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Anatomy and Physiology

Rationale: Comprehensive knowledge of anatomy and physiology is a fundamental prerequisite to medical sonographic imaging. The essential components of the study of an anatomy and physiology curriculum are listed below.

1. Discuss the structural levels of organization, anatomical components, and physiology
2. Define terminology and relationships related to anatomical directions, planes, and body cavities
3. Define homeostasis and its importance on the human body
4. Describe the anatomy and physiology of each of the organ systems of the body

I. Structure of the Body

A. Structural Levels of Organization

1. Chemical level
2. Cellular level
3. Tissues
4. Organs
5. Systems

B. Anatomic Position

1. Supine
2. Prone

C. Anatomic Directions

1. Superior/inferior
 - a. Cranial/caudal
2. Anterior/posterior
3. Medial/lateral
4. Proximal/distal
5. Superficial/deep

D. Planes or Body Sections

1. Sagittal
 - a. Midsagittal
 - b. Parasagittal
2. Coronal
3. Transverse

E. Body Cavities

1. Ventral
 - a. Thoracic cavity
 - 1) Mediastinum
 - 2) Pleural
 - b. Abdominopelvic cavity
 - 1) Abdominal

Anatomy and Physiology

- 2) Pelvic
- 3) Peritoneal/retroperitoneal
- c. Abdominopelvic regions
 - 1) Nine regions
 - a) Right and left hypochondriac regions
 - b) Epigastric region
 - c) Right and left lumbar regions
 - d) Umbilical region
 - e) Right and left iliac regions
 - f) Hypogastric region
 - 2) Four quadrants
 - a) Right upper
 - b) Right lower
 - c) Left upper
 - d) Left lower
- 2. Dorsal
 - a. Cranial cavity
 - b. Spinal cavity

II. Homeostasis

- A. Definition
- B. Significance

III. Cells

- A. Characteristics
 - 1. Size and shape
 - 2. Composition
 - 3. Structural parts of the cell
 - 4. Relationship of cell structure and function
- B. Membranes
 - 1. Passive transport
 - 2. Active transport
 - 3. Cell transport and disease
- C. Reproduction
 - 1. DNA
 - 2. DNA replications
 - 3. Mitosis
 - 4. Cell division
 - 5. Genetic code

Anatomy and Physiology

6. Changes in cell growth and reproduction
7. Inheritance and disease

IV. Tissues

- A. Epithelial Tissue
- B. Connective Tissue
- C. Muscle Tissue
- D. Nervous Tissue
- E. Tissue Repair

V. Organ Systems and Function of the Body

- A. Integumentary
 1. Skin
 2. Hair
 3. Nails
 4. Sense receptors
 5. Sweat glands
 6. Oil glands
- B. Musculoskeletal
 1. Bones
 2. Joints
 3. Muscles
 4. Tendons and ligaments
 5. Cartilage
- C. Nervous
 1. Brain
 2. Spinal cord
 3. Nerves
- D. Cardiovascular (Circulatory)
 1. Heart
 2. Circulation
 - a. Systemic
 - b. Pulmonary
 - c. Hepatic portal
 - d. Fetal

Anatomy and Physiology

3. Blood pressure
 4. Pulse
- E. Endocrine
1. Pituitary gland
 2. Pineal gland
 3. Hypothalamus
 4. Thyroid gland
 5. Parathyroid gland
 6. Thymus
 7. Adrenals
 8. Pancreas
 9. Ovaries
 10. Testes
- F. Lymphatic and Immune
1. Lymph nodes
 2. Lymph vessels
 3. Thymus
 4. Spleen
 5. Tonsils
- G. Respiratory
1. Nose
 2. Pharynx
 3. Larynx
 4. Trachea
 5. Bronchi
 6. Lungs
- H. Digestive
1. Primary organs
 - a. Mouth
 - b. Pharynx
 - c. Esophagus
 - d. Stomach
 - e. Small intestine
 - f. Large intestine
 - g. Rectum
 - h. Anal canal
 2. Secondary organs
 - a. Teeth
 - b. Salivary glands
 - c. Tongue
 - d. Liver
 - e. Gallbladder and bile ducts

Anatomy and Physiology

- f. Pancreas
 - g. Appendix
- I. Urinary
- 1. Kidneys
 - 2. Ureters
 - 3. Urinary bladder
 - 4. Urethra
- J. Reproductive
- 1. Female
 - a. Ovaries
 - b. Uterus
 - c. Fallopian tubes
 - d. Vagina
 - e. Vulva
 - 2. Male
 - a. Testes
 - b. Vas deferens
 - c. Epididymis
 - d. Urethra
 - e. Prostate
 - f. Seminal vesicles
 - g. Penis
 - h. Scrotum

Anatomy and Physiology

Pathophysiology

Rationale: Sonographers require a comprehensive knowledge of anatomic versus physiologic abnormalities to assist in the identification and diagnosis of disease. The study of pathophysiology is a branch of pathology, the general study of disease. Disease can be described as abnormality in body function that threatens well-being. The essential components of the study of pathophysiology are listed below.

1. List and describe the basic mechanisms of disease and risk factors associated with disease
2. List and describe the categories of pathogenic organisms and how they cause disease
3. Distinguish between the terms benign and malignant as they apply to tumors
4. Outline the events of inflammatory response and explain its role in disease

I. Mechanisms of Disease

- A. Infectious
 1. Virus
 2. Prions
 3. Bacteria
 4. Fungi
 5. Protozoa
- B. Neoplastic
 1. Benign
 2. Malignant
- C. Degenerative/Multifactorial
 1. Atherosclerosis
- D. Inflammatory
- E. Autoimmune
- F. Others
 1. Nutritional
 2. Congenital versus acquired
 3. Physical and chemical agents

II. Disease Terminology

- A. Signs
- B. Symptoms

Anatomy and Physiology

- C. Syndrome
- D. Acute
- E. Chronic
- F. Etiology
- G. Idiopathic
- H. Iatrogenic
- I. Communicable
- J. Pathogenesis
- K. Incubation
- L. Remission
- M. Primary
- N. Metastasis
- O. Morbidity
- P. Mortality

III. Epidemiology

- A. Endemic
- B. Epidemic
- C. Pandemic

IV. Risk Factors

- A. Genetic
- B. Age
- C. Lifestyle

Anatomy and Physiology

D. Stress

E. Environmental

F. Preexisting Condition

General Education

Mathematics

Rationale: In order for sonographers to be successful in applying knowledge of physics, a solid background in mathematics is essential. The study of physics, acoustic physics, and application for measurement and quantitative analysis of anatomical structures using sonography requires a prerequisite knowledge of mathematics. The essential components of a mathematics curriculum are listed below.

