Comprehensive Workbook of

Practical & Applied Physiology

As per Competency-based Medical Education Curriculum of NMC

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4th Edition

JAYPEE

Contents

SECTION 4

Self-directed Learning and Early Clinical Exposure

Self-directed Learning Modules (25 hours) and Early Clinical Exposure Modules (30 hours)

SELF-DIRECTED LEARNING MODULE: THE CELL

Competencies Addressed

PY 1.1 (MCI): Describe the structure and functions of mammalian cell.

Specific Learning Objectives

After this session, each student should be able to:

1. Describe the structure of the mammalian cell.
2. Describe the functions of the cell, cell membrane and cell organelles.
3. Describe the structure of cell membrane.
4. Describe the functions of cell membrane proteins.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this SDL: ***1 hour***

Module 1

Draw a well labeled diagram of mammalian cell, showing all the organelles and the details:

Module 2

Name the various cell organelles and write their functions:

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Module 3

Draw the well-labeled diagram of cell membrane (Fluid Mosaic model):

Module 4

Write the functions of cell membrane proteins:

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SELF-DIRECTED LEARNING MODULE: BODY FLUIDS AND ELECTROLYTES IN HEALTH AND DISEASE

Competencies Addressed

PY 1.6 (MCI): Describe the fluid compartments of the body, its ionic composition and measurement.
PY 1.7 (MCI): Describe the concept of pH and buffer systems of the body.

Specific Learning Objectives

After this session, each student should be able to:

1. Describe the importance of normal body fluid compartments and regulation of fluid volume, tonicity and pH.
2. Describe the role of serum electrolytes in maintaining normal body functioning.
3. Analyze the various disturbances in the fluid homeostasis through different case scenarios.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this SDL: ***7 hours***

Module 1

The students should consult various resources to find the answers to the following questions:

1. How much total body water is present in our body?
2. What are the compartments in which the total body water is divided?
3. How could you measure these compartments?
4. Why infants are more prone to dehydration as compared to adults?
5. What is the composition of each of the body fluid compartments?
6. What is Gibbs-Donnan effect?
7. How is the fluid volume regulated in healthy individuals?
8. Define osmolality of the body fluids. How is it regulated?
9. What do you understand by the term hypotonicity, isotonicity and hypertonicity?
10. How is the osmolality calculated in body fluids?
11. What is osmolal gap?
12. What is the normal pH of the body fluids?
13. How is the pH of blood regulated?
14. What is anion gap?

Resource Books

1. Textbook of Human Physiology by Guyton and Hall
2. Review book of Medical Physiology by Ganong
3. Textbook of Physiology by Manjinder Kaur

Module 2

Based on the knowledge from module 1, answer the following questions:

1. What is 1 mol of NaCl? *(if atomic wt. of Na = 23 and Cl = 35.5)*
2. How many osmoles will be given by:
   a. 1 mole of NaCl
   b. 1 mole of glucose
   c. 1 mole of Na_2SO_4
3. Name the following:
   a. Freely penetrating solutes
   b. Slowly penetrating solutes
   c. Non-penetrable solutes
4. Name the following:
   a. Hypotonic solutions
   b. Isotonic solutions
   c. Hypertonic solutions
5. What is the calculated osmolarity (mOsm/l) of a solution containing 12 mmol NaCl, 14 mmol KCl and 12 mmol $CaCl_2$?

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6. What will happen to cell volume when red cells previously equilibrated in a 280 mOsm solution of NaCl are placed in a solution of 140 mmol NaCl containing 20 mmol urea, a relatively large but permanent molecule?

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7. In the given diagram, which line best describes the following?
   a. Immersion of cell in aqueous solution of 300 mOsm of $CaCl_2$

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   b. Immersion of cell in aqueous solution of mixture of 200 mOsm of NaCl and 200 mOsm/L of glycerol?

