color change, responsiveness, air leak around mask)
   (2 Trauma
      (a Very difficult to perform with cervical spine immobilization in place

5. Two person bag-valve-mask ventilation method
   a. Most efficient method
   b. Indications
      (1 Bag-valve-mask ventilation on any patient
         (a Especially useful for cervical spine immobilized patients
         (b Difficulty obtaining or maintaining adequate mask seal
   c. Contraindications
      (1 Awake, intolerant patients
   d. Advantages
      (1 Superior mask seal
      (2 Superior volume delivery
   e. Disadvantages
      (1 Requires extra personnel
   f. Complications
      (1 Hyperinflation of patient's lungs

(2 Gastric distension
g. Method for use
(1 First rescuer maintains mask seal by appropriate method
(2 Second rescuer squeezes bag
h. Special considerations
(1 Observe chest movement
(2 Avoid overinflation
(3 Monitor lung compliance with ventilations
6. Three person bag-valve-mask ventilation
a. Indications
(1 Bag-valve-mask ventilation on any patient
(a Especially useful for cervical spine immobilized patients
(b Difficulty obtaining or maintaining adequate mask seal
b. Contraindications
(1 Awake, intolerant patients
c. Advantages
(1 Superior mask seal
(2 Superior volume density
d. Disadvantages
(1 Requires extra personnel
(2 "Crowded" around airway
e. Complications
(1 Hyperinflation of patient's lungs
(2 Gastric distension
f. Method for use
(1 First rescuer maintains mask seal by appropriate method
(2 Second rescuer holds mask in place
(3 Third rescuer squeezes bag and monitors compliance
g. Special considerations
(1 Avoid overinflation
(2 Monitor lung compliance with ventilations
7. Flow-restricted, oxygen-powered ventilation devices
a. The valve opening pressure at the cardiac sphincter is approx 30 cm H_2O
b. These devices operate at or below 30 cm H_2O to prevent gastric distension
c. Indications
(1 Delivery of high volume/ high concentration of O_2 (1 L/ sec)
(2 Awake compliant patients
(3 Unconscious patient with caution
d. Contraindications
(1 Noncompliant patients
(2 Poor tidal volume
(3 Small children
e. Advantages
(1 Self administered
(2 Delivers high volume/ high concentration O_2
(3 O_2 delivered in response to inspiratory effort (no O_2 wasting)
(4 O_2 volume delivery is regulated by inspiratory effort minimizing overinflation risk
(5 O_2 volume delivery is also restricted to less than 30 cm H_2O
f. Disadvantages
(1 Cannot monitor lung compliance
(2 Requires O_2 source

g. Complications
   (1 Gastric distension
   (2 Barotrauma
h. Method
   (1 Mask is held manually in place
   (2 Negative pressure upon inspiration triggers O_2 delivery or medic triggers release button
   (3 Patient is monitored for adequate tidal volume and oxygenation

8. Automatic transport ventilators
   a. Volume/ rate controlled
   b. Indications
      (1 Extended ventilation of intubated patients
      (2 In situations in which a BVM is used
      (3 Can be used during CPR
   c. Contraindications
      (1 Awake patients
      (2 Obstructed airway
      (3 Increased airway resistance
         (a Pneumothorax (after needle decompression)
         (b Asthma
         (c Pulmonary edema
   d. Advantages
      (1 Frees personnel to perform other tasks
      (2 Lightweight
      (3 Portable
      (4 Durable
      (5 Mechanically simple
      (6 Adjustable tidal volume
      (7 Adjustable rate
      (8 Adapts to portable O_2 tank
   e. Disadvantages
      (1 Cannot detect tube displacement
      (2 Does not detect increasing airway resistance
      (3 Difficult to secure
      (4 Dependent on O_2 tank pressure

9. Cricoid pressure - Sellick's maneuver
   a. Pressure on cricoid Ring
   b. Occludes esophagus
   c. Facilitates intubation by moving the larynx posteriorly
   d. Helps to prevent passive emesis
   e. Can help minimize gastric distension during bag-valve-mask ventilation
   f. Indications
      (1 Vomiting is imminent or occurring
      (2 Patient cannot protect own airway
   g. Contraindications
      (1 Use with caution in cervical spine injury
   h. Advantages
      (1 Noninvasive
      (2 Protects from aspiration as long as pressure is maintained
   i. Disadvantages
      (1 May have extreme emesis if pressure is removed
      (2 Second rescuer required for bag-valve-mask ventilation

(3 May further compromise injured cervical spine
j. Complications
(1 Laryngeal trauma with excessive force
(2 Esophageal rupture from unrelieved high gastric pressures
(3 Excessive pressure may obstruct the trachea in small children
k. Method
(1 Locate the anterior aspect of the cricoid ring
(2 Apply firm, posterior pressure
(3 Maintain pressure until the airway is secured with an endotracheal tube