1. Perform operations of algebraic expressions
2. Graph linear and quadratic functions
3. Solve equations and inequalities algebraically, and graphically
4. Graph polynomial, rational, algebraic, exponential, and logarithmic functions
5. Solve exponential and logarithmic equations
6. Describe fundamental geometric concepts and formulas

I. Fundamental Concepts

- A. Real Numbers
- B. Basic Rules of Algebra
- C. Radicals and Rational Exponents
- D. Polynomials
- E. Factoring
- F. Ordinal versus Linear Number System

II. Functions and Graphs

- A. Functions
- B. Combinations of Functions
- C. Inverses of Functions
- D. Graphs of Linear Functions
- E. Graphs of Quadratic Functions

General Education

III. Equations and Inequalities

- A. Intercepts and Zeros of Functions
- B. Solving Equations
 - 1. Algebraically
 - 2. Graphically
- C. Solving Inequalities
 - 1. Algebraically
 - 2. Graphically

IV. Polynomial Functions

- A. Quadratic Functions
- B. Polynomial Functions of Higher Degree
- C. Synthetic Division
- D. Real Zeros of Polynomials

V. Rational Functions

- A. Partial Fractions

VI. Exponential and Logarithmic Functions

- A. Graphs
- B. Equations
- C. Models

VII. Geometry

- A. Fundamental Concepts and Formulas
 - 1. Linear measurements
 - 2. Circles and spheres
 - a. Radius
 - b. Diameter
 - c. Circumference

General Education

- d. Area
- e. Orthogonal planes
- 3. Volumes
 - a. Spherical
 - b. Ellipsoidal
 - c. Cylindrical
 - b. Pyramidal and conical
 - c. Irregular volumes
 - d. Methods of measuring volumes
 - 1) Calculation from linear perpendicular measurements
 - 2) Calculation by Simpson's Rule

VIII. Measurement Comparisons and Change in Time

- A. Ratios

General Education

Physics

Rationale: Mastery of general physics is an essential prerequisite to the study of acoustic physics. The essential components of a physics curriculum are listed below.

1. Discuss Newton's laws of motion
2. Describe the properties of solids, liquids, and gases
3. Identify the characteristics of sound and the wave properties of sound
4. Describe the properties of heat and light
5. Discuss the behavior of electric charges and electromagnetic charges

I. Newton's Laws of Motion

- A. Inertia
- B. Acceleration
- C. Reciprocal Action

II. Laws of Conservation

- A. Momentum
- B. Energy
- C. Angular Momentum

III. Properties of Matter

- A. Solids
- B. Liquids
- C. Gases

IV. Temperature and Heat

- A. Thermal Energy and Thermodynamics
- B. Heat Transfer

General Education

V. Properties of Sound

- A. Waves
- B. Frequency Ranges
 - 1. Infrasound
 - 2. Audible
 - 3. Ultrasound

VI. Properties of Light

- A. Color
- B. Reflection and Refraction
- C. Emission

VII. Electricity

- A. Charge and Force
- B. Current and Ohm's Law

VIII. Properties of Electromagnetism

- A. Waves
- B. Frequency Spectrum

General Education

Communications

Rationale: Sonographers must be able to effectively communicate with patients, the public, and the healthcare team. The essential components of a communications curriculum are listed below.

1. Differentiate the various types of communication
2. Relate the effectiveness of good interpersonal skills
3. Discuss communication skills required within an organization
4. Describe the process and skills for creation and delivery of quality presentations
5. Demonstrate ability to compose formal written documents

I. Types

- A. Verbal
 1. Vocal characteristics
 2. Vocabulary
- B. Written
 1. Formal
 2. Informal
- C. Non-Verbal
 1. Expressive behaviors
 2. Body language
- D. Listening
 1. Passive
 2. Active

II. Components of Communication Skills

- A. Cognition
- B. Emotion
- C. Persuasion
- D. Impact
- E. Communication Barriers

General Education

III. Intraorganization Communication

- A. Direction of Communication
 1. Top-down
 2. Bottom-up
 3. Side-to-side
- B. Team Development
 1. Stages of development
 2. Member responsibilities
- C. Conflict
 1. Contributing factors
 2. Resolution

IV. Presentations

- A. Audience
 1. One-to-one
 2. Small group
 3. Large group
- B. Preparation
 1. Goals for audience
 2. Delivery format
 3. Visual aids
 4. Content
- C. Delivery
 1. Verbal
 2. Non-verbal

V. Written Correspondence

- A. Formal
- B. Informal
- C. Reports
- D. Resume/Cover Letter

General Education

Psychology and Human Behavior

Rationale: Sonographers require an understanding of the effects of personality, age, gender, culture, and conditions on human behavior in order to effectively interact with patients and the healthcare team. The essential components of a psychology curriculum are listed below.

1. List the physiological, cognitive, and affective foundations of behavior
2. Define the social basis for behavior
3. Discuss various personality traits

I. Neuroscience

- A. Nervous System
- B. Functional Anatomy
- C. Sensory Processes

II. Memory and Learning

- A. Developmental Stages
- B. Theories of Learning

III. Basics of Human Behavior

- A. Motivation
- B. Emotion
- C. Sensation and Perception
- D. Attachment, Morality, Identity
- E. Gender and Identity

IV. Personality

- A. Attitudes and Attribution
- B. Impressions and Influences

General Education

C. Adaptation

D. Culture

V. Psychological Disorders

A. Categories

B. Treatments

General Education

Statistics

Rationale: Sonographers must interpret data relevant to the profession. An understanding of statistical methodology and terminology is important to enhance critical thinking and for continued professional growth. The essential components of a statistics curriculum are listed below.