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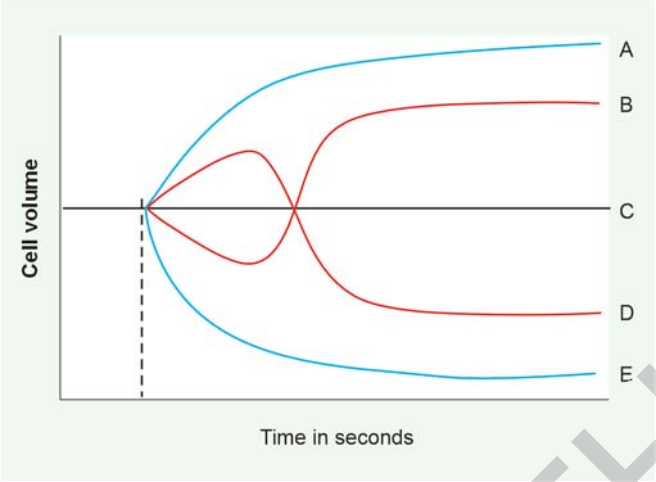
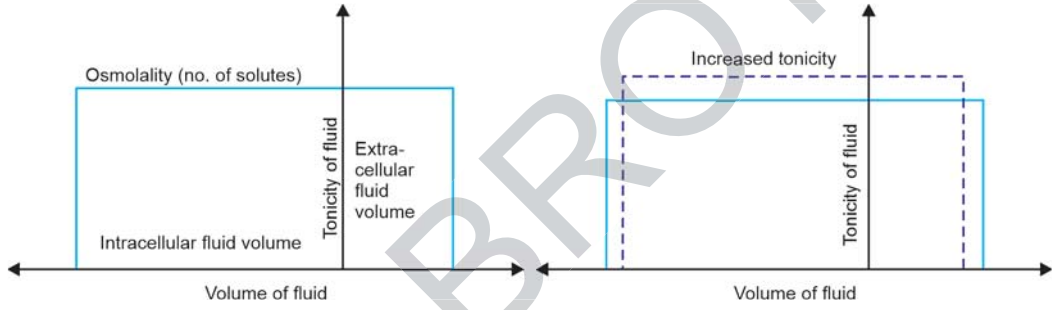


Let's see a few Darrow-Yannet diagrams describing the fluid volume and tonicity:



(a) D-Y diagram showing normal fluid volume and tonicity; (b) D-Y diagram showing hypertonicity and decreased fluid volume

8. What is the clinical application of D-Y diagram?

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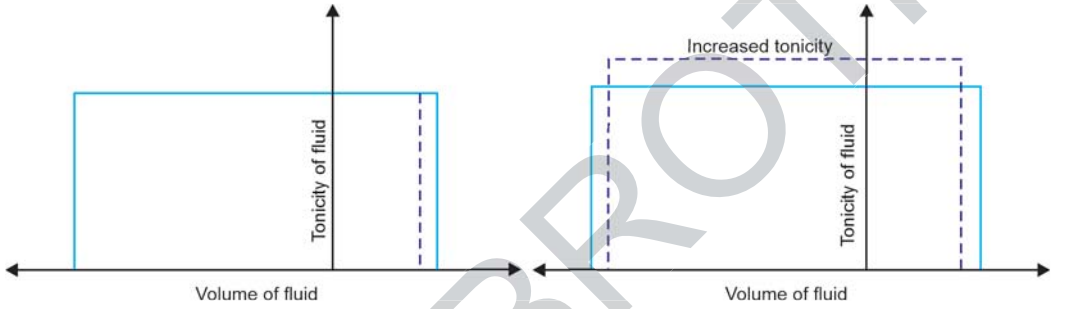
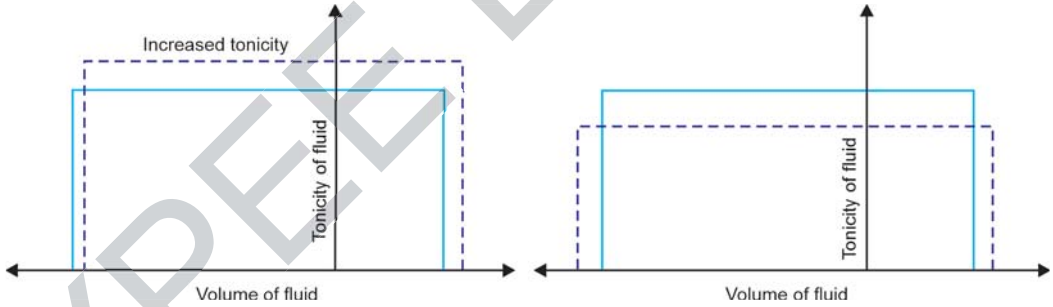
9. According to below diagram, draw the D-Y diagrams for the following:
   a. Loss of isotonic fluid
   b. Loss of hypotonic fluid
   c. After ingestion of lots of salt (salt tablets)
   d. After ingestion of large quantity of distilled water
   e. Infusion of hypotonic saline
   f. Infusion of isotonic saline
   g. Infusion of hypertonic saline
   h. Primary adrenal insufficiency
10. Draw D-Y diagram for the following (some unsolved questions):
    a. Severe diarrhea and vomiting
    b. In a patient of severe burns
    c. In a patient of road traffic accident losing 2 L of blood
    d. An athlete running in a marathon of 20 km, sweating profusely and drinking only plain water