10. Artificial ventilation of the pediatric patient
a. Flat nasal bridge makes achieving mask seal more difficult
b. Compressing mask against face to improve mask seal results in obstruction
c. Mask seal best achieved with jaw displacement (two person bag-valve-mask)
d. Bag-valve-mask ventilation
(1 Bag size
(a Full-term neonates and infants - minimum of 450 ml tidal volume (pediatric BVM)
(b Children up to eight years of age - pediatric BVM preferred but adult-sized BVM (1500 ml) may be used
(c Children over eight years of age require adult-sized BVM for adequate ventilation
(d Proper mask fit
(e Length based resuscitation tape
(f Bridge of nose to cleft of chin
(2 Proper mask position and seal (EC-clamp)
(a Place mask over mouth and nose; avoid compressing the eyes
(b Using one hand, place thumb on mask at apex and index finger on mask at chin (C-grip)
(c With gentle pressure, push down on mask to establish adequate seal
(d Maintain airway by lifting bony prominence of chin with remaining fingers forming an “E”; avoid placing pressure on the soft area under chin
(e May use one or two rescuer technique
(3 Ventilate according to current standards
(4 Obtain chest rise with each breath
(a Begin ventilation and say “squeeze”; provide just enough volume to initiate chest rise; DO NOT OVERVENTILATE
(5 Allow adequate time for exhalation
(a Begin releasing the bag and say “release, release”
(6 Continue ventilations using “squeeze, release, release” method
(7 Assess BVM ventilation
(a Look for adequate chest rise
(b Listen for lung sounds at third intercostal space, midaxillary line
(c Assess for improvement in color and/ or heart rate
(8 Apply cricoid pressure to minimize gastric inflation and passive regurgitation
(a Locate cricoid ring by palpating the trachea for a prominent horizontal band inferior to the thyroid cartilage and cricothyroid membrane
(b Apply gentle downward pressure using one fingertip in infants and the thumb and index finger in children
(c Avoid excessive pressure as it may produce tracheal compression and obstruction in infants

11. Ventilation of stoma patients
a. Mouth-to-stoma
(1 Locate stoma site and expose

(2 Pocket mask to stoma preferred
(a Seal around stoma site, check for adequate ventilation
(b Seal mouth and nose if air leak evident
b. Bag-valve-mask to stoma
(1 Locate stoma site and expose
(2 Seal around stoma site, check for adequate ventilation
(3 Seal mouth and nose if air leak evident

XVI. Airway obstructions
1. Causes
a. Tongue
b. Foreign body
c. Laryngeal spasm
d. Laryngeal edema
e. Trauma
2. Classifications/ assessment
a. Complete obstruction
b. Partial obstruction
(1 With good air exchange
(2 With poor air exchange
3. Management
a. Heimlich maneuver
b. Finger sweep
c. Chest thrusts
d. Suctioning
e. Direct laryngoscopy for the removal of foreign body in airway obstruction
(1 If patient is unconscious and you are unable to ventilate and BLS methods fail
(a Insert laryngoscope blade into patient's mouth
(b If foreign body is visualized carefully and deliberately remove foreign body with Magill forceps
f. Intubation

XVII. Suctioning
1. Suction devices
a. Hand-powered suction devices
(1 Advantages
(a Lightweight
(b Portable
(c Mechanically simple
(d Inexpensive
(2 Disadvantages
(a Limited volume
(b Manually powered
(c Fluid contact components not disposable
b. Oxygen-powered portable suction devices
(1 Advantages
(a Lightweight
(b Small in size
(2 Disadvantages
(a Limited suctioning power
(b Uses a lot of oxygen for limited suctioning power

c. Battery-operated portable suction devices
   (1 Advantages
      (a Lightweight
      (b Portable
      (c Excellent suction power
      (d) May "field" troubleshoot most problems
   (2) Disadvantages
      (a) More complicated mechanics
      (b) May lose battery integrity over time
      (c) Some fluid contact components not disposable
d. Mounted vacuum-powered suction devices
   (1) Advantages
      (a) Extremely strong vacuum
      (b) Adjustable vacuum power
      (c) Fluid contact components disposable
   (2) Disadvantages
      (a) Non-portable
      (b) Cannot "field service" or substitute power source

2. Suctioning catheters
   a. Hard or rigid catheters
      (1) "Yankauer" or "tonsil tip"
      (2) Suction large volumes of fluid rapidly
      (3) Standard size
      (4) Various sizes
   b. Soft catheters
      (1) Can be placed in oropharynx, nasopharynx, or down endotracheal tube
      (2) Various sizes
      (3) Smaller inside diameter than hard tip catheters
      (4) Suction tubing without catheter (facilitates suctioning of large debris)

3. Suctioning the upper airway
   a. Prevention of aspiration critical
      (1) Mortality increases significantly if aspiration occurs
      (2) Preoxygenate if possible
      (3) Hyperoxygenate after suctioning
   b. Description
      (1) Soft tip catheters must be prelubricated
      (2) Place catheter
      (3) Suction during extraction of catheter
      (4) Suction to clear the airway
      (5) Reevaluate patency of the airway
      (6) Ventilate and oxygenate

4. Tracheobronchial suctioning
   a. Use sterile technique, if possible
   b. Preoxygenation essential
   c. Description
      (1) Pre-lubricate soft tip catheter
      (2) Hyperoxygenate
         (a) May be necessary to inject 3 to 5 ccs of sterile water down endotracheal tube to loosen secretions
      (3) Gently insert catheter until resistance is felt
      (4) Suction upon extraction of catheter