1. Describe methods of study design
2. Evaluate a variety of graphs utilized to plot statistical data
3. Define commonly used statistical terminology
4. Analyze statistical data in professional journals and publications

I. Study Design

- A. Types of Data
- B. Sampling
- C. Surveys and Observational Studies
- D. Comparative Studies

II. Graphical Depiction of Data

- A. Frequency Distributions
- B. Bar Charts
- C. Pie Charts
- D. Histograms
- E. Dot Plots
- F. Stem Plots

III. Descriptive Statistics

- A. Measures of Central Tendency
- B. Measures of Variability

General Education

IV. Probability and Random Variables

- A. Relative Frequency
- B. Basic Properties
- C. Estimating Probabilities Empirically

V. Sampling Distributions

- A. Normal
- B. Gaussian
- C. Chi-square

VI. Confidence Intervals

- A. Point Estimation
- B. Population Mean
- C. Population Proportion

VII. Hypothesis Testing

- A. Test Procedures
- B. Testing Errors

VIII. Bivariate Data Analysis

- A. Scatter Plots
- B. Pearson Correlation Coefficient
- C. Simple Linear Regression

General Education

Information Technology

Rationale: Sonographers effectively use computer technology to perform diagnostic medical sonography. Application of computer basics is essential in understanding sonographic instrumentation. Information management requires a working knowledge of computer technology. The essential components of an information technology curriculum are listed below.

1. Define basic computer terminology
2. Discuss use of information technology in healthcare management
3. List devices used for storage in diagnostic imaging
4. Discover communication mechanisms used for electronic searches

I. Basic Computer Terminology

- A. Hardware Components
- B. Software
 1. Operating systems
 2. Web browser
 3. Word processor
 4. Spreadsheets
 5. Database management
 6. Presentation software
 7. Image editing

II. Information Systems

- A. File Management
- B. Electronic Record System

III. Storage and Archiving

IV. Communications

- A. Intranet
- B. Internet

General Education

V. Electronic Searching

- A. Search Engines
- B. Databases
- C. Evaluation of Information

Medical Ethics and Law

Rationale: Sonographers must be knowledgeable of medical law as it relates to their professional scope of practice. Exposure to medicolegal consequences are minimized through education in legal process, principles of decision making, ethical dilemmas, HIPAA (Health Insurance Portability and Accountability Act), and coding and reimbursement. Professionalism is demonstrated through practice according to nationally-recognized scopes of practice and codes of ethics. The essential components of a medical law and ethics curriculum are listed below.

1. Discuss the legal process and types of law
2. Describe best practices to avoid legal consequences and procedures for reporting medical errors
3. Define key terminology related to ethics and principles of ethical decisions
4. Discuss the Patient Care Partnership (Patient's Bill of Rights)
5. Discuss compliance regulations relating to patient privacy and confidentiality
6. Describe the healthcare coding and reimbursement system
7. Analyze consequences for non-compliance to coding and reimbursement policies

I. Medical Law

A. Definition of Law

B. Types of Law

1. Substantive versus procedural law
2. Common
3. Civil
4. Contract
5. Criminal
6. Tort
 - a. Unintentional
 - b. Intentional

C. The Process From Claim to Outcome

1. Filing complaint
2. Discovery
 - a. Depositions
 - b. Document request
3. Court
 - a. Trial
 - b. Appellate
 - c. Supreme

D. Terminology

1. Respondeat superior
2. Res ipsa loquitur

Medical Ethics and Law

- E. Risk Management
 - 1. Medical malpractice liability coverage
 - 2. Documentation
 - 3. Scope of practice
 - 4. Adherence to employment policies and procedures
 - 5. Informed consent
- F. Patient Care Partnership (Patient's Bill of Rights)
- G. Regulatory Standards
 - 1. Agencies
 - 2. Guidelines

II. Ethics

- A. Key Concepts
 - 1. Ethics
 - 2. Values
 - 3. Morals
 - 4. Codes of ethics and conduct
 - 5. Ethical problems
 - a. Ethical dilemma
 - b. Ethical dilemma of justice
 - c. Ethical distress
 - d. Locus of authority issues
- B. Terminology
 - 1. Autonomy
 - 2. Justice
 - 3. Fidelity
 - 4. Beneficence
 - 5. Nonmalfeasance
 - 6. Veracity
 - 7. Paternalism
 - 8. Utilitarianism
 - 9. Deontology

III. Patient Privacy and Confidentiality

- A. Health Insurance Portability and Accountability Act (HIPAA)
 - 1. Overview of purpose
 - a. Confidentiality
 - b. Patient health information
 - c. Electronic transmission of healthcare transactions

Medical Ethics and Law

d. Computer integrity

B. Compliance Practices

IV. Coding and Reimbursement

A. Governing Bodies

1. Center for Medicare and Medicaid Services (CMS)

V. Third-party reimbursement

VI. Universal Coding System

A. International classification of diseases (ICD-9)

1. Mechanism of tracking diseases

2. Symptom and diagnosis codes

B. Healthcare common procedure coding system (HCPCS)

1. Uniform coding system

2. Current procedural terminology (CPT) codes

C. Local Carrier Determination (LCD) Review Policies

1. Accreditation

2. Personnel certification

D. Process of Post-Review Audits

E. Consequences of Fraud

F. Applicable ‘Whistleblower’ Laws

1. Local

2. Federal

Medical Ethics and Law

ABBREVIATIONS

C

CMS

Center for Medicare and Medicaid Services

CPT

Current Procedural Terminology

H

HCPCS

Healthcare Common Procedure Coding System

HIPAA

Health Insurance Portability and Accountability Act

I

ICD-9

International Classification of Diseases

L

LCD

Local Carrier Determination

Medical Ethics and Law

UTILIZED REFERENCES

Craig M. *Essentials of Sonography and Patient Care*, 2nd ed. St.Louis, MO: Elsevier Saunders; 2006.

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Patient Care

Rationale: Sonographers assess clinical history, current medical condition, provide high quality patient care, respond to emergency situations, demonstrate awareness of infection control techniques, and provide a safe environment for both the patient and health care team. Oral, written, and non-verbal communication must adhere to the prescribed professional standards. The essential components of a patient care curriculum are listed below.

