National Education Curriculum

Common Curricula

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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

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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
  - 3. Trendelenberg
  - 4. Decubitus
  - 5. Up-right
- 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

i) Mediastinum
ii) Pleural

b. Abdominopelvic cavity
i) Abdominal
ii) Pelvic
iii) Peritoneal/retroperitoneal

c. Abdominopelvic regions
i) Nine regions
- Right and left hypochondriac regions
- Epigastric region
- Right and left lumbar regions
- Umbilical region
- Right and left iliac regions
- Hypogastric region

ii) Four quadrants
- Right upper
- Right lower
- Left upper
- Left lowe

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
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

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
    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

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

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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
- 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
D. Stress
E. Environmental
F. Preexisting Condition

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

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

VIII. Measurement Comparisons and Change in Time

A. Ratios

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

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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

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

Communications

Rationale: Sonographers must be able to effectively communicate with patients, the public and the health care 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

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

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 health care 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
- C. Adaptation
- D. Culture

V. Psychological Disorders

- A. Categories
- B. Treatments

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

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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

II. **Descriptive Statistics**

A. Measures of Central Tendency

B. Measures of Variability

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

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 health care management
3. List devices used for storage in diagnostic imaging
4. Discover communication mechanisms used for electronic searches

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I. Basic Computer Terminology

- A. Hardware Components
- B. Computers: Desktop, Laptop
  - 1. Monitor
  - 2. Hard Drive – USB and CD Drives
  - 3. Scanner
- C. Mobile: Tablet, Smartphone
- D. 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 Medical Record (all medical files related to patient)
- C. Hospital Information System (HIS)
- D. Reporting Software
- E. RIS: Radiology Information System (RIS):
  - 1. Information related to the Radiology Part of Patient's Medical Record
    - a. Request for Examination
    - b. Additional Comments Written by Provider
    - c. Pertinent Lab Values – Creatinine
    - d. Time and Date of Request
    - e. Time and Date of Completion of Exam

f. Known Allergies, Nursing Comments

g. Prior Results

III. Storage and Archiving

A. PACS (Picture Archiving and Communication System)

1. Allows images to be viewed electronically from anywhere at any time
2. Older exams may need to be retrieved for comparison
3. Allows measurements and annotations to be made and saved

B. Laser Film

C. CD/DVD

D. Thermal Printer

IV. Communications

A. Intranet

1. Only viewed by users within the institution

B. Internet

1. Viewed by all

C. Connectivity

1. DICOM
2. HL7
3. IHE

V. Electronic Searching

A. Search Engines

B. Databases

C. Evaluation of Information

1. Websites
2. Professional Journals
3. Copyright and Fair Use 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 health care coding and reimbursement system
7. Analyze consequences for non-compliance to coding and reimbursement policies

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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
- 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. Nonmaleficence
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
2. Confidentiality
   a. Patient Health Information
   b. Electronic Transmission of Health Care Rransactions

c. Computer Integrity

B. Compliance Practices

IV. Coding and Reimbursement

A. Governing Bodies

1. Center for Medicare and Medicaid Services (CMS)

Third-party reimbursement

V. Universal Coding System

A. International Classification of Diseases (ICD-10)

1. Mechanism of Tracking Diseases
2. Symptom and Diagnosis Codes

B. Health Care 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

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-10	International Classification of Diseases

L

LCD	Local Carrier Determination

Utilized References

1. Craig M., *Essentials of Sonography and Patient Care*, 3rd ed. St. Louis, MO: Elsevier Saunders; 2012.
2. Dandry Aiken, T., *Legal and Ethical Issues in Health Occupations*, 2nd ed. Saunders; 2014.
3. Nuclear Medicine Curriculum Guide from www.asrt.org.