(5) Do not exceed 15 seconds
(6) Ventilate and oxygenate

5. Gastric distention
   a. Air becomes trapped in the stomach
   b. Very common when ventilating non-intubated patients
   c. Stomach diameter increases
   d. Pushes against diaphragm
   e. Interferes with lung expansion
   f. Abdomen becomes increasingly distended
   g. Resistance to bag-valve-mask ventilation
   h. Management
      (1) Non-invasive
         (a) May be reduced by increasing bag-valve-mask ventilation time
            i) Adults - 1.5 to 2 seconds
            ii) Pediatrics - 1 to 1.5 seconds
         (b) Prepare for large volume suction
         (c) Position patient left lateral
         (d) Slowly apply pressure to epigastric region
         (e) Suction as necessary
      (2) Gastric tubes
         (a) Tube placed in the stomach for gastric decompression and/ or emesis control
         (b) Nasogastric decompression
            i) Indications
               a) Threat of aspiration
               b) Need for lavage
            ii) Contraindications
               a) Extreme caution in esophageal disease or esophageal trauma
               b) Facial trauma (caution)
               c) Esophageal obstruction
            iii) Advantages
               a) Tolerated by awake patients
               b) Does not interfere with intubation
               c) Mitigates recurrent gastric distension
               d) Mitigates nausea
               e) Patient can still talk
            iv) Disadvantages
               a) Uncomfortable for patient
               b) May cause patient to vomit during placement even if gag is suppressed
               c) Interferes with BVM seal
            v) Complications
               a) Nasal, esophageal or gastric trauma from poor technique
               b) Endotracheal placement
               c) Supragastric placement
               d) Tube obstruction
            vi) Method
               a) Prepare patient
                  b) Head neutral
                  c) Oxygenate
                  d) Suppress gag with topical anaesthetic or IV lidocaine
                  e) Anesthetize and dilate nares

f) Lubricate tube
g) Advance gently along nasal floor
h) Encourage patient to swallow or drink to facilitate passage
i) Advance into stomach
j) Confirm placement
k) Auscultate while injecting 30-50 ccs of air
l) Note gastric contents through tube
m) No reflux around tube
n) Secure in place

(c) Orogastric decompression
i) Indications
a) Same parameters as NG
b) Generally preferred for unconscious patients
ii) Contraindications
a) Same parameters as NG
iii) Advantages
a) May use larger tubes
b) May lavage more aggressively
c) Safe to pass in facial fracture
d) Avoids nasopharynx
iv) Disadvantages
a) May interfere with visualization during Intubation
v) Method
a) Neutral or flexed head position
b) Introduce tube down midline
c) Procedure same as NG
vi) Complications
a) Same as NG
b) Patient may bite tube

XVIII. Airway management
1. Manual maneuvers
a. Head-tilt/ chin-lift maneuver
(1) Technique
(a) Tilt head back
(b) Lift chin forward
(c) Open mouth
(2) Indications
(a) Unresponsive patients who
i) Do not have mechanism for c-spine injury
ii) Unable to protect their own airway
(3) Contraindications
i) Awake patients
ii) Possible c-spine injury
(4) Advantages
(a) No equipment required
(b) Simple
(c) Safe
(d) Non-invasive
(5) Disadvantages

(a) Head tilt hazardous to c-spine injured patients
(b) Does not protect from aspiration

b. Jaw-thrust without head-tilt maneuver
(1) Technique
(a) Head is maintained neutral
(b) Jaw is displaced forward
(c) Lift by grasping under chin and behind teeth
(d) Mouth opened
(2) Indications
(a) Patients who are
i) Unresponsive
ii) Unable to protect their own airway
iii) May have c-spine injury
(3) Contraindications
(a) Responsive patients
(b) Resistance to opening mouth
(4) Advantages
(a) May be used in c-spine injury
(b) May be performed with cervical collar in place
(c) Does not require special equipment
(5) Disadvantages
(a) Cannot maintain if patient becomes responsive or combative
(b) Difficult to maintain for extended period
(c) Very difficult to use in conjunction with bag-valve-mask ventilation
(d) Thumb must remain in patient's mouth in order to maintain displacement
(e) Separate rescuer required to perform bag-valve-mask ventilation
(f) Does not protect against aspiration

c. Modified jaw-thrust maneuver
(1) Technique
(a) Head maintained neutral
(b) Jaw is displaced forward at mandibular angle
(2) Indications
(a) Unresponsive
(b) Cervical spine Injury
(c) Unable to protect own airway
(d) Resistance to opening mouth
(3) Contraindications
(a) Awake patients
(4) Advantages
(a) Non-invasive
(b) Requires no special equipment
(c) May be used with cervical collar in place
(5) Disadvantages
(a) Difficult to maintain
(b) Requires second rescuer for bag-valve-mask ventilation
(c) Does not protect against aspiration