1. Demonstrate patient transfer and immobilization techniques with consideration to safety of patient and self
2. Discuss the use and care for intravenous lines, catheters, percutaneous drains, and oxygen administration devices
3. Discuss transducer preparation, insertion, and disinfectant techniques
4. Explain the importance of infection control, practicing proper techniques, and management and proper disposal of contaminated and biohazard materials
5. Describe isolation precautions and aseptic techniques
6. Discuss appropriate responses to condition specific medical emergencies
7. Identify various contrast media used with sonography and medical imaging procedures and their associated risks and contraindications
8. List basic pharmacological agents that may be used with sonographic procedures, examinations, and emergency situations
9. Analyze the significance of appropriate professional behaviors
10. Discuss critical thinking and its application to the healthcare environment
11. Define and apply medical terms
12. Demonstrate effective acquisition and reporting of patient history, physical and sonographic findings
13. Discuss the components of an effective emergency preparedness plan
14. Demonstrate key skills of cultural competence

I. Body Mechanics, Lifts, and Transfers

- A. Proper Body Mechanics
- B. Lifting
- C. Wheelchair Transfers
- D. Stretcher/Bed Transfers

II. Immobilization Techniques

- A. Age Specific
 1. Pediatric
 2. Adult
- B. Mechanisms of Immobilization

Patient Care

III. Patient Assessment and Administration of Care

- A. Vital Signs
- B. Special Considerations
 1. Sedated
 2. Unconscious
 3. Cognitively impaired
 4. Uncooperative
 5. Ventilated
- C. Compassionate Care
- D. Patient Directives

IV. Oxygen Therapy and Devices

- A. Types
 1. Nasal cannula
 2. Nasal catheter
 3. Face mask
 4. Oxygen tent
 5. Pulse oximeter
 6. Oxygen cylinders
- B. Precautions

V. Tubes, Lines, and Indwelling Catheters

- A. Intravenous
- B. Urinary Catheters
- C. Wound Drainage
- D. Nasogastric Tube
- E. Gastrostomy Tube
- F. Endotracheal Tube
- G. Chest Tube
- H. Percutaneous Catheter

Patient Care

- I. Fetal Monitor
- J. Assist Devices
- K. Other

VI. Transducer Care

- A. Types
- B. Preparation, Cleaning, Disinfection, and Storage

VII. Infection Control

- A. Nosocomial Infections
- B. Signs and Symptoms
- C. Precautions
 - 1. Standard precautions
 - a. Hand hygiene
 - b. Personal protective equipment
 - 1) Masks
 - 2) Eye protection
 - 3) Gloves
 - 4) Aprons/gowns
 - c. Sharps management
 - d. Biohazards
 - 2. Transmission based precautions
 - a. Airborne
 - b. Droplet
 - c. Contact

VIII. Isolation Techniques

- A. General
- B. Reverse Isolation

IX. Aseptic and Sterile Technique

- A. Medical, Surgical Asepsis
 - 1. Proper attire

Patient Care

- B. Establish and Maintain Sterile Field
- C. Hand Wash Technique
- D. Sterile Environments
 - 1. Intensive care unit (ICU)
 - 2. Operating room (OR)

X. Response to Medical Emergencies

- A. First Aid
- B. Emergency Cart
- C. Head injuries
- D. Shock
- E. Diabetic Crisis
- F. Respiratory Distress
 - 1. Respiratory arrest
- G. Cardiac Arrest
 - 1. Cardiopulmonary Resuscitation (CPR)
- H. Cardiovascular Event
 - 1. Stroke
 - 2. Transient ischemic attack (TIA)
- I. Minor Emergencies
 - 1. Nausea and vomiting
 - 2. Syncope
 - 3. Seizures
- J. Wounds
 - 1. Hemorrhage
 - 2. Burns
 - 3. Dehiscence
 - 4. Ulcerations

XI. Contrast Media

- A. Types

Patient Care

1. Intravenous injections
2. Other

B. Risks and Contraindications

C. Adverse Reactions and Patient Management

XII. Basic Pharmacology

XIII. Professionalism

A. Professional Standards of Practice

B. Code of Ethics

C. Professional Image

1. Appearance and hygiene
2. Positive attitude

D. Non-Discrimination

E. Respect for Patient Dignity

F. Barriers to Employment

G. Continuous Quality Improvement (CQI)

XIV. Critical Thinking

A. Problem Solving and Decision Making

XV. Medical Terminology

A. Word Roots, Prefixes, and Suffixes

B. Definitions

C. Pronunciations

D. Abbreviations

Patient Care

XVI. Patient Evaluation

- A. Patient Identification
 - 1. Double identifier
 - 2. Time out
 - 3. Hand off
- B. Informed Consent
- C. Pertinent Medical History
- D. Critical Analysis of Patient History and Physical Findings
 - 1. Medical record
 - 2. Medical chart
 - 3. Correlative diagnostic assessment reports
- E. Documentation of History and Sonographic Findings
 - 1. Technical notes
 - 2. Oral case presentation

XVII. Emergency Preparedness

XVIII. Cultural Competence

- A. Awareness of One's Own Cultural World View
- B. Knowledge of Different Cultural Practices and World Views
- C. Attitude Toward Cultural Differences
- D. Cross-Cultural Skills

Patient Care

ABBREVIATIONS

C

CPR
CQI

Cardiopulmonary Resuscitation
Continuous Quality Improvement

I

ICU

Intensive Care Unit

O

OR

Operating Room

T

TIA

Transient Ischemic Attack

Patient Care

UTILIZED REFERENCES

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Sonographic Physics & Instrumentation

Rationale: Sonographers apply principles of ultrasound in the operation of medical sonographic equipment to produce a sonogram. Knowledge of the interaction of ultrasound with tissue is important for image optimization, acquisition and interpretation of sonographic images, and critical to the accurate diagnosis of disease.

