



**Faculty of Medicine and Allied Medical Sciences
(FM&AMS)**



Module 6: Urinary System

Academic year 2020

Phase 2

Year 2

Term 3

Urinary System

Purpose of this Study Guide

The purpose of the study guide is to

- Organize your learning so you can access it in future practice.
- Develop a productive lifelong learning strategy.
- Develop your clinical reasoning skills in preparation for clinical rotation.
- To relate your thinking between the systems.

This guide is the result of untiring work of faculty members from all the departments involved in this module. These include Physiology, Anatomy, Biochemistry and Medical Education departments at Isra University.



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Module details

Course	MBBS
Phase	Two
Year	Two
Term	Three
Commencement date	Monday 24th February 2020
Duration of module	04 weeks
Pre-requisites	Successful completion of Module 1, II, III, IV & V
Disciplines covered	Physiology, Biochemistry, Anatomy,
Competencies covered	I (<i>Skilful</i>), and II (<i>Knowledgeable/ problem solver</i>), III (<i>Community Health Promoter</i>)
Module assessment	
Assessment methods	One Correct Answer (MCQs) & Structured Essay Questions (SEQs), Spot examination, Viva examination
Year 2 coordinator	Dr. Yaar Mohammad Nizamani



Introduction

Hello and welcome to the Urinary system module. This module as its name suggests focuses on the normal structure and function of the renal system, which you would learn in the first couple of weeks. After which the focus will shift to urine formation and concentration of the urine. Lastly, the theme ends with topics related to the renal failure.

An important issue to understand is that patients suffering from kidney diseases are dealt with in the hospital setting by **Nephrologists**. Meanwhile, surgeons – **urologists**, deal with renal disorders requiring surgery. In the female sex, the Gynaecologists deal latter disorders. It is imperative to understand that these boundaries are artificial, as patient not enter the doctor's room with a label to differentiate / recognize them. Hence, the margins between urology and nephrology are blur. The same stand for almost every other specialty. Some of the common symptoms to start off with are tiredness, backache, headache and nausea.

Second, an essential aspect to consider is that most renal disorder can be understood if you consider how different diseases affect the structure and function of the kidney. Therefore, the affects produced as a result of the disease (*symptoms as mentioned above*) as well as physical exam findings and both radiological and blood investigations can help diagnose renal diseases. Luckily, the renal diseases for undergraduate students are quite straightforward which you will study in detail in Diseases of the urinary system module during third-year MBBS.

Lastly, in relation to the previous modules passed several new concepts will be introduced in context to the renal system. Such as homeostasis - how body tend to maintain homeostasis (in relation to pH, osmolality, electrolytes; maintenance of blood volume and pressure from cardiovascular system. During this module, you will learn the role of renal system in maintaining homeostasis as well.

K.D!



Aim

The aim of this module is to

- Consolidate the basic understanding of the structure, function and biochemical reaction at molecular level of the urinary system.
- Demonstrate their understanding about how different diseases disrupt the function of the urinary system and disrupting the structural change.
- Link the structure and functional abnormalities to the clinical signs and symptoms,
- Recognize the effect of the urinary diseases on different organ-systems of the body,
- Interpret blood reports frequently prescribed in clinical diseases such as serum electrolytes, renal function tests, arterial blood gas reports, urine DR,
- Acquire knowledge about the role of different radiological investigations in diagnosing renal disorders.

Structure of the Course

To achieve these aims, this module comprises of 4 weeks including three weeks of study followed by module assessment in fourth week. This module builds on the knowledge of biomolecules: protein in particular previously taught during Module 1A: Underpinnings of medical practice. Meanwhile structure and functions of renal system builds on the overview of anatomy of the urinary system and general principles of physiology taught during first-year MBBS.

Content distribution:

Theme 1: Structure & function of the urinary system	Week 1
Theme 2: Mechanism of urine formation & concentration	Week 2
Theme 3: Renal failure and its types	Week 3
Theme 4: Assessment week	Week 4



General objectives:

Knowledge

At the end of this module, first-year medical student should be able to

- Explain the basic anatomy of the renal system (*i.e. kidneys, ureter, bladder and urethra*)
- Explain the development of the renal system and abnormalities that may arise during development,
- Describe the microscopic structure of the renal system,
- Describe the normal physiological functions of the renal system and specifically its importance in maintain homeostasis.
- Apply the basic scientific knowledge regarding the metabolism of proteins and amino acids and show how defects can lead to a disease.
- Identify different types of injuries to the renal system and explain the mechanism of how different disease affect the renal structure by disrupting its function,
- Describe the psychosocial impact of the renal diseases (*on patient, family and society as a whole*) in relation to Pakistan,
- Describe how renal diseases the psychosocial aspects