2. Nasal airway
a. Soft rubber with beveled tip
(1) Distal tip rests in hypopharynx
(2) For adults, length measured from nostril to earlobe
(3) Diameter roughly equal to patient's little finger

b. Indications
   (1) Unconscious patients
   (2) Altered response patients with suppressed gag reflex
c. Contraindications
   (1) Patient intolerance
   (2) Caution in presence of facial fracture or skull fracture
d. Advantages
   (1) Can be suctioned through
   (2) Provides patent airway
   (3) Can be tolerated by awake patients
   (4) Can be safely placed "blindly"
   (5) Does not require mouth to be open
e. Disadvantages
   (1) Poor technique may result in severe bleeding
      (a) Resulting epistaxis may be extremely difficult to control
   (2) Does not protect from aspiration
f. Placement
   (1) Determine correct length and diameter
   (2) Lubricate nasal airway
   (3) With bevel towards septum, insert gently along the nasal floor parallel to the mouth
   (4) Do not force
   (5) Measurement from corner of the mouth to the jaw angle rather than tip of the ear
   (6) Too long airway causes airway obstruction

3. Oral airway
   a. Hard plastic airway designed to prevent the tongue from obstructing glottis
   b. Indications
      (1) Unconscious patients
      (2) Absent gag reflex
   c. Contraindications
      (1) Conscious patients
   d. Advantages
      (1) Non-invasive
      (2) Easily placed
      (3) Prevents blockage of glottis by tongue
   e. Disadvantages
      (1) Does not prevent aspiration
      (2) Unexpected gag may produce vomiting
   f. Complications
      (1) Unexpected gag may produce vomiting
      (2) Pharyngeal or dental trauma with poor technique
   g. Placement
      (1) Open mouth
      (2) Remove visible obstructions
      (3) Place with distal tip toward glottis using tongue depressor as adjunct
      (4) Alternate method - place airway with distal tip toward palate and rotate into place
   h. Pediatrics
      (1) Place with tongue depressor
      (2) Place with tip toward tongue, not palate

4. Endotracheal tube
   a. Tube passed into the trachea in order to provide externally controlled breathing through a BVM or ventilator

(1) Sizes
  (a) 2.5-9.0 mm inside diameter (id)
  (b) Length 12-32 cm
(2) Types
  (a) Cuffed 5.0-9.0
    i) Proximal end 15 mm adapter
    ii) Proximal end inflation port with pilot balloon
    iii) Cm markings along length
    iv) Distal end beveled tip
    v) Distal end balloon cuff
  (b) Uncuffed 2.5-4.5
    i) Proximal end 15 mm adapter
    ii) Distal end bevel tip
    iii) Distal end depth markings
    iv) No balloon cuff or pilot balloon

b. Indications
(1) Present or impending respiratory failure
(2) Apnea
(3) Failure to protect own airway

c. Contraindications

d. Advantages
(1) Provides a secure airway
(2) Protects against aspiration
(3) Route for medication

e. Disadvantages
(1) Special equipment needed
(2) Bypasses physiologic function of upper airway
  (a) Warming
  (b) Filtering
  (c) Humidifying

f. Complications
(1) Bleeding
(2) Laryngeal swelling
(3) Laryngospasm
(4) Vocal cord damage
(5) Mucosal necrosis
(6) Barotrauma

g. Techniques of insertion
(1) Orotracheal intubation by direct laryngoscopy
  (a) Directly visualizing the passage of an ET tube into the trachea
  (b) Indications
    i) Apnea
    ii) Hypoxia
    iii) Poor respiratory effort
    iv) Suppression or absence of gag reflex
  (c) Contraindications
    i) Caution in unsuppressed gag reflex
  (d) Advantages
    i) Direct visualization of anatomy and tube placement
    ii) Ideal method for confirming placement
    iii) May be performed in breathing and apneic patients

(e) Disadvantages
i) Requires special equipment
(f) Complications
i) Dental trauma
ii) Laryngeal trauma
iii) Misplacement
a) Right mainstem
b) Esophageal
(g) Equipment
i) Laryngoscope
a) Device used to visualize glottis during endotracheal intubation
b) Battery pack/ handle with interchangeable blades
c) Blade types
d) Straight (Miller) lifts epiglottis
e) Curved (MacIntosh) lifts epiglottis by fitting into vallecula
ii) 10 cc syringe to inflate/ deflate balloon cuff
iii) Water soluble lubricant to lubricate endotracheal tube, promote ease of passage, and decrease trauma
iv) Stylet - semi-rigid wire for molding and maintaining tube shape
v) Securing device
a) Tape
b) Commercially available endotracheal tube holder
vi) Suction
vii) Body substance precautions
a) Gloves
b) Mask
c) Eyewear or faceshield

h. Endotracheal intubation technique
(1) Medical patient
(a) Orotracheal intubation by direct laryngoscopy
(b) Place patient supine in sniffing position to facilitate visualization
(c) Method
i) Position used when the potential for c-spine injury does not exist
a) Sniffing position
b) Optimal hyperextension of head with elevation of occiput
c) Brings the axes of the mouth, the pharynx, and the trachea into alignment
ii) When potential for c-spine injury exists head is held firmly in neutral position during intubation
iii) Ensure optimal oxygenation and ventilation with 100% O_2
iv) Ensure all equipment is prepared
a) Lubricated tube with stylet in place
b) Best position is "hockey stick"
c) Bend directly behind balloon cuff
d) Working laryngoscope
e) Blade locks securely in place
f) Light is bright and steady (unpleasant to look at)
g) Test cuff by inflating and then deflating
v) Ideally, hyperoxygenate patient for 30 seconds to 1 minute
vi) Insert laryngoscope blade
a) Gently insert to hypopharynx

b) Lift tongue and jaw with firm, steady pressure
c) Avoid fulcrum against teeth
vii) Identify vocal cords
viii) Gently pass ET tube until observe passage of balloon cuff past cords
ix) Remove stylet
x) Inflate balloon cuff
xi) Ventilate patient
xii) Confirm placement with multiple methods
xiii) Reconfirm placement with major patient movement or head movement

