Physiology 131 Practical 2nd term

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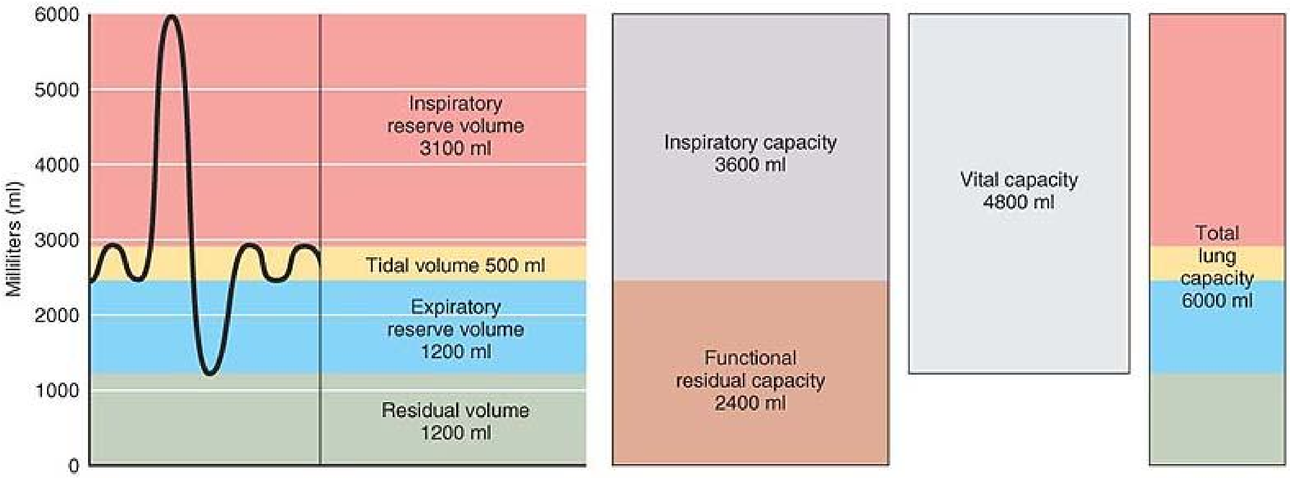
Respiratory Practical

Bell type Spirometry



(a) Spirographic record for a male

	Measurement	Adult male average value	Adult female average value	Description
Respiratory volumes	Tidal volume (TV)	500 ml	500 ml	Amount of air inhaled or exhaled with each breath under resting conditions
Respiratory volumes	Inspiratory reserve volume (IRV)	3100 ml	1900 ml	Amount of air that can be forcefully inhaled after a normal tidal volume inhalation
Respiratory volumes	Expiratory reserve volume (ERV)	1200 ml	700 ml	Amount of air that can be forcefully exhaled after a normal tidal volume exhalation
Respiratory volumes	Residual volume (RV)	1200 ml	1100 ml	Amount of air remaining in the lungs after a forced exhalation
Respiratory capacities	Total lung capacity (TLC)	6000 ml	4200 ml	Maximum amount of air contained in lungs after a maximum inspiratory effort: TLC = TV + IRV + ERV + RV
Respiratory capacities	Vital capacity (VC)	4800 ml	3100 ml	Maximum amount of air that can be expired after a maximum inspiratory effort: VC = TV + IRV + ERV (should be 80% TLC)
Respiratory capacities	Inspiratory capacity (IC)	3600 ml	2400 ml	Maximum amount of air that can be inspired after a normal expiration: IC = TV + IRV
Respiratory capacities	Functional residual capacity (FRC)	2400 ml	1800 ml	Volume of air remaining in the lungs after a normal tidal volume expiration: FRC = ERV + RV

(b) Summary of respiratory volumes and capacities for males and females

Note: all of the respiratory volumes can be obtained using bell-type spirometry except for RV. This will make TLC and FRC also incapable of being measured using this spirometry. Helium is usually used to measure the residual volume.