Answers

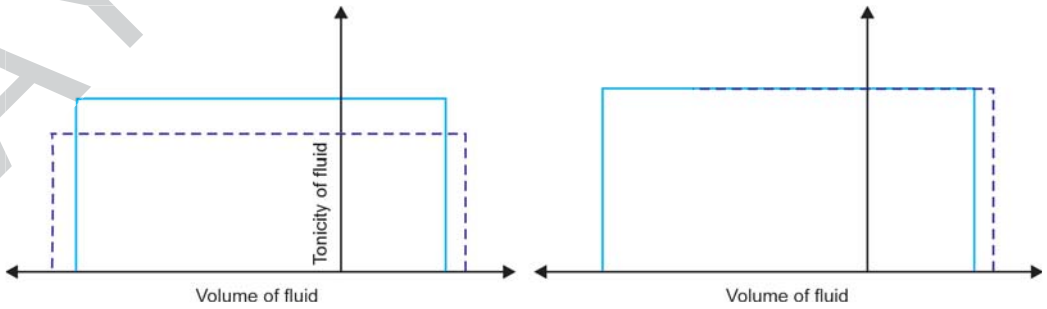
1. 1 mole of NaCl = 23 + 35.5 = 58.5 g
2. a. 2 moles b. 1 mole c. 3 moles
3. a. urea b. glycerol c. sodium
4. a. <0.9% NaCl and <5% dextrose
   b. 0.9% NaCl , 5% dextrose and Ringer Lactate
   c. >0.9% NaCl, >5% dextrose and mannitol
5. 1 mole of NaCl gives 2 mOsm/L, 1 mole of KCl gives 2 mOsm/L and 1 mmol of $CaCl_2$ gives 3 mOsm/L
   Therefore, NaCl will give 2 × 12 = 24 mOsm/L, KCl will give 2 × 14 = 28 mOsm/L; $CaCl_2$ will give 3 × 12 = 36 mOsm/L.
   Hence, the net calculated osmolality will be 24 + 28 + 36 = 88 mOsm/L.
6. Cells shrink initially, then swell over time and lyse. (140 mmol/L of NaCl = 2 × 140 = 280 mOsm/L ; 20 mmol/L of urea should result in a hypertonic solution. But urea is freely permeable, hence it will reach the equilibrium soon. This will result in the hypotonic fluid in which the cells are suspended).
7. a. It is an isotonic solution, hence C.
   b. It is initially a hypertonic solution but glycerol slowly penetrates into the cell making the solution hypotonic, hence B.
9.