(2) Nasotracheal intubation
(a) Passage of ET tube through nasopharynx into trachea
(b) Indications
i) Breathing patients requiring intubation
(c) Contraindications
i) Caution with facial trauma
ii) Caution with deviated septum
(d) Advantages
i) Does not require laryngoscope
ii) Does not require sniffing position
iii) More easily secured
iv) Patient cannot bite tube
(e) Disadvantages
i) "Blind" technique
ii) Can only be performed on breathing patients
(f) Method
i) Patient's head is placed in neutral position
ii) Standard pre-intubation precautions
a) Suction
b) Oxygenation
c) Equipment preparation
iii) Preform tube
a) Bend into circle while preparing patient
b) Use endotrol tube
c) Endotracheal tube with attached line that adjusts direction of the distal tip (substitutes for stylet)
iv) Hyperoxygenate
v) Gently insert lubricated tube
a) Bevel towards septum
b) Along nasal floor
c) Through largest or most compliant nostril
vi) Advance tube until loudest exchange of air is heard (approximately 15cm)
a) May need to slightly rotate tube
vii) Advance tube through vocal cords on inspiration
viii) Inflate cuff
ix) Confirm placement
x) Secure tube

(3) Digital intubation
(a) Direct palpation of glottic structures to intubate trachea
(b) Indications
i) Apnea

ii) Confined space
iii) Inability to directly visualize
(c) Contraindications
i) Breathing patient
ii) Present gag reflex
(d) Advantages
i) Does not require laryngoscope
ii) Does not require sniffing position
iii) May be passed through fluid obstructions
(e) Disadvantages
i) Semi-blind technique
ii) May only be done on apneic patients
(f) Method
i) Pre-intubation precautions
ii) Open mouth
a) Extending tongue with gauze will facilitate palpation of glottis
iii) Palpate and lift epiglottis
iv) Palpate arytenoid cartilage
v) Pass tube between epiglottis and arytenoids
vi) Inflate balloon cuff
vii) Confirm placement
viii) Secure tube
(4) Transillumination techniques (lighted stylet)
(a) Use of a lighted stylet to transilluminate the glottis and facilitate intubation
(b) Indications
i) Inability to directly visualize glottis
ii) Cervical spine injury
(c) Contraindications
i) Present gag reflex
ii) Airway obstruction
(d) Advantages
i) Minimal manipulation of cervical spine
ii) Adds visual parameter to blind technique
(e) Disadvantages
i) Difficult in bright light
(f) Method
i) Pre-intubation precautions
ii) Place patient in neutral position
iii) Bend tube into "J"
iv) Turn on stylet
a) Insert midline into pharynx
v) Observe for focused midline glow
vi) Advance additional 1-2 cm
vii) Remove stylet
viii) Inflate balloon cuff
ix) Confirm placement
x) Secure tube

i. Confirming placement
(1) Methods
(a) Direct re-visualization
i) Re-visualize glottis

ii) Note tube depth
a) Average tube depth in males is 22 cm at the teeth
b) Average tube depth in women is 21 cm
(b) Note condensation in the tube
(c) Auscultation
i) Epigastric area
a) Air entry into stomach indicates esophageal placement
ii) Bilateral bases
a) Equal volume and expansion
iii) Apices
a) Equal volume
iv) Unequal or absent breath sounds indicate
a) Esophageal placement
b) Right mainstem placement
c) Pneumothorax
d) Bronchial obstruction
(d) Palpation of balloon cuff at sternal notch by compressing pilot balloon
(e) Pulse oximetry
(f) Expired CO_2
i) Measures presence of CO_2 in expired air
a) Colormetric
b) Digital
c) Digital/ waveform
(g) Bag-valve-mask ventilation compliance
i) Increased resistance to BVM compliance may indicate
a) Gastric distension
b) Esophageal placement
c) Tension pneumothorax
(2) Evidence of a misplaced tube regardless when it was last checked must be reconfirmed
(3) Confirmation must be performed
(a) By multiple methods
(b) Immediately after tube placement
(c) After any major move
(d) After manipulation of neck (manipulation of neck may displace tube up to 5 cm)