(2) Physiological factors that influence lung volumes & capacities include:

- Sex (as seen above)
- Weight (↑ weight ➔ ↓ lung volume
- Age

- Child hood ➔ adulthood there will be ↑ lung volume
- Adulthood ➔ elderly there will be ↓ lung volume (especially vital capacity)

  - Height (↑ height ➔ ↑ lung volume (especially vital capacity))
  - Athletes ↑
  - Posture (standing will ↑ lung volume)

(3) Lung volumes and capacities are altered in a variety of pathological conditions including:
   a. Obstructive lung disease: normal or slightly ↑ TLC with ↑↑ FRC (e.g. asthma & emphysema).
   b. Restrictive lung disease: ↓ lung volume & capacity (e.g. pulmonary fibrosis, pleural effusion, pneumothorax, lung tumors).

(4) The physiological significance of the residual volume and the functional residual capacity include the following:
   a. Facilitates the work of breathing.
   b. Prevents the collapse of lungs.
   c. Allows continuous exchange of gases between the breaths.

Dynamic Spirometry

Some Definitions:

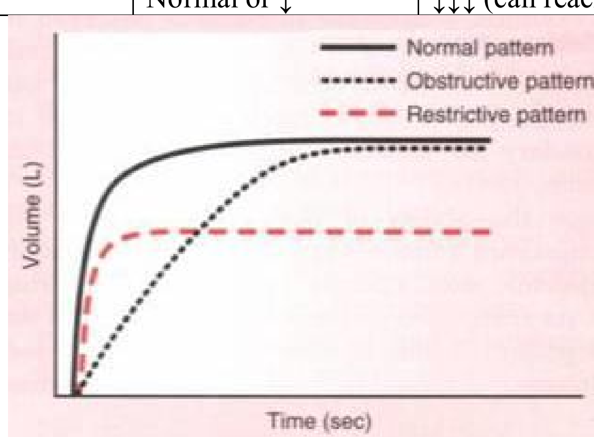
- **Forced expiratory volume in 1 sec (FEV1):** the volume of air forcefully expired during the first second after a full breath and normally accounts for > 75% of the FVC.
- **Forced Vital Capacity (FVC):** The volume of air expired with maximal force after maximal inspiratory effort.

Answers to questions:

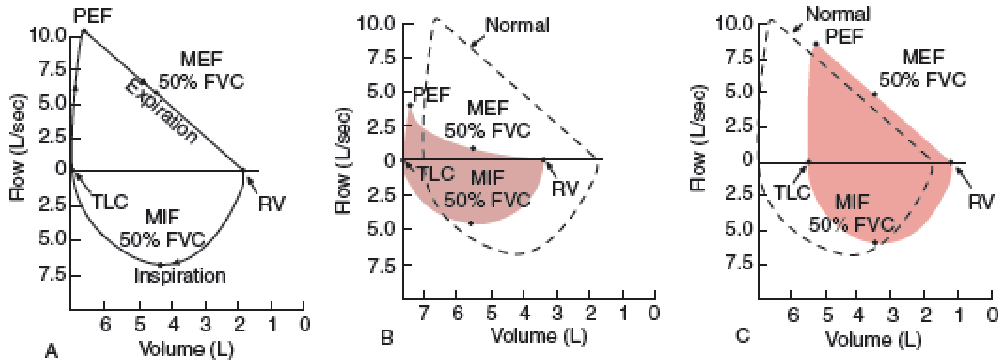
(1) From the FEV_1 produced (on page 5), calculate:-
   a. **FVC**: 4.5L
   b. **FEV_1:** 3.7 L
   c. **FEV_1%:** $FVC/FEV_1 \times 100 = 3.5/4.5 = 82\%$ (normal).

(2) The FEV_1% is a good index of airway resistance while expiring.
   a. The values expected for a normal person is >75%
   b. It takes healthy subjects to expire their vital capacity 3-5 seconds.
   c. In pathologies the following effects take place:

	Obstructive	Restrictive
FEV_1/FVC %	↓↓↓ (far below 80%)	Normal or slightly ↑
FEV_1	↓	↓
FVC	Normal or ↓	↓↓↓ (can reach 3L)