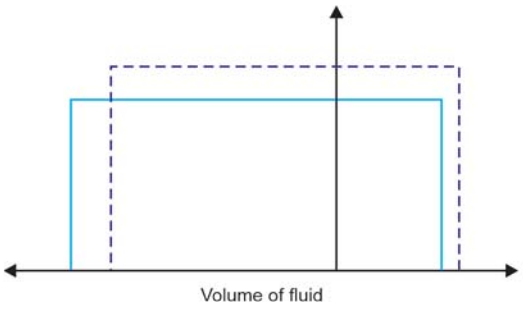
(a) Loss of isotonic saline (b) Loss of hypotonic fluid



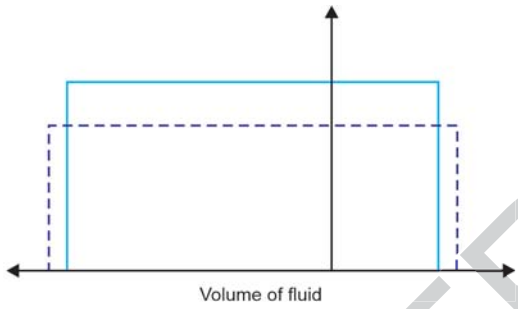
(c) Ingestion of salt tablets (d) Drinks large quantity of distilled water



(e) Infusion of hypotonic fluid (f) Infusion of isotonic saline



(g) Infusion of hypertonic saline



(h) Primary adrenal insufficiency

Module 3

Case Scenario

Rama Devi is an 85-year-old female admitted to the medical ward due to increasing agitation and confusion. She is lethargic and difficult to arouse. Her vital signs on admission to the ward are: BP: 90/60 mm Hg; P: 120/min and irregular; respiration: 28/min and shallow; temperature: 101°F.

A gastrostomy feeding tube is in place (through the abdominal wall into her stomach) with an infusion of tube feeding formula at 50 cc/hour.

Assessment of skin turgor indicates tenting of the skin.

Rama has an IV of 5% dextrose infusing at 75 cc/hour that was started 1 hour ago.

1. What do you suspect is the electrolyte imbalance Rama is experiencing?
2. Is there a fluid imbalance too?
3. What lab and diagnostic tests could confirm this hypothesis?
   Rama's lab reports are:
   a. Na: 160 mEq/L,
   b. K: 4.0 mEq/L,
   c. Cl: 110 mEq/L,
   d. Serum osmolality = 330 mOsm/kg.
4. You determine that Rama Devi has: _____
5. What is the most likely cause of this electrolyte imbalance?
6. She also has a fluid imbalance. Is it isotonic, hypotonic or hypertonic?
7. Explain the fluid shifts that have occurred between Rama's ICF and ECF. How does this explain the symptoms she is experiencing?
8. What tonicity of IV fluids should Rama get? Explain the choice in terms of fluid movement between ICF and ECF.
9. How can this electrolyte imbalance be prevented in the future?

Answers

1. Sodium imbalance.
2. Yes, Hypovolemia.
3. BMP.
4. Hypernatremia.
5. Dehydration.
6. Hypertonic.
7. Draw the appropriate D-Y diagram. Fluid is shifting out of her cells into the blood and they are shrinking due to too much Na.
8. She needs isotonic fluids to facilitate normal movement of IFC and EFC.
9. Hydration.

SELF-DIRECTED LEARNING MODULE: NUTRITION

Competency Addressed

PY 4.4 (MCI): Describe the physiology of digestion and absorption of nutrients.

Specific Learning Objectives

After this session, each student should be able to:

1. Enumerate the various macro and micronutrients required for a healthy body.
2. Discuss the dietary sources, recommended daily allowance and functions of various nutrients.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this SDL: ***2 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.

SELF-DIRECTED LEARNING MODULE: METABOLIC SYNDROME

Competency Addressed

PY 8.5 (MCI): Describe the metabolic and endocrine consequences of obesity and metabolic syndrome, stress response. Outline the psychiatry component pertaining to metabolic syndrome.

Specific Learning Objectives

After this session, each student should be able to:

1. Describe the etiopathogenesis of obesity and metabolic syndrome.
2. Describe the effect of obesity on various physiological processes of the body.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this SDL: ***2 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.

SELF-DIRECTED LEARNING MODULE: PUBERTY

Competency Addressed

PY 9.2 (MCI): Describe and discuss puberty: Onset, progression, stages, early and delayed puberty and outline adolescent and psychological association.

Specific Learning Objectives

After this session, each student should be able to:

1. Describe the onset, progression and stages of puberty in adolescent boys and girls.
2. Describe the effects of early or delayed puberty in adolescents.
3. Describe the psychological effects of the puberty in adolescents.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this SDL: ***2 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.