Skills

- Interpret the basic blood and radiological investigations (*Urine detail report, urea and electrolytes, arterial blood gases and radiological investigations in diagnosing renal diseases and function of the renal system*)
- Demonstrate the correct technique of performing male and female catheterization on a manikin (*optional as covered in third-year*)



Main Content Area

- Macroscopic and microscopic (*histology*) structure of the urinary system: kidney, ureter and bladder and urethra,
- Posterior abdominal wall and lumbar region,
- Developmental anatomy of the urinary system and its abnormalities,
- Functions of the renal system (*acid-base balance, hormonal, filtration etc.*),
- Glomerular filtration,
- Metabolism of protein and amino acids; urea cycle
- Metabolism of minerals: sodium, potassium, chloride and phosphate
- Renal circulation and autoregulation,
- Tubular reabsorption & secretions,
- Mechanism of concentration of urine,
- Micturition,
- Urinary incontinence,
- Epidemiology of renal diseases (*incidence and prevalence & burden on economy*),
- Pathophysiological principles of renal diseases,
- Dietary requirements for patients suffering from renal diseases,
- Psychosocial aspects related to patients suffering from renal diseases (*optional*)



Educational opportunities

Main Content Area	Lectures	Practical	Clinical Skills	Small Group Discussions	Tutorials	Self-study
Macroscopic and microscopic (<i>histology</i>) structure of the urinary system: kidney, ureter and bladder and urethra,						
Posterior abdominal wall and lumbar region,						
Developmental anatomy of the urinary system and its abnormalities,						
Functions of the renal system (<i>acid-base balance, hormonal, filtration etc.</i>)						
Glomerular filtration,						
Renal circulation and autoregulation						
Tubular reabsorption & secretions,						
Mechanism of concertation of urine,						
Micturition						
Urinary incontinence						
Epidemiology of renal diseases						
Dietary requirements of patients suffering from renal diseases						
Psycho-social aspects of patients suffering from renal diseases						
Metabolism of protein and amino acids; urea cycle						
Metabolism of minerals: sodium, potassium, chloride and phosphate						
Personal and professional development: Study skills						
Total						

Lectures 01 hour (50 minutes approximately)

Practical/ Laboratory 02 hours

Tutorials/ small group discussions (SGD) 02 hours

A – Must know,

B – Should know,

C – Nice to know

L – Lecture,

SGD – Small group discussion,

SS – Self-study



Instructional Objectives of the module

Anatomy – Educational Objectives

Topic: Macroscopic structure of the kidney

Content area:

1. Structure of the kidney: cortex, medulla, pelvis and calyces (A)
2. Location of the kidney, borders, pole and contents (A)
3. Nephron (A)
4. Kidney – blood supply; relations; nerve supply; & lymphatic drainage (A)

Instructional Objectives:

- Describe the structure of the kidney
- Explain the position of the kidney and its relation to nearby organs and hilum
- Describe the structure of the nephron

Topic: Macroscopic structure of the ureter

Content area:

1. Ureter - structure, location of kinks, course, relations and blood supply (A)
2. Ureter - blood supply and nerve supply (A)

Instructional Objective:

- Describe the structure of the ureter and its course in relation to nearby viscera.
- Describe the blood supply of the ureter.
- Explain the clinical significance of the kinks.

Topic: Bladder & Suprarenal glands

Content area:

1. Structure of the bladder – relations, blood supply and nerve supply (A)
2. Structure of the suprarenal glands – location, microscopic structure, blood supply and nerve supply (A)

Instructional Objective:

- Describe the macroscopic structure of the bladder and its function.
- Describe the macroscopic and microscopic structure of the supra renal glands and their function.

Topic: Histology of Kidney, Ureter and Bladder

Content area

1. Microscopic structure of kidney, ureter and bladder (A)

Instructional Objective

- Describe the microscopic structure of the kidney, ureter and bladder in context of the epithelium present.



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Topic: Development of the urinary system and its abnormalities

Content area

1. Development of urinary system (kidney, ureter and bladder) (A)
2. Anomalies of the urinary system (A)

Instructional Objective

- Explain the development of urinary system and its anomalies.