Flow Volume Loop



1. (answers are given according to the flow volume loop given on Page 5 on the question paper:
   a) VC = 4L. (All the width of the x-axis or TLC-RC).
   b) PEFR = 11 L (the maximum flow rate during expiration see figure A above as "PEF").
   c) PIFR = 6 L (the maximum flow rate during inspiration)
   d) MEF50 = 5 L (the flow in expiration at 50% vital capacity).
   e) MIF50 = 6 L (the flow in inspiration at 50% vital capacity).
2. In a normal individual all of the parameters (including FVC MEF50, PEFR, PIFR…etc) will be within normal ranges.
3. The force-independent part of the expiratory loop is curvilinear in obstructive lung disease is due to narrowing of the smaller airways. (The rising phase in the expiratory loop is force dependent, and the falling phase is force independent).
4. The clinical significance of MEF50 measurements is to diagnose obstructive lung disease (↓ in MEF50 with normal simultaneous PEFR ➔ obstructive lung disease). If there is decrease in MEF50 with simultaneous decrease in PEFR, then it is restrictive lung disease.

Diuresis Answers:

CALCULATIONS(v.v.v.v. IMPORTANT)

The calculations that will be explained below will be based on (This is what usually comes in the exam ☺):

- The urine collection time is given in minutes (min).
- The volume of urine is in milliliters (mL).
- Sodium concentration is given in mmol/liter (mmol/L or milliMolar mM the same thing)
- Sodium excretion is usually asked to be given in millimoles (mmol).
- Sodium excretion rate is in micromoles/minute (μmol/min).

1. To calculate **urine excretion rate (ml/min)** you use the following formula:
$$\frac{\text{volume of urine (mL)}}{\text{time (min)}}$$
2. To calculate the **total sodium excretion (mmoles)** you use the following formula:
$$\frac{\text{sodium concentration (mmol/L)} \times \text{volume of urine (mL)}}{1000}$$
3. To calculate the **sodium excretion rate (μmol/min)** you use the following formula:
$$\frac{\text{sodium concentration (mmol/L)} \times \text{volume of urine (mL)}}{\text{time (min)}}$$

e.g. : collection time = 30 mins, volume of urine= 33 ml, sodium concentration = 56 mM.:

- Urine excretion rate: 33/30=1.10 ml/min
- Total Sodium Excretion : 56 × 33 / 1000 = 1.8 mmoles
- Sodium excretion rate: 56 × 33 / 30 = 61.6 μmol/min

1. The pH of urine does not fall below 4.5 because:
   a) There is a limitation to the rate of active transport of the H+ ions into the distal tubules.
   b) The concentration difference between H+ ions across the tubular cells is too big for H" ion active transport to continue

   The physiological importance of pH not falling below 4.5 is to prevent damage to the walls of the urinary tract.

2. answers to calculations,,,, (note1: these calculations are NOT important for the exam, make them the last thing to study ☺, note2: values are referring to table in p.116):
   a) Average urine excreted in the three hours after drinking the 1 liter of water =(33+206+260+214+54+36)/3 = 267 ml/hour
   Average urine excreted in the three hours before drinking the 1 liter of water =118/2 = 59 ml/hour

   So the extra amount of urine excreted = 267 – 59 = 208 ml/hour more urine.
   The rest of the calculations should be done in the same way and they are not solved here because of their exam unimportance!
3. It will take 24 hours to excrete 1 liter of ingested isotonic saline because the mechanism of ANP is a slow mechanism. ANP is stimulated by ↑ blood volume and will act on excretion of isotonic saline in 3 ways:
   a) It will inhibit aldosterone secretion from adrenal cortex.

b) It will ↑ GFR by vasodilation of afferent arteriole.
c) It will ↑ GFR by relaxation of the mesangial cells and thus ↑ the filtration coefficient.

Note: ADH mechanism is responsible of excretion of 1 liter of ingested water within 3 hours and begins its action after 30 minutes.

1. Lasix can increase the loss of body fluids by blocking the Na+/K+/2Cl cotransporter in the thick ascending limb of the loop of Henle. This will cause ↓ reabsorption and thus ↑ loss of sodium in urine, and the water and chloride will follow it. This is known as osmotic diuresis.
2. Explanation for sometimes not urinating water within 3 hours after taking 1 liter of water could be due to loss of water by other means (i.e. feces, skin, lungs, vomiting, etc..)
3. *The test on question 3 was not done so its questions are not coming in the exam!*

GTT (Glucose Tolerance Test)

Basic Explanation of the graphs:

The characteristics of curve (a)

- The patient's fasting glucose level is between 70-110 (normal).
- After 30 minutes of ingesting 75 g of glucose his blood glucose level rose (past of rise) to a level lower than 180 (in the normal range). There was no glucose in the urine (normal).
- After 2 hours (Post Prandital Time) his blood glucose level fell to the range between 70-110 (normal)

From the following criteria we found that the subject is **normal**.