SELF-DIRECTED LEARNING MODULE: EFFECT OF CASTRATION ON PHYSIOLOGICAL FUNCTIONS

Competency Addressed

PY 9.7 (MCI): Describe and discuss the effects of removal of gonads on physiological functions.

Specific Learning Objectives

After this session, each student should be able to:

1. Describe the effect of castration (removal of gonads) before puberty in young boys and girls.
2. Describe the effect of castration (removal of gonads) after puberty in young boys and girls.

Domain: ***Knows***

Level: ***Knows How***

No. of hours required for this SDL: ***2 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.

SELF-DIRECTED LEARNING MODULE: MENOPAUSE

Competency Addressed

PY 9.11 (MCI): Discuss the hormonal changes and their effects during perimenopause and menopause.

Specific Learning Objectives

After this session, each student should be able to:

1. Describe the hormonal changes in perimenopause and menopause in a woman.
2. Describe the physiological changes in the women during and after menopause.

Domain: ***Knows***

Level: ***Knows How***

No. of hours required for this SDL: ***2 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.

SELF-DIRECTED LEARNING MODULE: ADAPTATIONS FOR TEMPERATURE REGULATION

Competency Addressed

PY 11.2 (MCI): Describe and discuss the adaptation to altered temperature (heat and cold).

Specific Learning Objectives

After this session, each student should be able to:

1. Describe the various physiological changes occurring in the human body when exposed to an extreme hot environment.
2. Enlist and describe the adaptations of the body to the hot environment.
3. Describe the various physiological changes occurring in the human body when exposed to an extreme cold environment.
4. Enlist and describe the adaptations of the body to the cold environment.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this SDL: ***2 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.

SELF-DIRECTED LEARNING MODULE: AGING

Competency Addressed

PY 11.7 (MCI): Describe and discuss physiology of aging, free radicals and antioxidants.

Specific Learning Objectives

After this session, each student should be able to:

1. Describe the various physiological changes occurring in the human body during aging.
2. Describe the free radical injury and antioxidant status during aging process.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this SDL: ***2 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.

HEMATOLOGY
(Integrated with Pathology and General Medicine)

EARLY CLINICAL EXPOSURE: CASE SCENARIOS

Competency Addressed

PY 2.5 (MCI): Describe different types of anemia and jaundice.

Specific Learning Objectives

After finishing this module, you should be able to:

1. Analyze the clinical problem on the basis of its signs and symptoms, laboratory findings, to reach a differential diagnosis for that problem.
2. Describe the pathophysiology of the given clinical condition based on the clinical and laboratory findings.
3. Discuss the rationale of management, based on the derangement of physiological parameters in a case scenario.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this ECE: ***6 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.
4. *For more cases, refer* Early Clinical Exposure in Clinical Physiology by Manjinder Kaur.

Case 1

A 35-year-old female complains of breathlessness, loss of appetite, apathy and easy fatigability. Examination of the patient revealed ***pallor, koilonychia, increased heart rate and systolic murmur***.

Laboratory investigations of this patient were obtained as under:

Hemoglobin: 6.0 gm%	PCV: 38%
RBC count: 3 million/c.c.	S. ferritin: 50 microgram/dL
MCV: 70 fL	TIBC: 380 microgram/dL
MCHC: 28%	PBF: RBC are microcytic and hypochromic

Based on the above case, answer the following questions:

Q1. What do you think, this patient is suffering from?

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Q2. How would you grade the anemia of this patient based on clinical classification?

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Q3. What do you understand by microcytic and hypochromic RBCs in this patient?

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Q4. How is the deficient nutrient absorbed and utilized in our body?

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Q5. Define anemia.

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Q6. Classify anemia according to the etiology (cause).

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Q7. Classify anemia according to the morphology of RBCs.

	Hypochromic	*Normochromic*
Microcytic		
Normocytic		
Macrocytic		

Case 2

A 45-year-old male complains of indigestion, diarrhea, soreness in angles of mouth, loss of appetite and tingling sensation in the hands and feet. Examination of the patient revealed ***angular stomatitis, angry tongue and peripheral neuropathy.***

Laboratory investigations of these patients were obtained as under:

Hemoglobin: 9.0 g% RBC count: 1 million/c.c.