Topic: Posterior abdominal wall and lumbar plexus

Content area

1. Posterior abdominal wall – vertebral column, blood supply, muscles, nerve supply (A)
2. Lumbar plexus – (A)

Instructional Objective:

- Describe the regulation of the gastrointestinal system.
- List the constituents of saliva and its function.

Topic: Radiological anatomy of the urinary tract

Content area

1. Radiological imaging techniques. E.g. x-ray and IVPs.

Instructional Objective

- Know the radiological morphology of the renal system (kidneys, ureters, bladder, urethra and adrenal glands).



Physiology – Educational objectives

Topic: Overview of the renal system and its function

Content area:

1. Endocrine function (Erythropoietin, Renin-angiotensin-aldosterone, 1,25 Dehydroxy corticosterone)
2. Electrolyte balance (N^{++} , K^+ & H^+)

Topic: Glomerular filtration

Content area:

1. Functional characteristics of glomerular membrane (A)
2. Factors effecting the rate of filtration - size and type of molecule, physical forces (A)
3. Autoregulation of Glomerular Filtration Rate (GFR) (A)
4. Measurement of GFR – inulin, creatinine clearance (A)
5. Measurement of renal blood flow - para amino hippuric acid (PAH) (A)

Instructional objective:

- Define glomerular filtration rate
- Explain how the functional characteristics of glomerular membrane (GM) are similar to those of an ultra-filter.
- Describe the effect of size and change of molecule effect the rate of filtration through GM,
- Explain how the GFR is auto regulated in terms of myogenic mechanism and tubule-glomerular balance.
- List the substances that are used to measure GFR.

Topic: Renal circulation and auto-regulation

Content area:

1. Renal blood flow and Renal plasma flow (A)
2. Clearance principle and role of Para amino hippuric acid (A)
3. Sympathetic stimulation's effect on Renal Plasma flow (A)

Instructional Objective:

- List the approximate values of the renal blood flow and renal plasma flow.
- Explain how the renal plasma flow can be estimated by the clearance principle.
- Describe the role of Para amino hippuric acid as a test substance in estimating renal clearance.
- Describe the effect of sympathetic stimulation on renal plasma flow.
- Describe the autoregulation of the renal blood flow.

Topic: Tubular reabsorption

Content area

1. Anions and cations reabsorption (Na^{++} , K^+ , Ca^+ & PO_4) (A)
2. Reabsorption of urea, glucose (A)
3. Mechanism of reabsorption (A)
4. Active and passive reabsorption (A)



Instructional Objective

- Describe the reabsorption of electrolytes (Na^{++} , K^+ , Ca^+ & PO_4) in different tubular segments,
- Describe the reabsorption of water, urea and glucose,
- Describe the reabsorption of active transport and cations that are actively reabsorbed,
- Describe the effect of GFR, aldosterone, atrial natriuretic factor and sodium load at distal tubules and rate of sodium reabsorption,
- Describe the characteristics of T_m limited reabsorption with specific reference to glucose,
- Describe the physical forces that operate to transfer fluid from the lateral clefts to the peritubular capillaries.

Topic: Tubular secretions

Content area

1. Secretion of endogenous substances and ions (creatinine, uric acid, K^+ & H^+) (A)
2. Formation of HCO_3 ion (A)

Instructional Objective

- Describe the mechanism of secretion of H^+ , K^+ ions,
- Explain how HCO_3 ion absorption is coupled with H^+ secretion,
- Explain the concept of formation of HCO_3 and control of H^+ ion secretion.

Topic: Mechanism of concentration of the urine

Content area

1. Filtered load (A)
2. Counter current multiplier system (A)
3. Antidiuretic hormone (A)
4. Pathophysiology of Syndrome of Inappropriate ADH (SIADH), Diabetes insipidus, nephrogenic diabetes insipidus. (B)

Instructional Objective

- Define filtered load and its average proportion of filtrate that is reabsorbed at each segment of the nephron,
- Explain how the renal medulla excrete concentrated urine in hyperosmolar state,
- Describe the role of ADH and counter current system in hyperosmolar state,
- Describe the counter current multiplier system of the loop of Henle,
- Describe the role of vasa recta in preserving the hyperosmolar state in renal medulla,
- Describe the role of ADH in urine concentration,
- Explain the physiological basis of Syndrome of Inappropriate ADH (SIADH), Diabetes insipidus, nephrogenic diabetes insipidus.