The characteristics of curve (b)

- The patient's fasting glucose level is between 70-110 (normal).
- After 30 minutes of ingesting 75 g of glucose his blood glucose level rose (past of rise) to a level lower than 180 (in the normal range) but **glucose appeared in the urine** (abnormal).
- After 2 hours (Post Prandital Time) his blood glucose level fell to the range between 70-110 (normal)

From the following criteria we found that the subject is having **congenital renal tubular defect**. The problem is that his kidneys are incapable to reabsorb all the glucose from the urine indicating decreased renal threshold for glucose. This is due to a deficiency in the kidney glucose transporters.

The characteristics of curve (c)

- The patient's fasting glucose level is between 70-110 (normal).
- After 30 minutes of ingesting 75 g of glucose his blood glucose level rose (past of rise) to a level **higher than 180** (**abnormal**). Therefore glucose appeared in the urine. (The ↑ above 180 is abnormal. But it is **normal for the kidneys** not to leak some glucose if glucose level in the blood rises above 180).
- After 2 hours (Post Prandial Time) his blood glucose level fell to the range between 70-110 (normal)

From the following criteria we found that the subject is suffering from **alimentary glycosuria** caused by either liver Disease, Hyperthyroidism, After gatrectomy, Very high carbohydrate diet.

The characteristics of curve (d)

- The patient's fasting glucose level is **above 126 (abnormal).**
- After 30 minutes of ingesting 75 g of glucose his blood glucose level rose (past of rise) to a level **higher than 180** (**abnormal**). Therefore glucose appeared in the urine. (The ↑ above 180 is abnormal. But it is **normal for the kidneys** not to leak some glucose if glucose level in the blood rises above 180).
- After 2 hours (Post Prandial Time) his blood glucose level remained much higher than 126.

From the following criteria we found that the subject is suffering from **Diabetes Mellitus**.

Answers to the questions

1. The range of normal fasting blood glucose is 70-110 mg/dl (3.9-6.1 mmol/l).
2.
    a. The reason for the rising phase in the GTT curve is the ingestion and absorption of glucose into blood.
    b. The reason for the falling phase in the GTT curve is the action of insulin to ↑ the uptake and utilization of glucose by the cells.
3. The blood glucose may fall below fasting levels approximately 2.5 hours after the glucose load because of insulin overshoot.
4. The renal threshold is the plasma glucose level at and after which glucose will start appearing in urine. The normal value in the venous plasma is 180 mg/dl and in the arterial plasma is 200 mg/dl. The difference between the arterial and venous plasma glucose levels will ↑ when the renal threshold is exceeded due to loss of some glucose into the urine.
5. The causes of glycosuria include:
    a. Diabetes Mellitus (DM).
    b. Congenital Renal Tubular Defect
    c. Alimentary glycosuria:
        i. Liver Disease.
        ii. Hyperthyroidism
        iii. After gatrectomy
        iv. Very high carbohydrate diet.
6. The difference in GTT between the a normal subject and a diabetic person include:
    a. The fasting Plasma Glucose Level (PGL) will be ↑ >126 in diabetic patients while it will be normal in a normal person.
    b. The plasma glucose level will exceed renal threshold in a diabetic person, while it is not the case in a normal person.
    c. The plasma glucose level does not come back to the fasting level in a diabetic person after 2 hours but in a normal subject it will come back to normal.
7. answers:
    a. Glucose can be given in IV in
        i. An unconscious patient
        ii. A patient with the tendency to vomit.
    b. If the glucose is taken IV, then the glucose level will rise more rapidly and to a higher level after the glucose intake because the intestines are bypassed.
8. Other tests for diagnosis of diabetes mellitus are the fasting plasma glucose level, and for the prognosis of diabetes is HbA_{1C}.
9. High Calorie diet should be avoided by a diabetic person.