



FISIOLOGIA I - channel 4

13 CFU - 1° and 2° Semester

Teaching Staff

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LEARNING OBJECTIVES

▪ FISIOLOGIA E BIOFISICA

- Knowledge of the biophysical laws involved in body function regulation
- Knowledge of the basic neurophysiology, particularly related to the mechanisms underlying cell excitability
- Knowledge of the theoretical basis aimed at understanding the translation of such laws to clinical practice

▪ FISIOLOGIA

- Knowledge of the nutritional value of food, nutritional status, energy expenditure and energy requirements, physiological use of diet nutrients.
- Knowledge of adaptive mechanisms during exercise and in extreme environments. Knowledge of the experimental approach and the chance to translate results from bench to bedside. Knowledge of the mechanisms involved in the maintenance of homeostasis in relation to internal and environmental modifications.
- Knowledge of the electrophysiological and functional mechanisms in single cells, tissues, organs and their interactions.
- Knowledge of the cardiovascular, respiratory, renal, gastroenteric systems and their interactions.

COURSE STRUCTURE

▪ FISIOLOGIA E BIOFISICA

Lecture-style instruction

Cooperative teaching (student centered) by sharing educational materials and media supports

Should teaching be carried out in mixed mode or remotely, it may be necessary to introduce

changes with respect to previous statements, in line with the programme planned and outlined in the syllabus.

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DETAILED COURSE CONTENT

▪ **FISIOLOGIA E BIOFISICA**

THE CELL AS AN INTEGRATED SYSTEM

Dynamic balance, cell functions, the cell as a thermodynamic system, energy and entropy, the cell as a chemical system.

Gas and solute exchanges through cell membranes (Fick's law, passive diffusion, facilitated diffusion, controlled diffusion, primary and secondary active transport).

Homeostasis, steady state, regulation of cellular functions.

GAS LAWS AND THEIR APPLICATIONS

Ideal gas law, Boyle's law, Charles and Gay-Lussac's law, second law of Gay-Lussac, Avogadro's law, Dalton's law, Graham's Law, Henry's Law, Laplace's law. Applications in physiology and diseases.

FLUID COMPARTEMENTS AND HOMEOSTASIS

Human body fluid compartments: intracellular and extracellular compartments, compartments volumes and methods for their measurements. Sources and removal of body fluids. Water and salts balance.

Exchanges of water and electrolytes through biological membranes. Concentration and electrochemical gradients. Saline, isotonic and iso-osmotic solutions, and their use. Osmotic pressure: definition, units of measurements, plasma values. Van't Hoff's law, Gibbs-Donnan equilibrium. Hydrostatic pressure. Colloid osmotic and oncotic pressure: plasmas value and fluctuations. Consequences of oncotic pressure modifications. Starling's law and capillary exchanges. Edema.

PRINCIPLES OF HEMODYNAMICS AND HEMORHEOLOGY

Systemic circulation: generalities. Blood volume and velocity in different areas of the vascular system. Morphological and physiological characteristics of vessels: arteries, capillaries and veins. Blood flow: physical factors affecting blood flow. Bernoulli's principle. Pressure, flow and resistance: Hagen-Poiseuille Law. Blood viscosity: relationship between viscosity and hematocrit. Turbulent blood flow. Laplace's law applied to vessels.

Vascular tone: nervous, hormonal and humoral control.

ION CHANNELS AND MEMBRANE POTENTIAL

Cell excitability: cell membrane polarization (ion distribution across the membrane and its genesis,

polarization measurement, conductance).

Ion channels: voltage-gated ion channels for sodium, potassium, calcium, chloride (characteristics, functions, main agonist and antagonists), patch clamp, canalopathies.

Electric potentials: membrane potential, electrochemical potential, Nernst equation, Goldman equation. Genesis and characteristics of an action potential. All-or-none law. Refractory period.

Membrane repolarization. Graded potentials.

Excitability conduction along cell membranes. Propagation velocity. Saltatory or continuous conduction, myelin sheath.