j. Corrective measures
(1) Esophageal placement
(a) Ready to vigorously suction as needed
(b) Likelihood of emesis is increased especially if gastric distension is present
(c) Ideally preoxygenate prior to reintubation
(d) Misplaced tube may be removed after proper tracheal placement is confirmed or it may be removed beforehand provided diligent and vigorous airway suctioning is ready
(2) Right mainstem placement
(a) Loosen or remove securing device
(b) Deflate balloon cuff
(c) While ventilation continues, SLOWLY retract tube while simultaneously listening for breath sounds over left chest
(d) STOP as soon as breath sounds are heard in left chest
(e) Note tube depth
(f) Reinflate balloon cuff
(g) Secure tube

k. Securing the tube
   (1) As critical as the intubation itself
   (2) Multiple methods and products available
   (3) Adjuncts include
      (a) Securing to maxilla rather than mandible
      (b) Tincture of benzoin to facilitate tape adhesion

l. Field extubation
   (1) Generally, the only reason to field extubate is the patient is unreasonably intolerant of the tube
   (2) Awake patients are at high risk of laryngospasm immediately following extubation
   (3) There may be a problem re-inducting and re-intubating a laryngospastic patient
   (4) Indications
      (a) Able to protect and maintain airway
      (b) Risks for need to reintubate significantly reduce
      (c) Must not be sedated
   (5) Contraindications
      (a) Any risk of recurrence of respiratory failure
   (6) Complications
      (a) Highest risk of recurrence of laryngospasm is immediately post extubation
      (b) Respiratory distress or failure may return necessitating re-intubation
   (7) Method
      (a) Ensure oxygenation
      (b) Intubation equipment and suction immediately available
      (c) Confirm patient responsiveness
      (d) Suction oropharynx
      (e) Deflate cuff
      (f) Remove upon cough or expiration
   (8) Special considerations
      (a) Need for field extubation is extremely rare
      (b) Intolerance of ET tube evidenced by gag reflex should be addressed by increasing sedation rather than removing tube

m. Pediatric endotracheal intubation
   (1) Laryngoscope and size appropriate blades
      (a) Straight blades are preferred
      (b) General guidelines
         i) Premature infant - 0 straight
         ii) Full-term infant to one year of age - 1 straight
         iii) Two years of age to adolescent - 2 straight
         iv) Adolescent and above - 3 straight or curved
   (2) Appropriate size endotracheal tube
      (a) Formula = (16 + age in years) ÷ 4
      (b) Anatomical clues
      (c) General guidelines
         i) Premature infant - 2.5 to 3.0 uncuffed
         ii) Full-term infant - 3.0 to 3.5 uncuffed
         iii) Infant to one year of age - 3.5 to 4.0 uncuffed
         iv) Toddler - 4.0 to 5.0 uncuffed
         v) Preschool - 5.0 to 5.5 uncuffed
         vi) School age - 5.5 to 6.5 uncuffed
         vii) Adolescent - 7.0 to 8.0 cuffed
      (d) Depth of insertion

i) 2-3 cm below the vocal cords
a) Uncuffed - place the black glottic marker of the tube at the level of the vocal cords
b) Cuffed - insert until the cuff is just below the vocal cords
ii) 3 x inside diameter - 1
iii) General guidelines
a) Premature infant - 8 cm
b) Full-term infant - 8 to 9.5 cm
c) Infant to one year of age - 9.5 to 11 cm
d) Toddler - 11 to 12.5 cm
e) Preschool - 12.5 to 14 cm
f) School age - 14 to 20 cm
g) Adolescent - 20 to 23 cm

(e) Appropriate sized endotracheal tube stylet

(3) Endotracheal tube securing device
(a) Tape
(b) Commercial device

(4) Technique
(a) Separate parent/ guardian and patient
(b) Manually open airway
(c) Insert appropriate airway adjunct if needed
(d) Ventilate patient with 100% oxygen via age appropriate sized bag
(e) Place the patient's head in the sniffing position
(f) Pre-oxygenate the patient with 100% oxygen a minimum of 30 seconds
(g) Prepare all equipment
i) Lubricate endotracheal tube with sterile water/ saline or water-soluble gel
ii) Lubricate stylet if utilized
(h) Insert the laryngoscope to the right side of the mouth and sweep the tongue to the left side
(i) Lift tongue with firm, steady pressure
i) Avoid fulcrum against teeth or gums
(j) Use the tip of the blade to lift epiglottitis
(k) Identify the vocal cords
(l) Introduce the endotracheal tube to the right side of the mouth
(m) Pass the tube through the vocal cords to about 2-3 cm below the vocal cords
(n) Confirm proper tube placement
i) Observe for symmetrical chest expansion
ii) Auscultate for equal breath sounds over each lateral chest wall high in the axillae
iii) Absence of breath sounds over the abdomen
iv) Improved heart rate and color
v) If available, end-tidal carbon dioxide detector
(o) Secure tube noting placement of distance marker at teeth/ gums
(p) Reconfirm tube placement

5. Multi-lumen airways
a. Pharyngo-tracheal lumen airway (PTL)
(1) An endotracheal tube encased in a large pharyngeal tube
(2) Designed to be passed blindly
(3) Dual ventilation ports provide means to ventilate regardless of whether the ET tube is placed in the esophagus or the trachea
(4) Indications

(a) Alternative airway control when conventional intubation procedures are not available or successful

(5) Advantages
- (a) Can ventilate with tracheal or esophageal placement
- (b) No facemask to seal
- (c) No special equipment
- (d) Does not require sniffing position