S. iron: 170 microgram/dL

MCV: 100 fL MCH: 50 pg; Reticulocyte count: 6%

PBF-**RBC are macrocytic and normochromic with some large nucleated RBC, neutropenia with hypersegmented neutrophils and decreased platelets per high-power field.**

Based on the above case, answer the following questions:

Q1. What do you think, this patient is suffering from?

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Q2. Will you order any other investigation for this patient?

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Q3. What are the causes of this type of anemia?

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Q4. What is the cause of peripheral neuropathy in this type of anemia?

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Q5. What do you understand by macrocytic and normochromic RBCs in this patient?

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Q6. Why do you see large nucleated RBC (megaloblasts) in PBF, in this condition?

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Q7. How is the deficient nutrient absorbed and utilized in our body?

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Q8. Why this type of anemia is seen in patients with gastric atrophy?

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Q9. What are the other conditions with a similar blood picture? What are the causes for the same?

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Q10. How will you manage this patient?

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Q11. What will happen if you give only folic acid supplementation in pernicious anemia?

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Q12. Do you see the signs and symptoms of neuropathy in patients with folic acid deficiency?

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Q13. What is the mode of action of vitamin B_{12} and folic acid in erythropoiesis?

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Case 3

A 20-year-old male complains of pain in loin and passage of dark urine after eating fava beans. Examination of the patient revealed nothing significant.

Laboratory investigations of this patient were obtained as under:

Hemoglobin: 10 g% RBC count: 3 million/c.c.

(Note: Plasma hemoglobin and methemoglobin levels are raised)

PBF-**RBC are normocytic and normochromic with polychromasia, basophilic stipplings and marked poikilocytosis.**

Based on the above case, answer the following questions:

Q1. What do you think, this patient is suffering from?

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Q2. What are the causes of this type of anemia?

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Q3. What is mechanism of action of the deficient enzyme in this condition?

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Q4. How can you prevent this condition?

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Q5. What are the other types of hemolytic anemia and what is the cause in each one of them?

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Q6. What are target cells? In which condition, they are seen?

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NERVE MUSCLE PHYSIOLOGY

(Integrated with Pharmacology, Pathology, Anesthesiology, General Medicine)

EARLY CLINICAL EXPOSURE: CASE SCENARIOS

Competencies Addressed

PY 3.4 (MCI): Describe the structure of neuromuscular junction and transmission of impulses.
PY 3.5 (MCI): Discuss the action of neuromuscular blocking agents.
PY 3.6 (MCI): Describe the pathophysiology of myasthenia gravis.

Specific Learning Objectives

After finishing this module, the student should be able to:

1. Analyze the clinical problem on the basis of its signs and symptoms, laboratory findings, to reach a differential diagnosis for that problem.
2. Describe the pathophysiology of the given clinical condition based on the clinical and laboratory findings.
3. Discuss the rationale of management, based on the derangement of physiological parameters in a case scenario.

Domain: ***Knows***
Level: ***Knows How***
No. of hours required for this ECE: ***2 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.
4. *For more cases, refer* Early Clinical Exposure in Clinical Physiology by Manjinder Kaur.

History

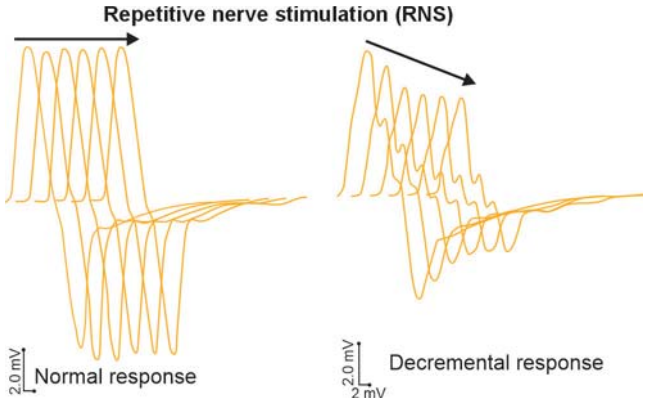
A 25-year-old lady comes to OPD with chief complaint of weakness and fatigability. Generally, during morning she does not feel any significant weakness but, as the day passes and she gets involved in routine household works, weakness gradually starts to increase. The condition improves by some rest or sleep. She also reports double vision and difficulty in swallowing.