SYNAPTIC TRANSMISSION

Excitable cells communication. Electric and chemical synapses. Synaptic types. Neurotransmitters and neuropeptides: synthesis, transport, release and secretion, neurotransmitter release cycle, vesicle cycle (trafficking).

Neuromuscular junction. Endplate potential, miniature potential, quantal neurotransmitter release. Synaptic integration and transmission in CNS (EPSP, IPSP, spatial and temporal summation).

Ionotropic and metabotropic receptors.

Synaptic plasticity, Hebbian theory, long-term and short-term plasticity (long-term potentiation e long-term depression).

NEUROTRANSMITTERS AND RECEPTORS

Acetylcholine, nicotinic receptors, muscarinic receptors, cholinergic synapses, main agonists and antagonists, notes on related diseases (Myasthenia gravis).

Glutamate glutamine cycle, NMDA, AMPA and Kainate receptors, metabotropic receptors, involvement in synaptic plasticity (LTP), main agonists and antagonists, glutamate excitotoxicity, notes on related diseases (Alzheimer's disease, glutamate hypothesis of schizophrenia).

GABA, Ionotropic and metabotropic receptors, , Notes on benzodiazepine, barbiturate and alcohol mechanism of action..

Catecholamine and their receptors, Role in SNA, Notes on stress and catecholamine

Dopamine and its receptors, Notes on related diseases (addiction, Parkinson's disease Schizophrenia)

Serotonin and its receptors, Drugs acting on serotonin receptors

Endocannabinoids and opioids, notes on drug abuse (cocaine, amphetamine, heroine, hallucinogens, etc.)

Nitric oxide pathway and retrograde transmission

MUSCLE CONTRACTION

Skeletal muscles: structure, myofibrils, sarcomere and mechanisms of contraction, Sliding filament theory of muscle contraction, Neuromuscular junction, Excitation-Contraction Coupling, single muscle twitch and tetanus, isometric and isotonic contraction, length-tension curve, force-velocity curve, muscle energetics, oxygen consumption, muscle work, performance, and fatigue. Muscle fibers. Skeletal muscle innervation. Electromyogram.

Smooth muscle: generalities, unitary and multiunit muscles, sstructure, contraction mechanisms, contraction regulation (arteriolar tone), biomechanics.

Cardiac muscle: generalities, structure, contraction mechanisms, contraction regulation, biomechanics.

NERVOUS SYSTEM: GENERALITIES

Neuron: morphologic, functional, biochemical and trophic unit of the nervous system

Glia: macroglia and microglia. Myelin synthesis at central and peripheric level.

▪ FISILOGIA

BLOOD AND LYMPH

Blood composition. Corpuscular and liquid component. Hematocrit. Plasmatic proteins. Electrophoretic proteinogram. Common blood tests. Complete blood count.

Red blood cells. Erythropoiesis and iron metabolism. Life span and destruction of red blood cells. Globular resistance and hemolysis. Respiratory function of red blood cells..Hemoglobin affinity for gases. Hemoglobin's acquisition and delivery of O₂.

Leukocytes function. Distribution, count, pathophysiology.

Platelets function. Hemostasis and coagulation.

Blood in temperature control.

Lymphatic system. Lymph node stations, lymph composition and function. The blood-tissue barrier.

CARDIOVASCULAR SYSTEM

Arteries structure and function. Arterial bed characteristics. Nervous, endocrine and paracrine regulation of arterioles.

Capillary bed. Generalities. Types of capillary endothelium. Transcapillary exchange: diffusion, filtration, absorption and macropynocytosis. Microcirculation. Pathophysiology of edema.

Venous bed. Venous compliance. Veins and posture. Venous return to the heart.

Phlebogram and its features. Venous pressure and its variations, jugular pulse.

Heart functions. Electrophysiology of heart muscle. Myocardium excitability. Heart automaticity. Stannius ligature. Cardiac pacemakers. All-or-none law. Refractory periods. Effects of extrinsic innervation on heart properties. Chemical mediators of the heart. Mechanical events of the cardiac cycle. Movements of the valves and pressure variations during the cardiac cycle phases in atria and ventricles. Duration of cardiac cycle phases and limits in its variation. Cardiac output. Frank-Starling law in the heart. Cardiac work. Cardiac metabolism and oxygen consumption. Laplace law in the heart. Heart rate and its regulation. Flutter, fibrillation and extrasystoles. Cardiovascular nervous control. Cardiac control center in medulla oblongata. Hypothalamic centers. Cardiovascular reflex regulation. Vascular and extravascular cardiac mechanoreceptors.