1. Describe sound waves, propagation of ultrasound through tissue, reflection, refraction, and scattering
2. Explain transducer technology, and discuss the advantages and limitations of the various types
3. Discuss the basic features of medical sonographic equipment, including operator controls and image processing
4. Describe the role of advanced scanning features, including harmonics, coded excitation, and compounding
5. Explain how pulsed Doppler, color flow imaging, and amplitude imaging is achieved
6. Recognize and describe image artifacts and techniques to minimize or eliminate them
7. Describe the importance of performance, safety, and output measurements and standards

I. Basic Principles and Wave Analysis

A. General Principles

1. Scientific notation
2. Metric notation
3. Common units
 - a. Time – sec
 - b. Power – watts
 - c. Work – joule
 - d. Acoustic impedance – rayls
4. Measurement dimensions
 - a. Distance
 - 1) Linear
 - 2) Circumference
 - b. Area
 - c. Volume

B. Nature of Sound

1. Definition of sound
 - a. Wave classifications
 - 1) Electromagnetic
 - 2) Mechanical
 - a) Longitudinal
 - b) Transverse
 - b. Wave anatomy
 - 1) Cycle
 - a) Phase
 - b) Frequency

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- c) Period
- d) Wavelength
- 2) Compression
- 3) Rarefaction
- 4) Nodes/antinodes
- 2. Acoustic spectrum
 - a. Infrasound
 - b. Audible sound
 - c. Ultrasound
- 3. Sound wave interaction/interference
 - a. Huygen's principle
 - b. Constructive
 - c. Destructive
 - d. Beat frequency
- 4. Types of waves
 - a. Continuous wave
 - b. Pulse wave characteristics, units, and ranges
 - 1) Pulse repetition frequency
 - 2) Pulse repetition period
 - 3) Pulse duration
 - 4) Spatial pulse length
 - 5) Duty factor

C. Wave Characteristics

- 1. Definition of terms
 - a. Propagation speed
 - b. Frequency
 - 1) Typical ranges
 - 2) Penetration
 - c. Wavelength
 - d. Acoustic impedance
- 2. Relationship between terms
- 3. Common units of terms
- 4. Acoustic variable
 - a. Density
 - b. Pressure
 - c. Temperature
 - d. Particle motion

D. Properties of Acoustic Waves

- 1. Amplitude
- 2. Pressure
- 3. Power
- 4. Intensity

E. Decibels

- 1. Definition

Sonographic Physics & Instrumentation

- a. Related to intensity
- b. Related to amplitude
2. Examples corresponding to half value layers

II. Propagation of Acoustic Waves through Tissues

A. Speed of Sound

1. Average speed in tissues
2. Range of propagation speeds in the body
 - a. Air
 - b. Water
 - c. Muscle
 - d. Fat
 - e. Various parenchyma
 - f. Bone
 - g. Average for soft tissue
3. Media properties
 - a. Elasticity
 - b. Density
 - c. Compressibility/bulk modulus
 - d. Relationship between properties

B. Reflection

1. Definition of reflection
2. Specular reflector and highlights
 - a. Interface size and contour
 - b. Dependence on angle
 - c. Dependence on acoustic impedance mismatch
 - 1) Definition of acoustic impedance
 - 2) Common units
 - 3) Determine ease of reflection versus transmission
3. Scatterer
 - a. Definition of scattering
 - b. Frequency dependence
 - c. Interface contour
 - d. Contrast media

C. Refraction

1. Definition of refraction
2. Snell's law

D. Attenuation

1. Definition of attenuation
2. Sources of attenuation
 - a. Reflection/Scattering
 - b. Refraction

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- c. Interference
 - d. Diffusion
 - e. Absorption
 - 3. Dependence on frequency
 - 4. Typical values in soft tissue
 - 5. Relationship between coefficient, depth, frequency
 - 6. Effects on images
 - a. Frequency versus spatial resolution
 - b. Penetration versus spatial resolution
- E. Harmonics
- 1. Tissue harmonics versus contrast harmonics
 - 2. Generation of odd or even multiples of original frequency wave
 - 3. Effect of high pressure area on sound wave
 - 4. System requirements
 - a. Wide dynamic range
 - b. Transmitter
 - c. Bandwidth/passband limitations
 - 5. Advantages and limitations
 - 6. Clinical applications

III. Sonographic Transducers and Sound Beams

- A. Piezoelectric Properties
- 1. Definition of piezoelectric effect
 - 2. Curie point
 - 3. Dipole alignment process
 - 4. Piezoelectric materials
- B. Transducer Construction and Characteristics
- 1. Transducer housing
 - a. Protective
 - b. Orientation
 - c. Care
 - 2. Backing material
 - a. Insulation
 - b. Damping
 - 1) Relationship of damping, pulse length, axial resolution, sensitivity
 - 2) Passive versus dynamic damping
 - 3. Matching layer
 - a. Purpose of matching layer
 - b. Relationship to wavelength, pulse length, sensitivity
 - 4. Crystal/Element
 - a. Resonant, operating versus nominal frequency
 - b. Dependence of crystal thickness to resonance frequency
 - c. Frequency characteristics

Sonographic Physics & Instrumentation

- 1) Bandwidth
 - a) Narrow versus broad bandwidth
 - b) Effect of damping
 - c) Q factor
- C. Sound Beam Formation and Beam Shape
1. Definition of near field/Fresnel zone
 - a. Length of near field
 - 1) Relationship to transducer frequency and crystal diameter
 - b. Shape of near field
 - 1) Beam width
 - 2) Natural focus
 2. Definition of far field/Fraunhofer zone
 - a. Shape of far field
 - 1) Relationship to transducer frequency and crystal diameter
 3. Focused beam
 - a. Definition of focal plane, focal point, focal distance, focal zone
 - 1) Maximum versus minimal areas of beam intensity
 - b. Method of focusing
 - 1) Single element/mechanical transducers
 - 2) Multi-element/dynamic transducers
 - c. Clinical uses with variable focuses
 - d. Interference phenomena
 - 1) Huygen's principle
 - 2) Diffraction (divergence)
 - 3) Bandwidth
 4. Pressure profiles
 - a. Identify axial, transverse, and polar pressure profiles
 - b. Relationship between bandwidth and each profile
 - c. Axial profile labeling
 - 1) Pressure axis
 - 2) Central beam axis
 - 3) Near field
 - 4) Far field
 - 5) Application to assess near field and far field fluctuations
 - d. Transverse profile labeling
 - 1) Pressure axis
 - 2) Beam width axis
 - 3) Distance from transducer axis
 - 4) Application to provide beam diameter information
 - e. Polar profile labeling
 - 1) Pressure axis
 - 2) Angle theta
 - 3) Main lobe
 - 4) Side lobe
 - 5) Application to provide information about energies outside of main beam