(6) Disadvantages
- (a) Cannot be used in awake patients
- (b) Adults only
- (c) Pharyngeal balloon mitigates but does not eliminate aspiration risk
- (d) Can only be passed orally
- (e) Extremely difficult to intubate around

(7) Method
- (a) Head neutral
- (b) Pre-intubation precautions
- (c) Insert at the midline using jaw-lift
- (d) Ventilate through pharyngeal tube (green) first
  - i) Chest rise indicates ET tube is in esophagus
    - a) Inflate pharyngeal balloon and ventilate
  - ii) No chest rise indicates ET tube in trachea
    - a) Inflate ET tube balloon cuff
    - b) Ventilate through ET tube

(8) Complications
- (a) Pharyngeal or esophageal trauma from poor technique
- (b) Unrecognized displacement of ET tube into esophagus
- (c) Displacement of pharyngeal balloon

(9) Special considerations
- (a) Good assessment skills are essential to properly confirm placement
- (b) Mis-identification of placement has been reported
- (c) Reinforce multiple confirmation of placement techniques

b. Combitube

(1) Pharyngeal and endotracheal tube molded into a single unit

(2) Indications
- (a) Alternative airway control when conventional intubation measures are unsuccessful or unavailable

(3) Contraindications
- (a) Children too small for the tube
- (b) Esophageal trauma or disease
- (c) Caustic ingestion

(4) Advantages
- (a) Rapid insertion
- (b) No special equipment
- (c) Does not require sniffing position

(5) Disadvantages
- (a) Impossible to suction trachea when tube is in esophagus
- (b) Adults only
- (c) Unconscious only
- (d) Very difficult to intubate around

(6) Method
- (a) Head - neutral position

(b) Pre-intubation precautions
(c) Insert with jaw-lift at midline
(d) Inflate pharyngeal cuff with 100 ccs of air
(e) Inflate distal cuff with 10-15 ccs of air
(f) Ventilate through longest tube first (pharyngeal)
i) Chest rise indicates esophageal placement of distal tip
ii) No chest rise indicates tracheal placement, switch ports and ventilate
(7) Special considerations
(a) Good assessment skills are essential to confirm proper placement
(b) Mis-identification of placement has been reported
(c) Reinforce multiple confirmation techniques

XIX. Pharmacological adjuncts to airway management and ventilation
1. Sedation in emergency intubation
a. Sedatives are used in airway management to
(1) Reduce anxiety
(2) Induce amnesia
(3) Decrease the gag reflex
b. Indications
(1) Combative patients
(2) Patients who require aggressive airway management but who are too conscious to tolerate intubation
(3) Agitated patients
c. Contraindications
(1) Known sensitivity to the medications
d. Advantages
(1) Decreases anxiety
(2) Induces amnesia
e. Disadvantages
(1) Respiratory depression
(2) Vomiting/ aspiration
f. Pharmacology
(1) Decreases anxiety
(2) Increases patient compliance
(3) Often produces amnesia to procedure
(4) Enhances ease of intubation
(5) Types of medications used
(a) Haloperidol
(b) Barbiturates
(c) Benzodiazepines
(d) Etomidate
(e) Narcotics
(f) Ketamine
g. Complications
(1) Airway compromise
(2) Regurgitation/ aspiration
(3) Loss of protective reflexes
(4) Sedating patient with tenuous airway may completely collapse what airway they have
h. Method

2. Neuromuscular blockade in emergency intubation
   a. The use of neuromuscular blocking agents to induce skeletal muscle paralysis
   b. The patient is much easier to intubate once paralyzed
   c. Indications
      (1) Combative patients who need to be intubated
   d. Contraindications
      (1) Absolute
         (a) Inability to ventilate once paralyzed
      (2) Relative
         (a) Patients who will be difficult to ventilate (i.e. facial hair, etc)
         (b) Patients who will be difficult to intubate (short necks, etc.)
   e. Advantages
      (1) Enables the paramedic to intubate some patients who need aggressive airway management (i.e. head injury, etc.) but may be otherwise uncooperative
   f. Disadvantages
      (1) Paralysis of the diaphragm/ apnea
      (2) Inability of the patient to protect their own airway
   g. Pharmacology
      (1) Skeletal muscles contract in response to nerve stimulus
      (2) Junction of muscle and nerve fiber is neuromuscular junction
      (3) Acetylcholine (ACH) allows nerve impulse to cross neuromuscular junction
      (4) Neuromuscular blockade relaxes muscle by impeding the action of ACH
      (5) Does not provide sedation
      (6) Types
         (a) Depolarizing agents
            i) Substitute themselves into neuromuscular junction
            ii) May cause fasciculations (uncontrollable muscle twitching)
            iii) Examples
               a) Succinylcholine
                  b) Rapid onset/ short duration (90 seconds/ 5-10 minutes)
                  c) Use with caution in burns, crush, blunt trauma (hyperkalemia)
         (b) Non-depolarizing agents
            i) Block uptake of ACH into junction
            ii) Do not cause fasciculations
            iii) Examples
               a) Vecuronium
                  b) Rapid onset - 2 minutes
                  c) Short duration - 45 minutes
               d) Pancuronium
                  e) Rapid onset - 3-5 minutes
                  f) Longer duration - 1 hour
   h. Complications
      (1) Inability to intubate
      (2) Inability to ventilate
      (3) Vomiting
      (4) Airway compromise
   i. Method for rapid sequence intubation