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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 health care 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

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
    1. Patient Privacy/Modesty
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
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
            i) Masks

ii) Eye protection
iii) Gloves
iv) Aprons/gowns

a. Sharps management
b. 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
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

1. Intravenous Injections
2. Other

B. Risks and Contraindications

C. Adverse Reactions and Patient Management

XII. Basic Pharmacology

A. Anticoagulants

B. Hypertension Medications

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)

Critical Thinking

A. Problem Solving and Decision Making

XIV. Medical Terminology

A. Word Roots, Prefixes and Suffixes

B. Definitions

C. Pronunciations

D. Abbreviations

XV. 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

Emergency Preparedness

XVI. 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

Abbreviations

C

CPR	Cardiopulmonary Resuscitation
CQI	Continuous Quality Improvement

I

ICU	Intensive Care Unit

O

OR	Operating Room

T

TIA	Transient Ischemic Attack

Utilized References

1. Commission on Accreditation of Allied Health Education Programs (CAAHEP) *Standards and Guidelines for Diagnostic Medical Sonography*.

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3. *Diagnostic Ultrasound Clinical Practice Standards.* Plano, TX: Society of Diagnostic Medical Sonography; 2008.

4. *Code of Ethics for the Profession of Diagnostic Medical Sonography*. Plano, TX: Society of Diagnostic Medical Sonography 2008.

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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

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I. Basic Principles and Wave Analysis

- A. General Principles
  - 1. Scientific Notation
  - 2. Metric Notation
  - 3. Common Units
    - a. Time – sec
    - b. Power – watts, pascal
    - c. Work – joule
    - d. Acoustic impedance – rayls
  - 4. Measurement Dimensions
    - a. Distance
      - i) Linear
      - ii) Circumference
    - b. Area
    - c. Volume
- B. Nature of Sound
  - 1. Definition of Sound
    - a. Wave classifications
      - i) Electromagnetic
      - ii) Mechanical
        - Longitudinal
        - Transverse
    - b. Wave anatomy
      - i) Cycle
        - Phase
        - Frequency
        - Period

- Wavelength

ii) Compression

iii) Rarefaction

iv) 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
        i) Pulse repetition frequency
        ii) Pulse repetition period
        iii) Pulse duration
        iv) Spatial pulse length
        v) Duty factor

C. Wave Characteristics
1. Definition of Terms
    a. Propagation speed
    b. Frequency
        i) Typical ranges
        ii) Penetration
    c. Wavelength
    d. Acoustic impedance
2. Relationship Between Term
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
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
i) Definition of Acoustic Impedance
ii) Common Units
iii) 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
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

i) Relationship of damping, pulse length, axial resolution, sensitivity

ii) 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

i) Bandwidth

- Narrow versus broad bandwidth
- Effect of damping
- Q factor

C. Sound Beam Formation and Beam Shape

1. Definition of Near Field/Fresnel Zone

a. Length of near field

i) Relationship to transducer frequency and crystal diameter

b. Shape of near field

i) Beam width

ii) Natural focus

2. Definition of Far Field/Fraunhofer Zone

a. Shape of far field

i) Relationship to transducer frequency and crystal diameter

3. Focused Beam

a. Definition of focal plane, focal point, focal distance, focal zone

i) Maximum versus minimal areas of beam intensity

b. Method of focusing

i) Single element/mechanical transducers

ii) Multi-element/dynamic transducers

c. Clinical uses with variable focuses

d. Interference phenomena

i) Huygen's Principle

ii) Diffraction (divergence)

iii) Bandwidth

4. Pressure Profiles
    a. Identify axial, transverse and polar pressure profiles
    b. Relationship between bandwidth and each profile
    c. Axial profile labeling
        i) Pressure axis
        ii) Central beam axis
        iii) Near field
        iv) Far field
        v) Application to assess near field and far field fluctuations
    d. Transverse profile labeling
        i) Pressure axis
        ii) Beam width axis
        iii) Distance from transducer axis
        iv) Application to provide beam diameter information
    e. Polar profile labeling
        i) Pressure axis
        ii) Angle theta
        iii) Main lobe
        iv) Side lobe
        v) Application to provide information about energies outside of main beam