Systemic blood pressure. Systolic, diastolic, differential, mean. Mechanisms of short- and long-term regulation of systemic blood pressure. Arterial pulse.

Systemic arterial chemoreceptors. Cortico-hypothalamic influences on the cardiovascular system.

Humoral control of cardiovascular system. Renin-angiotensin-aldosterone system. Bradykinin. Catecholamines and dopamine. Serotonin.

Vascular districts. Cardiac redistribution. Circulation time. Coronary, brain, cutaneous, muscle, hepatosplanchnic, lung, kidney, spleen, fetal circulations. Lymphatic flow.

Cardiopulmonary function evaluation. Systemic blood pressure measurement. Heart sounds: auscultatory Sites and characteristics. Cardiac catheterization: applications. Cardiac output

measurement methods. Cardiac work measurement. Electrocardiography: Einthoven triangle, mono- and bipolar leads, precordial leads. Standard ECG conventions, analysis of common ECG patterns, heart axis calculation and its functional significance. Vectorcardiogram. Echocardiogram.

RESPIRATORY SYSTEM

Generalities and comparative physiology. Upper airways. Nasal and tracheobronchial filter.

Respiratory mechanics. General considerations. Functions of the upper airways. Respiratory mechanical processes in eupnea: costal and diaphragmatic components. Accessory muscles of respiration. Intrapleural depression. Pneumothorax. Physiological importance of tensioactive substances acting on surface tension (surfactants) and elastic recoil of lung and chest wall. Lung and chest wall compliance. Airways work of breathing. Lung hysteresis.

Respiratory activity and nervous regulation. Respiratory centers and their functional significance. Vagus respiratory function. Respiratory reflexes. Fast and slow adapting tensoreceptors. Lung volumes and capacities. Alveolar ventilation. Pulmonary gas exchange.

Oxygen and carbon dioxide transport in the blood. Hemoglobin and its combination with oxygen or with carbon dioxide. O₂ and CO₂ transport in the body. Transport kinetics. Myoglobin. Physiological blood reaction: buffer system, relationship between CO₂ and pH, functional significance of Henderson-Hasselbach equation, blood HbO₂ and HbCO₂ dissociation curves.

Chemical regulation of respiration. Hydrogen ion concentration and breathing.

Lack of oxygen. Aortic and carotid chemoreceptors. Types of anoxia. Cyanosis. Voluntary hyperventilation effects. Effects of Hyperoxemia. Voluntary apnea. Hemo- respiratory modifications during exercise.

Lung metabolism. Biotransformation inhaled or circulating substances. Biotransformation of hormones and mediators. Pulmonary metabolism of proteins, lipids and carbohydrates.

Pulmonary function tests. Spirometry. Determination of dead space. Alveolar air samples withdrawing methods. Techniques of artificial respiration. Determination of the respiratory quotient. Pathophysiology. Dyspnea and its characteristics.

URINARY SYSTEM

Kidney functions. Generalities. Elements of functional anatomy. Nephron as the functional unit of the kidney. Differences between cortical and juxtamedullary nephrons. Renal vascular bed.

Glomerular functions. Mechanisms involved in glomerular filtration. Effective glomerular filtration pressure, ultrafiltrate characteristics, resistances against ultrafiltrate or tubular fluid. Glomerular filtration rate. Quantitative evaluation filtration volume: clearance of inulin and clearance of urea. Mechanisms modifying the ultrafiltrate volume. Filtered load concept and functional significance.

Tubules functions. Obligatory reabsorption in the proximal tubule. Active and passive transport. Concept of renal threshold and transport maximum. Glucose reabsorption and glycosuria. Facultative reabsorption in the distal tubule. Aldosterone action.