XX. Translaryngeal cannula ventilation

1. High volume/ high pressure ventilation of lungs through cannulation of trachea below the glottis
   a. Oxygen delivery differs from other methods
   b. Delivers a large volume of O_2 through a small port
   c. Delivers a very high pressure to the lungs compared to other methods (50 psi versus less than 1 psi through a regulator)
2. Indications
   a. Apnea
   b. Delayed or inability to ventilate the patient by other means
3. Contraindications
   a. Total airway obstruction (both inspiratory and expiratory)
   b. Equipment not immediately available
4. Advantages
   a. Rapidly performed
   b. Provides adequate ventilation when performed properly
   c. Does not manipulate the cervical spine
   d. Does not interfere with subsequent attempts to intubate
5. Disadvantages
   a. Requires jet ventilator
   b. Expends high volumes of oxygen more rapidly
   c. May not protect against aspiration
6. Equipment
   a. Large bore IV catheter (14-16 gauge)
   b. 10 cc syringe
   c. 3 ccs of water or saline (optional)
   d. Oxygen source (50 psi)
   e. Jet ventilator
7. Method
   a. Prepare equipment
   b. Identify cricothyroid membrane
   c. Insert needle with syringe midline through cricothyroid membrane at a slight angle towards sternum
   d. Withdraw on syringe plunger until air is freely withdrawn (bubbles if fluid is in syringe)
   e. Advance additional 1 cm
   f. Hold needle steady, advance catheter to hub
   g. Attach jet ventilator
   h. Ventilate once per five seconds
      (1) Exhalation is passive through the glottis
8. Complications
   a. Bleeding
      (1) From improper catheter placement
   b. Subcutaneous emphysema
      (1) From excessive air leak around catheter site or undetected laryngeal trauma
   c. Airway obstruction
      (1) Result of excessive bleeding or subcutaneous air which compresses trachea
   d. Barotrauma
      (1) Resulting from overinflation
   e. Hypoventilation

XXI. Cricothyrotomy
1. Surgical access to the airway through the cricothyroid membrane
2. Indications
   a. Total upper airway obstruction (epiglotitis, acute anaphylaxis, respiratory tract burns, etc.)
   b. Massive facial trauma
   c. Delayed or inability to intubate or ventilate the patient by other means
   d. Contraindication to intubation
   e. Posterior laceration of the tongue
   f. Inability to open the mouth
3. Contraindications
   a. Inability to identify anatomical landmarks
   b. Crush injury to the larynx
   c. Tracheal transection
   d. Underlying anatomical abnormality (trauma, tumor, subglottic stenosis, etc.)
4. Advantages
   a. Rapidly performed
   b. Much faster and technically easier than tracheostomy
   c. Does not manipulate the cervical spine
5. Disadvantages
   a. Difficult to perform in children
   b. Difficult to perform on patients with short, muscular, or fat necks
6. Equipment
   a. Endotracheal or tracheostomy tube
   b. Scalpel
   c. Curved hemostats
   d. Suction apparatus
7. Method
8. Complications
   a. Incorrect tube placement/ false passage
   b. Thyroid gland damage
   c. Severe bleeding
   d. Subcutaneous emphysema
   e. Laryngeal nerve damage

XXII. Special patient considerations
1. Patients with larngectomies (stomas)
   a. Mucous plug
      (1) Laryngeotomies possess less efficient cough
      (2) Mucous commonly obstructs tubes
      (3) Tube may be removed/ cleaned and replaced
   b. Stenosis
      (1) Stoma spontaneously narrows
         (a) Potentially life-threatening
         (b) Soft tissue swelling decreases stoma diameter
      (2) Trach tube is difficult or impossible to replace
      (3) ET tube must be placed before total obstruction
   c. Suctioning
      (1) Must be done with extreme caution if laryngeal edema is suspended
      (2) Procedure
         (a) Preoxygenate
         (b) Inject 3 cc sterile saline down trachea

(c) Instruct patient to exhale
(d) Insert suction catheter until resistance detected
(e) Instruct patient to cough or exhale
(f) Suction during withdrawal

d. Tube replacement
(1) Lubricate appropriately sized tracheostomy tube or ET tube (5.0 or larger)
(2) Instruct patient to exhale
(3) Gently insert tube about 1-2 cm beyond balloon cuff
(4) Inflate balloon cuff
(5) Confirm comfort, patency and proper placement
(6) Ensure false lumen was not created

2. Dental appliances
a. Dentures, partial plates, etc.
b. Best removed before intubation

3. Airway management considerations for patients with facial injuries
a. Facial injuries suggest the possibility of cervical spine injury
(1) In-line stabilization
(a) Trauma technique endotracheal intubation
b. Foreign body/ blood in oropharynx
(1) Suction airway
c. Inability to ventilate/ intubate orally
(1) Requires surgical intervention