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- D. Axial Resolution
 1. Dependence on spatial pulse length/ pulse duration, damping, bandwidth
 2. Relationship to transducer frequency
 3. Numerical example

- E. Lateral Resolution
 1. Dependence on beam width, transducer frequency, transducer size, focal characteristics
 2. Relationship from transducer face

- F. Slice Thickness or Elevational Resolution
 1. Dependence on beam width, focal characteristics, and frequency
 2. Relationship to lateral and axial resolution

- G. Transducer Types
 1. Mechanical construction/operation
 - a. Contact
 - b. Liquid-path
 2. Multiple element construction
 - a. Linear array
 - b. Curved array
 - c. Annular array
 - d. Multi-dimensional array
 3. Electronic operation
 - a. Sequenced
 - b. Phased/simultaneous
 - c. Annular/hybrid
 - d. Multi-dimensional
 - e. Beam steering
 - 1) Transmission time delays
 - 2) Reception time delays
 - f. Beam focusing
 - 1) Time delays
 - 2) Dynamic aperture
 - g. Firing variations
 - 1) Apodization
 - 2) Subdicing
 4. Emerging technologies

- H. Transducer Care and Maintenance
 1. Effects of alcohol, autoclave, and physical damage
 2. Proper cleansing routine

IV. Principles of Pulse Echo Imaging

- A. A-mode

Sonographic Physics & Instrumentation

1. Information displayed on image
 - a. Amplitude, depth/time
 2. Advantages and disadvantages
 3. Clinical applications
- B. M-mode
1. Information displayed on image
 - a. Amplitude, depth, time
 2. Advantages and disadvantages
 3. Clinical applications
- C. B-mode
1. Information displayed on image
 - a. Amplitude, depth
 2. Advantages and disadvantages
 3. Clinical applications
- D. Volumetric Scanning Modes
1. Definition of voxel
 2. Information displayed on image
 3. Orthogonal planes
 4. Advantages and disadvantages
 5. Clinical applications
- E. Scanning Speed Limitations
1. Definition of range equation
 2. Real-time systems-relationships between
 - a. Pulse repetition frequency
 - b. Frame rate
 - c. Number of lines per frame
 - d. Number of focal regions
 - e. Field of view or sector angle
 - f. Image depth/penetration
 - g. Spatial resolution
 - h. Temporal resolution
- F. System Controls
1. Purpose and definition
 - a. Freeze
 - b. Print
 - c. Depth/field of view (FOV)
 - d. Focus
 - e. Overall gain
 - f. Time gain compensation (TGC)
 - g. Transducer frequency selection
 - 1) Examination presets
 - h. Calipers

Sonographic Physics & Instrumentation

- i. Power/Mechanical Index (MI)/Thermal Indices (TI)
- j. Cine loop
- k. Harmonics
- l. Compound imaging
- m. Extended field of view
- n. Scan modes
- o. Emerging technologies

V. Hemodynamic and Doppler Imaging

A. Hemodynamics

- 1. Factors that influence blood flow
 - a. Cardiac function
 - b. Compliance
 - c. Muscle tone
 - d. Vessel branching patterns and dimensions
 - e. Luminal vessel diameter
- 2. Pressure gradient
 - a. Relationship between heart stroke volume, heart rate, blood volume
 - b. Dependence on flow and resistance
 - c. Effect of peripheral resistance
 - d. Sources of resistance
- 3. Hemodynamic resistance
 - a. Blood viscosity
 - b. Friction
 - c. Inertia
- 4. Poiseuille's Law
 - a. Relationship between pressure, flow volume, and resistance
 - b. Effect of vessel radius to velocity and flow volume
 - c. Effects of temperature, exercise, and pharmacologics
 - 1) Specific to various systems
- 5. Bernoulli's equation
 - a. Relationship between velocity and pressure
- 6. Flow patterns
 - a. Steady flow
 - b. Pulsatile flow
 - c. High resistance
 - d. Low resistance
 - e. Laminar
 - f. Turbulent flow
 - 1) Reynolds number
 - 2) Bruit
 - f. Effects of stenosis on flow characteristics
 - g. Effects of peripheral resistance
- 7. Venous resistance
 - a. Hydrostatic pressure

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- b. Effects of respiration
 - c. Muscle pump
 - d. Gravitational pressure
 - e. Incompetency
 - f. Fistula formation
 - g. Pressure versus volume effects
- B. Doppler Physical Principles
- 1. Doppler effect
 - a. Principle as related to sampling red blood cell movement
 - b. Doppler equation
 - 2. Factors influencing the magnitude of the Doppler shift frequency
 - a. Range of the Doppler shift frequency
 - b. Effects of beam angle, transmitted frequency
 - c. Relationship between frequency shift and flow velocity, flow direction
 - d. Relationship between blood pressure and blood volume
- C. Doppler Instruments
- 1. Definition of continuous wave
 - a. Range ambiguity
 - b. Spectral appearance
 - c. Advantages and disadvantages
 - 2. Definition of pulsed-wave Doppler
 - a. Range resolution
 - b. Nyquist limit
 - c. Advantages and disadvantages
 - 3. Duplex instruments
 - a. Definition
 - b. Basic principles
 - c. Instrumentation
 - 1) Receiver
 - 2) Demodulator
 - a) Quadrature phase detector
 - 3) Wall filter
 - 4) Directional knobs
 - 4. Spectral analysis
 - a. Appearance on the spectral display
 - 1) Flow direction
 - 2) Flow velocity
 - 3) Velocity profiles
 - a) Plug
 - b) Turbulent
 - c) Laminar
 - b. Waveform magnitude or brightness
 - 1) Fast Fourier transform (FFT)
 - c. Qualitative versus Quantitative evaluation

Sonographic Physics & Instrumentation

- D. Color Flow Imaging
 - 1. Sampling methods
 - a. PW Doppler
 - b. RBC sampling
 - c. Tissue sampling
 - 2. Display of Doppler information
 - a. Flow direction
 - b. Average velocity
 - c. Velocity maps
 - d. Angle dependence
 - 3. Advantages and disadvantages
 - 4. Instrumentation
 - a. Autocorrelation
 - 1) Time domain processing
 - 2) Dwell time
 - 3) Color sensitivity
 - b. Relationship between color box size and frame rate
 - 1) Ensemble length/packet size/pulse packet
 - 2) Line density
 - 3) Depth of penetration
 - c. Color maps
 - 1) Hue
 - 2) Saturation
 - 3) Brightness/luminance/intensity