Physical Examination

Ptosis, diplopia, proximal muscle weakness, normal deep tendon reflex, no sensory impairment.

Laboratory Investigations

- Positive anticholinesterase test.
- Electrodiagnostic testing shows rapid reduction in amplitude of the repetitive nerve stimulation (decremental response).



LET'S THINK!

Q1. What do you think, this patient is suffering from?

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Q2. As the day passes by, why does patient gradually start getting more and more fatigue?

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Q3. Why does rest improve the symptoms?

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Q4. Why subject has diplopia and ptosis?

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Q5. How do you interpret the electrodiagnostic finding?

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Q6. What could be the physiological basis of management?

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Q7. What is the pathology in Lambert-Eaton syndrome? How is it different from myasthenia gravis?

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CARDIOVASCULAR PHYSIOLOGY
(Integrated with Pathology and General Medicine)

EARLY CLINICAL EXPOSURE: CASE SCENARIOS

Competency Addressed

PY 5.11 (MCI): Describe the pathophysiology of shock, syncope and cardiac failure.

Specific Learning Objectives

After finishing this module, student should be able to:

1. Analyze the clinical problem on the basis of its signs and symptoms, laboratory findings, to reach a differential diagnosis for that problem.
2. Describe the pathophysiology of the given clinical condition based on the clinical and laboratory findings.
3. Discuss the rationale of management, based on the derangement of physiological parameters in a case scenario.

Domain: ***Knows***

Level: ***Knows How***

No. of hours required for this ECE: ***6 hours***

Resource Books

1. Textbook of Human Physiology by Guyton and Hall.
2. Review book of Medical Physiology by Ganong.
3. Textbook of Physiology by Manjinder Kaur.
4. *For more cases, refer* Early Clinical Exposure in Clinical Physiology by Manjinder Kaur.

Case 1

History

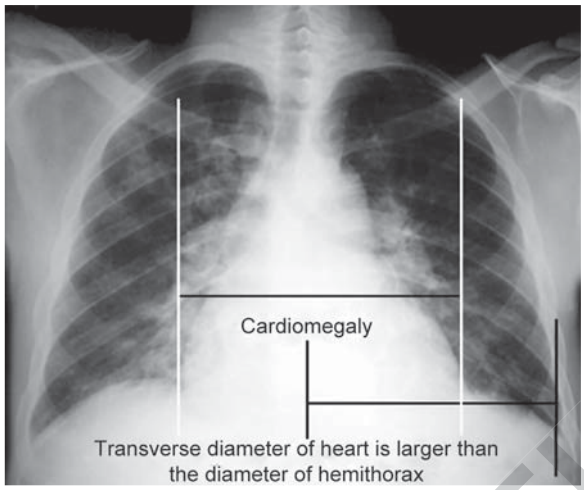
A 55-year-old male presents to OPD with complaints of shortness of breath. This breathlessness appears on normal exertion which, few years back, he could do without any problem. During sleep he often gets attacks of severe shortness of breath and coughing which awakes him from sleep. This episode of coughing persists even in sitting position.

General Physical Examination

The patient is calm, conscious, well oriented to time, place and person. Pulse: 90/min with a characteristic pulsus alternans, BP = 130/ 90 mm Hg, pitting edema is seen on the ankles (++), JVP is 7 cm.