Urine concentration. Loop of Henle and countercurrent multiplier system. Vasa recta countercurrent current. Vasopressin action.

Tubular secretion. Secretion of hydrogen, potassium and ammonium ions. Urine acidification.

Renal circulation. Extrinsic control of renal circulation. Autoregulation of renal blood flow related to systemic blood pressure.

Systemic functions of the kidney. Control of systemic blood pressure. Osmolarity control. Adjustment of body fluids composition and volume. Erythropoietin production. Endocrine functions.

Applied physiology. Renal function tests: the concept of clearance and its application to control glomerular and tubular functions, and vascular bed. Significance of glucose and water loads. Osmotic and water diuresis. Fluid deficit: dehydration and its systemic consequences. Fluid excess: water intoxication, edema. Kidney contributions to the regulation acid-base balance; alkalosis and acidosis.

Physiology of the urinary bladder. Bladder filling and emptying. Action of the nervous system. Neurogenic bladder. Cystography.

GASTROINTESTINAL SYSTEM, METABOLISM AND NUTRITION

Digestive system. Chewing. Salivary secretion. Saliva composition and function. Conditioned reflexes. Swallowing. Gastric emptying. Movements of the stomach. Gastric secretion. Nervous and humoral regulation of gastric secretion. Pancreatic secretion. Secretin and pancreaticozymin. Pancreatic juice. Small intestine and colon secretion. Small bowel movements. Bowel intrinsic innervation. Intraluminal

pressure regimes. Movements of the villi. Myogenic and neurogenic mechanisms of bowel movements. Enteric extrinsic innervation. Visceral reflexes. Colonic motility. Defecation. Digestive tract functional tests: collection of pure gastric juice; endoscopy; registration of motor activity. Gastrointestinal hormones.

Liver. Functional units of the liver. Hepatic artery and hepatic portal vein. Oxygen consumption. An overview of the main liver functions. Liver role in hematopoiesis and blood* coagulation. Bile production and excretion. Hepatic bile versus gallbladder bile. Enterohepatic circulation. Hemoglobin degradation process jaundice and its various forms. Complete or partial removal of the liver. Liver regeneration. Liver detoxifying and protective effects. Liver failure and its consequences.

Metabolism. Chemical transformation: release and transport of energy.

Mechanisms of biological oxidation. Carbohydrate metabolism: food carbohydrates, intermediate metabolism of carbohydrates and blood sugar regulation. Lipid metabolism: lipid chemistry, digestion of neutral fats, fat absorption, lipemia, events following fats absorption, liver and lipid metabolism, fatty liver and lipotropic factors, relationship between liver and ketogenesis, integration between lipid and carbohydrate metabolism. Protein metabolism: proteins digestion, amino acid pool, examples of amino acids utilization, nitrogen balance, specific metabolic roles of amino acids, exogenous and endogenous metabolism. Nucleic acid metabolism. Hormones metabolic actions. Basal metabolism.

Nutrition. Principles of dietetics. Energy requirements. Composition of a normal diet. Food requirements in particular conditions (pregnancy, lactation, infancy, aging, etc.). Mechanisms of hunger and satiety.

PH REGULATION

PH control in intracellular and extracellular fluids, buffer systems, acid-base balance disorders and the compensatory mechanisms.

TEMPERATURE CONTROL

Regulation of body temperature in humans, physiological and pathological changes in body temperature, heat balance, thermogenesis, heat dissipation, temperature regulation, physiological responses to heat and cold.

ADAPTATION

Adaptations to exercise. Body responses to exercise (cardiovascular, respiratory, plasmatic, and muscular responses), physical inactivity-induced diseases. High-altitude adaptations. Body responses to altitude, altitude sickness.

Diving adaptations. Pathophysiology of hyperbaric gas, Hyperbaric syndrome. Absence of gravity effects.

TEXTBOOK INFORMATION

▪ FISILOGIA E BIOFISICA

1. Fisiologia medica, a cura di F. Conti - EdiErmes
2. Fisiologia Medica di Guyton e Hall - Elsevier
3. Fisiologia e Biofisica medica, a cura di F. Baldissera - Poletto Editore

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