Topic: Micturition

Content area

1. Urinary bladder – functional anatomy and neural control (A)
2. Mechanism of bladder filling. (A)
3. Micturition abnormalities (autonomic vs automatic bladder) (B)

Instructional Objective



- Describe the functional anatomy of the urinary bladder,
- Explain the role of pressure-volume relationship during bladder filling,
- Discuss the role of neural control in bladder emptying – Spinal reflex and higher Central Nervous System (CNS) regulation,
- Explain the mechanism how anatomical and physiological abnormalities produce voiding difficulties.

Topic: Fluid and electrolyte balance

Content area

1. Normal distribution of body water and solutes in an adult (A)
2. External balance of water and electrolytes. (A)
3. Forces responsible for fluid and electrolyte exchange across the cellular membranes (A)

Instructional Objective

- List the approximate values for the distribution of body water and solutes in an adult.
- Describe the effect of age, sex and body fat on total body water when expressed as a percentage of body weight.
- Describe the forces responsible for fluid and electrolyte exchange across the cellular membranes.

Topic: Principles of acid-base balance

Content area

1. Regulation of pH of body fluids (A)
2. Buffer system/ defence mechanisms – Respiratory and Renal system (A)
3. Types of buffers (A)
4. Urine acidification (A)
5. Role of distal tubules in acid-base balance. (A)

Instructional Objectives

- Describe the importance of pH regulation of body fluids in relation to homeostasis,
- Explain how different defence mechanism help to regulate pH of body fluids and defence against H^+ ions,
- Define buffers and list different types of buffers,
- Explain how both kidneys and respiratory system help to contribute in the maintenance of acid-base balance.
- Discuss the role of HCO_3^- reabsorption and secretion of H^+ ions in maintenance of acid-base balance and regulation.
- Describe the role of distal tubule in adapting to the acidosis by excreting NaH_2PO_4 and ammonia ions.

Topic: Metabolic and respiratory acidosis/ alkalosis

Content area:

1. Metabolic and respiratory acidosis/ alkalosis – causes, compensatory mechanism
2. Respiratory and renal system compensation
3. Anion gap

Instructional objectives



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- List the causes of Metabolic and respiratory acidosis/ alkalosis,
- Explain the role/mechanism of action of renal and respiratory system in compensating for the above-mentioned states.
- Describe the anion gap and its clinical significance.

Topic: Renal function tests

Content area:

1. Blood tests: Blood Urea Nitrogen (BUN), Creatinine test, Calcium and Phosphate test (A) – hormonal tests will be covered in module 7.
2. Urine tests – Hormonal components will be covered in module 7: Endocrine system in detail. (C)
3. Arterial blood gases – Oxygen, carbon dioxide, pH (B)
4. Imaging/ Radiological tests (C)

Instructional Objective:

- Describe the purpose of the purpose of the above-mentioned tests in screening for diseased states and monitoring the function during diseased state.
- Discuss the specificity and sensitivity of each test.



Biochemistry – Educational objectives

Topic: Metabolism of ammonia

Content area

1. Degradation of proteins to amino acids (A)
2. Amino acids as non-proteinous nitrogen derivatives – metabolic degradation & catabolism (A)
3. Amino acid disorders (A)
4. Transamination and oxidative deamination (A)
5. Role of ketoacids (A)

Instructional Objective

- Outline biosynthesis of proteins and amino acids.

Topic: Metabolism of amino-acids

Content area

1. Degradation of proteins to amino acids (A)
2. Amino acids as non-proteinous nitrogen derivatives – metabolic degradation & catabolism (A)
3. Amino acid disorders (A)
4. Transamination and oxidative deamination (A)
5. Role of ketoacids (A)

Instructional Objective

- Describe the metabolism of phenylalanine and tyrosine and its metabolic disorders (A)
- Describe the metabolism of tryptophan and its abnormalities.
- Explain the interconversion of amino acids and synthesis of Non-Essential Amino acids (NEAA).
- Describe the metabolism of branched chain amino acids; catabolism of carbon skeleton of amino acids; catabolism of S. containing amino acids, Reaction of metabolism of amino acids deamination and transamination.

Topic: Urea cycle

Content area

1. Formation and transport of ammonia (A)
2. Urea cycle: Biochemical pathways, control points, enzyme deficiencies (A)

Instructional Objective

- Describe the clinical significance of the urea cycle,
- List the rate limiting steps of the urea cycle.
- List the factors that inhibits urea cycle.