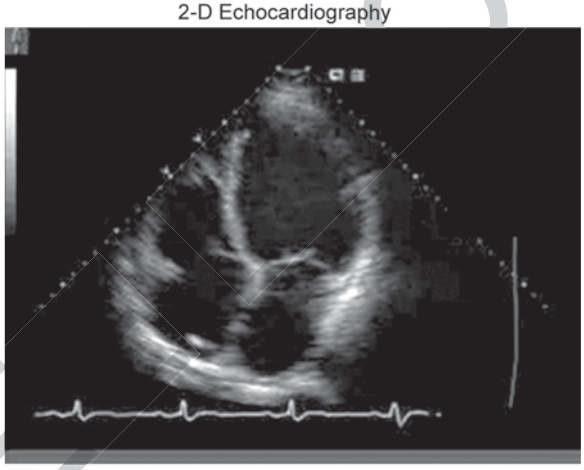
Systemic Examination of:

- **Abdomen** shows hepatomegaly.
- **Respiratory system:** Bilateral dull percussion note on costophrenic angles. Auscultation reveals the basal crepitations in both the lungs.
- **Cardiovascular system:**
  - X-ray chest: Cardiomegaly.



- ECG shows signs of right and left ventricular hypertrophy.
- 2D echocardiography shows dilation of all the cardiac chambers with poor contractility of cardiac walls and reduced ejection fraction.

2-D Echocardiography



Dilated chambers of heart with poor contractility

Based on above clinical condition, answer the following questions:

Q1. What is the cause of shortness of breath in this patient?

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Q2. What is the cause of increased pulse rate in this patient?

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Q3. What is the cause of raised JVP and liver enlargement in this patient?

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Q4. What is the cause of bilateral dull percussion note in chest?

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Q5. What is the cause of basal crepitations in chest?

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Q6. What is your probable diagnosis based on physical and laboratory findings?

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Q7. How can you manage this patient keeping in view the pathophysiology of this condition?

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Case 2

History

Parents of a 5-year-girl had brought her to emergency in semiconsciousness state. She had 7–8 episodes of loose motions and 4 episodes of vomiting in a day. It was associated with intermittent abdominal pain. There is a history of consumption of samosas from a street vendor, 2 days back.

General Physical Examination

The patient is drowsy, opening eyes only on painful stimulus. Pulse: 100/min, regular, low volume pulse, BP = 90/70 mm Hg, temperature 100°F. Skin turgor is reduced; mouth and tongue are dry. Respiratory rate is 24/min and shallow.

Based on above clinical condition, answer the following questions:

Q1. What is your likely diagnosis for this patient?

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Q2. What is the pathophysiology behind this clinical condition?

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Q3. How can you manage this patient based on pathophysiology?

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Case 3

History

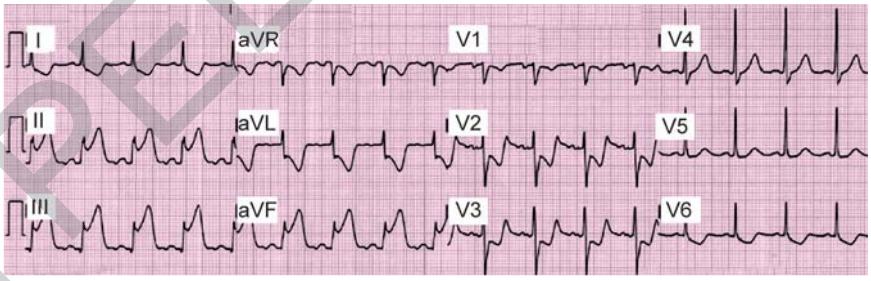
A 68-year-old obese male patient was brought to emergency by ambulance. He complained of sharp, stabbing pain in the center of the chest and discomfort in the left shoulder. He had previous history of episodes of chest discomfort which he described as chest heaviness. The pain and discomfort was aggravated on exertion. He had mild dyspnea and nausea accompanying the pain. He also had intermittent palpitations since last evening.

Physical Examination

Vital signs on arrival to the emergency showed a BP of 160/100 mm Hg, pulse = 96/min, and a respiratory rate of 18 per minute. His physical examination did not reveal any other significant finding.

Laboratory Investigations

- Elevated level of enzyme CPK-MB
- Elevated level of Troponin–T
- ECG—shows the normal sinus rhythm with ST segment elevation.



- 2D echocardiography shows inferior wall infarct.

Based on above clinical condition, answer the following questions:

Q1. What is your likely diagnosis for this patient?

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Q2. What is the pathophysiology behind this clinical condition?

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Q3. How can you manage this patient based on pathophysiology?

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Comprehensive Workbook of

Practical & Applied Physiology

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