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
      i) Transmission time delays
      ii) Reception time delays
   f. Beam focusing
      i) Time delays
      ii) Dynamic aperture
   g. Firing variations
      i) Apodization
      ii) 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
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
      i) Examination presets
   h. Calipers
   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
        i) 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
        i) Reynolds number
        ii) Bruit
    g. Effects of stenosis on flow characteristics
    h. Effects of peripheral resistance
7. Venous Resistance
    a. Hydrostatic pressure
    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

i) Receiver

ii) Demodulator

- Quadrature phase detector

iii) Wall filter

iv) Directional knobs

4. Spectral Analysis

a. Appearance on the spectral display

i) Flow direction

ii) Flow velocity

iii) Velocity profiles

- Plug
- Turbulent
- Laminar

b. Waveform magnitude or brightness

i) Fast Fourier transform (FFT)

c. Qualitative versus quantitative evaluation

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

i) Time domain processing

ii) Dwell time

iii) Color sensitivity

b. Relationship between color box size and frame rate

i) Ensemble length/packet size/pulse packet

ii) Line density

iii) Depth of penetration

c. Color maps

i) Hue

ii) Saturation

iii) 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

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
        i) Ranges associated with system components
        ii) Typical units
4. Demodulation
    a. Rectification
        i) Half-wave
        ii) 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
        i) Bits, bytes, words, pixels
        ii) Nature of binary numbers
    b. Steps in processing echo information
        i) Analog-to-digital converter
            - Types of sampling
            - Effects of sampling frequency
        ii) Preprocessing

iii) Digital memory

- Spatial resolution
  - Relationship between pixels and field of view
- Contrast resolution
  - Relationship between memory size and bit depth
- Post processing
- Digital-to-analog converter
- Display devices

F. Imaging Processing

1. Preprocessing Functions
   a. Time gain compensation
   b. Logarithmic compression curves
   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
      i) Photographic film
      ii) Emulsion film
   c. Recorders
   d. Printer
      i) Thermal
      ii) Laser
2. Digital Format
   a. Digital media
   b. Picture Archiving and Communication Systems (PACS)
      i) Digital Imaging and Communications in Medicine (DICOM)
         - 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/elevational resolution
   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
   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
         i) Vertical depth calibration
         ii) Horizontal calibration
      e. TGC characteristics
      f. Uniformity
      g. System sensitivity
   2. Tissue Equivalent Phantom
      a. Dead zone
      b. Range accuracy
         i) Vertical depth calibration
         ii) Horizontal calibration
      c. Detail resolution
         i) Axial resolution
         ii) Lateral resolution
         iii) Slice thickness/elevational resolution
      d. TGC characteristics
      e. System sensitivity
      f. Contrast resolution
         i) Dynamic range
            - 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
      i) Mpa
      ii) MmHg
   b. Peak pressures
2. Power
   a. Units
      i) mW
   b. Methods of determining power (radiation force, hydrophone)
3. Intensity
   a. Units
      i) mW/cm^2
      ii) W/cm^2
   b. Spatial and temporal considerations
   c. Average and peak intensities
   d. Methods of determining intensity
   e. Intensities
      i) Spatial Average-temporal Average (SATA)
      ii) Spatial Peak-Temporal Average (SPTA)
      iii) Spatial Peak-Pulse Average (SPPA)
      iv) Spatial Peak-Temporal Peak (SPTP)
      v) Spatial Average-Temporal Peak (SATP)
   f. 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
3. Equipment Components

I. Emerging Technologies
1. Elastography
2. Panoramic
3. 4D Video

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

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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. Work Load
  - 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
  - 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

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
        i) Loss of career
        ii) Retraining

B. Institutional/Departmental
    1. Financial
        a. Equipment accommodations
        b. Worker's compensation
        c. Staffing
    2. Attitudinal Changes
        a. Morale
        b. Awareness

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