- E. Color Power/Energy Mode
 - 1. Displayed information – formats
 - a. Flow direction
 - b. Displayed velocity
 - c. Velocity maps
 - d. Angle independence
 - 2. Advantages and disadvantages

VI. Sonographic Instrumentation

- A. System Components
 - 1. Beam former
 - 2. Signal processor
 - 3. Image processor

- B. Timer
 - 1. Range equation

- C. Transmitter/Pulse Generator
 - 1. Effect of transmitter voltage on penetration, intensity, and patient exposure

Sonographic Physics & Instrumentation

D. Receiver

1. Amplification
 - a. Controlled by overall gain knob
 - b. Effect on returning signal and image
2. Compensation
 - a. Depth attenuation
 - b. Controlled by TGC
 - c. Effect on return signal and image
3. Compression
 - a. Definition of dynamic range
 - 1) Ranges associated with system components
 - 2) Typical units
4. Demodulation
 - a. Rectification
 - 1) Half-wave
 - 2) Full-wave
 - b. Smoothing/enveloping
5. Rejection
 - a. Signal to noise ratio
 - b. System control for rejection

E. Image Storage Devices

1. Role of scan converter
 - a. Image storage
 - b. Scan Conversion
2. Digital Devices
 - a. Binary system
 - 1) Bits, bytes, words, pixels
 - 2) Nature of binary numbers
 - b. Steps in processing echo information
 - 1) Analog-to-digital converter
 - a) Types of sampling
 - b) Effects of sampling frequency
 - 2) Preprocessing
 - 3) Digital memory
 - a) Spatial resolution
 - i. Relationship between pixels and field of view
 - b) Contrast resolution
 - i. Relationship between memory size and bit depth
 - c) Post processing
 - d) Digital-to-analog converter
 - e) Display devices

F. Imaging Processing

1. Preprocessing functions
 - a. Time gain compensation
 - b. Logarithmic compression curves

Sonographic Physics & Instrumentation

- c. Write magnification
 - d. Panning
 - e. Other
 - 2. Postprocessing functions
 - a. Freeze frame
 - b. Black/white inversion
 - c. Read magnification
 - d. Contrast variation curves
 - e. B-color
 - f. Other
 - 3. Manufacturer dependent functions
 - a. Persistence
 - b. Frame averaging
 - c. Edge enhancement
 - d. Smoothing
 - e. Interpolation
 - f. Emerging technologies
 - g. Other
- G. Scanning Speed Limitations
- 1. Range equation
 - 2. Real-time system relationships
 - a. Pulse repetition frequency
 - b. Frame rate
 - c. Number of lines per frame
 - d. Number of focal regions
 - e. Field of view or sector angle
 - f. Image depth/penetration
 - g. Spatial resolution
 - h. Temporal resolution
- H. Display Devices
- I. Recording and Archiving Devices
- 1. Analog format
 - a. Display
 - b. Single, multi-image, or laser cameras
 - 1) Photographic film
 - 2) Emulsion film
 - c. Recorders
 - d. Printer
 - 1) Thermal
 - 2) Laser
 - 2. Digital format
 - a. Digital media
 - b. Picture archiving and communication systems (PACS)
 - 1) Digital imaging and communications in medicine (DICOM)

Sonographic Physics & Instrumentation

- a) Industry standards
- c. Emerging technologies
3. Advantages and disadvantages

VII. Artifacts

- A. Definition
 1. Assumptions of sonographic beams and instruments
- B. Performance and Interpretation Recognition
 1. Appearance on display
 - a. Display of non-structural echo signals
 - b. Missing real structural echo signals
 - c. Displacement of echo signals on display
 - d. Distortion of echo signal
 2. Definition of each artifact
 3. Mechanisms of production
- C. Resolution and Propagation Association
 1. Axial resolution
 2. Lateral resolution
 3. Slice thickness/beam width artifact
 4. Acoustic speckle
 5. Temporal resolution
- D. Propagation
 1. Reverberation
 - a. Comet-tail
 - b. Ring-down
 2. Mirror image
 3. Duplication
 4. Side lobes or grating lobes
 5. Velocity error
 6. Refraction
 7. Edge shadowing
 8. Range ambiguity
 9. Multipath
- E. Attenuation
 1. Shadowing
 2. Enhancement
 3. Focal enhancement or focal banding
- F. Miscellaneous
 1. Dead zone/near field artifact/main bang
 2. Excessive gain or TGC

Sonographic Physics & Instrumentation

3. Excessive reject
 4. Electrical noise
- G. Doppler and Color Flow
1. Aliasing
 2. Mirror imaging or ghosting
 3. Color registration
 - a. Ghosting or flash
 - b. Bleed
 - c. Noise
 4. Incident beam angle
 5. Clutter
 6. Slice thickness
 7. Reverberation
- H. Volumetric Imaging

VIII. Quality Assurance/Quality Control of Sonographic Instruments

- A. Program
1. Purpose
 2. Frequency
 3. Documentation
- B. Evaluation of Instrument Performance
1. Test objects
 2. Various tissue equivalent phantoms
- C. Parameters
1. Test object
 - a. Dead zone
 - b. Axial resolution
 - c. Lateral resolution
 - d. Range accuracy
 - 1) Vertical depth calibration
 - 2) Horizontal calibration
 - e. TGC characteristics
 - f. Uniformity
 - g. System sensitivity
 2. Tissue equivalent phantom
 - a. Dead zone
 - b. Range accuracy
 - 1) Vertical depth calibration
 - 2) Horizontal calibration
 - c. Detail resolution
 - 1) Axial resolution

Sonographic Physics & Instrumentation

- 2) Lateral resolution
 - 3) Slice thickness/elevational resolution
 - d. TGC characteristics
 - e. System sensitivity
 - f. Contrast resolution
 - 1) Dynamic range
 - a) Image congruency test
 3. Doppler phantoms
 - a. Maximum depth
 - b. Pulsed Doppler sample volume accuracy
 - c. Velocity accuracy
 - d. Color flow sensitivity
 - e. Image congruency test
- D. Statistical Indices
1. Chi square
 2. Sensitivity/specificity
 3. Negative/positive predictive value; prevalence of disease
 4. Accuracy

IX. Bioeffects and Safety

- A. General Terms
1. Hydrophone
 2. Calorimeter
 3. Thermocouple
 4. Dosimetry
 5. In vivo
 6. In vitro
- B. Acoustic Output Quantities
1. Pressure
 - a. Units
 - 1) MPa
 - 2) MmHg
 - b. Peak pressures
 2. Power
 - a. Units
 - 1) mW
 - b. Methods of determining power (radiation force, hydrophone)
 3. Intensity
 - a. Units
 - 1) mW/cm^2
 - 2) W/cm^2
 - b. Spatial and temporal considerations
 - c. Average and peak intensities

Sonographic Physics & Instrumentation

- d. Methods of determining intensity
 - e. Intensities
 - 1) Spatial average-temporal average (SATA)
 - 2) Spatial peak-temporal average (SPTA)
 - 3) Spatial peak-pulse average (SPPA)
 - 4) Spatial peak-temporal peak (SPTP)
 - 5) Spatial average-temporal peak (SATP)
 - 4. Intensity and power values for operating modes
- C. Acoustic Output Labeling Standard
- 1. Definition of thermal index
 - a. Thermal Index for Soft Tissue (TIS)
 - b. Thermal Index for Bone (TIB)
 - c. Thermal Index for Cranial Bone (TIC)
 - 2. Definition of mechanical index (MI)
 - a. Stable cavitation
 - b. Transient cavitation
- D. Acoustic Exposure
- 1. Prudent use
 - 2. Methods to reduce acoustic exposure
 - a. As low as reasonably achievable (ALARA)
- E. Primary Mechanisms of Biologic Effect Production
- 1. Cavitation mechanisms
 - 2. Thermal mechanisms
- F. Experimental Biologic Effect Studies
- 1. Animal studies
 - 2. In vitro studies
 - 3. Epidemiologic studies
 - 4. Limitations
- G. Guidelines and Regulations
- 1. Organizational statements
 - a. Clinical safety
 - b. Prudent use
 - c. Bioeffects
 - d. Epidemiology
 - e. In vitro
 - f. Safety in training and research
 - g. Other
 - 2. National Electrical Manufacturers Association (NEMA)
 - 3. Food and Drug Administration (FDA)
- H. Electrical and Mechanical Hazards
- 1. Patient susceptibility
 - 2. Operator susceptibility

Sonographic Physics & Instrumentation

3. Equipment components

I. Emerging Technologies

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ABBREVIATIONS

A

AIUM American Institute of Ultrasound in Medicine
ALARA As Low As Reasonably Achievable
A-mode Amplitude Mode

B

B-mode Brightness Mode

C

CRT Cathode Ray Tube
CW Continuous Wave

D

DICOM Digital Imaging and Communications in Medicine
DMS Diagnostic Medical Sonography/Sonographer

F

FDA Food and Drug Administration

M

MI Mechanical Index
M-mode Motion Mode

N

NEMA National Electrical Manufacturers Association

Q

QC Quality Control

P

PACS Picture Archiving and Communication Systems
PW Pulsed Wave

S

SPTA Spatial Peak-Temporal Average

T

TGC Time-Gain Compensation
TI Thermal Indices

Sonographic Physics & Instrumentation

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WRMSD

Rationale: Sonographers must incorporate ergonomic principles to avoid negative short and long-term consequences of scanning. Through proactive education and preventative techniques, the occurrence of work-related musculoskeletal disorders (WRMSD) can be minimized and/or prevented. The essential components of a WRMSD curriculum are listed below.

1. Define ergonomics
2. Describe the risk factors, causes, symptoms, and physical consequences for WRMSD in sonographers
3. Describe prevention techniques to minimize risk
4. Discuss the diagnosis and treatment of WRMSD
5. Describe devices and modifications designed to minimize WRMSD
6. Evaluate the psychological, emotional, and financial impact of WRMSD

I. Ergonomics

- A. Definition of WRMSD
- B. Synonyms
- C. History

II. Risk factors

- A. Pre-existing physical conditions
- B. Equipment and examination room design
- C. Work environment
 1. Workload
 2. Types of sonographic examinations
 - a. Repetitive
 - b. Volume
 3. Scanning posture
- D. Personal activities

III. Prevention Techniques

- A. Posture
 1. Individual posture
 - a. Standing
 - b. Sitting
 2. Position of examination table

WRMSD

3. Position of patient
 4. Position of equipment
- B. Supports for Arm and Wrist
 - C. Physical Conditioning
 - D. Miscellaneous Prevention Techniques

IV. Ergonomic Design of Work Environment

- A. Monitors
- B. Keyboards
- C. Transducers
- D. Voice Recognition
- E. Furniture
- F. Lighting
- G. Flooring
- H. Ancillary Devices

V. Physical Manifestations

- A. Carpal Tunnel Syndrome
- B. Tendonitis
 1. Tenosynovitis
 2. DeQuervain's disease
- C. Bursitis
- D. Thoracic Outlet Syndrome
- E. Cubital Tunnel Syndrome
- F. Rotator Cuff Tear

WRMSD

VI. Symptoms

- A. Stages and Progression of Disease

VII. Diagnosis and Treatment

- A. Clinical Assessment
- B. Imaging Examinations
- C. Treatment
 - 1. Physical therapy
 - 2. Medical
 - 3. Surgical
 - 4. Alternative

VIII. Impact of WRMSD

- A. Personal
 - 1. Psychological
 - a. Fear of reporting
 - b. Relationship with colleagues and employers
 - c. Adapting to injury
 - d. Loss of career
 - 2. Financial
 - a. Short term
 - b. Long term
 - 1) Loss of career
 - 2) Retraining
- B. Institutional/Departmental
 - 1. Financial
 - a. Equipment accommodations
 - b. Worker's compensation
 - c. Staffing
 - 2. Attitudinal changes
 - a. Morale
 - b. Awareness

WRMSD

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