Content area:

1. Metabolism of sodium, potassium, phosphate and chloride – Role, regulation, estimation and interpretation (**A**)
2. Hyponatremia, hypernatremia, hyper and hypokalaemia, (**B**)

Instructional objectives:

- Discuss the role of minerals such as sodium, potassium, chloride and phosphate in relation to renal functions,
- Describe the regulation of sodium, potassium, chloride and phosphate.

Isra University



Real Life incident 1 – Renal calculi

You have recently started studying the nephrology/ urology module. One day your uncle asks you to get doctor's appointment for one of his friend arriving from the Nawabshah and ask you to accompany him during the visit.

He arrives at Isra university hospital in the outpatient department. During the consultation, Dr Junaid asks him about his condition. He describes developing severe pain in the lower back, which radiates from right lion region to the groin. He labels the pain as colicky in nature and intermittent. The doctor suggests that he must see another doctor who is urologist and refer him to Dr Imran Memon.

You accompany him to the ward. After admission, he is prescribed a pain relieving medication and undergoes radiological (*X-ray KUB and abdominal ultrasound*) and blood tests. After interpreting the investigation, Dr Imran explains to your uncle's friend that he is suffering from renal calculi. The doctor discusses with patient the x-ray and ultrasound results, which indicates one big stone at the right renal calyces and one in the right ureter.

Reflection:

You return home and want to know

- How the patient presented with the symptoms and what caused the pain?
- How the renal stones are developed and how they can be prevented?
- You want to know the course of the ureter and common sites for stone formation.



Real Life incident 2 – Dialysis and Renal transplantation

You visit your friend's house to meet his father who is placed on renal transplantation list in the Sindh Institute of Urology and Transplantation (SIUT). He is notified to arrive at the hospital for pre-operative assessment. Previously, he had been going through the frequent invasive procedures where tubes are inserted into his left hand that are connected to a dialysis machine at a nearby hospital.

He describes how his condition has impacted his family's life. Especially, when he has to restrict his water intake as well and stick to low salt diet. You have been through the urology/nephrology module and are aware about all the topics mentioned above. You want to help your friend's dad with any relevant information to ease his concerns in a friendly chat.

He wants to know,

- Why he has to follow strict diet that is low in salt and specific protein diet with limited water intake?
- Why he had to undergo pre-assessment before the surgery and all point of blood and radiological tests since he had been done through them before?
- What will happen during transplantation?
- Whose donated organ he would be given?
- Will he have to undergo dialysis again?
- Will he need any medication after the transplantation?



Recommended and additional Reading for the module

Embryology:

Recommended reading

- Webster S & De Wreede R. (2012). **Embryology at a Glance**. John Wiley & Sons. (*pre-lecture reading*)
- Sadler, Thomas W. **Langman's medical embryology**. Wolters Kluwer Health, 2014. 13th edition

Additional reading

- Moore, Keith L., *et al.* **The developing human: clinically oriented embryology**. Philadelphia: *Saunders/Elsevier*, 2013 9th edition.
- **Snell's Clinical Embryology for medical students** (Latest Edition)

Histology

Recommended reading

- Peckham, M. (2011). **Histology at a Glance (Vol. 50)**. John Wiley & Sons. (*pre-lecture reading*)
- Fawcett, D. W., and R. P. Jensch. "**Bloom and Fawcett's Concise Histology 2nd.**" *Arnold-Hodder Headline Group*. London (2002): 1-360.

Additional reading:

- Junqueira, C. L., J. Carneiro, and R. O. Kelley. "**Basic histology.**" Basic histology (2013) 13th edition.
- Young, Barbara, ed. **Wheater's functional histology: a text and colour atlas**. Elsevier Health Sciences, 2014. 6th edition

Anatomy:

Recommended reading

- Faiz O, Blackburn S & Moffat D. (2011). **Anatomy at a Glance** (Vol. 66). John Wiley & Sons. (*pre-lecture reading*)
- Drake, Richard, A. Wayne Vogl, and Adam WM Mitchell. **Gray's anatomy for students**. Elsevier Health Sciences, 2015. 3rd edition.

Additional reading

- Moore, Keith L., Arthur F. Dalley, and Anne MR Agur. **Clinically oriented anatomy**. Wolters Kluwer Health, 2014. 7th edition.

Physiology:

Recommended reading

- Ward, J. P., & Linden, R. W. (2013). **Physiology at a Glance**. John Wiley & Sons. (*pre-lecture reading*)
- Sherwood L, **Human Physiology: From cells to systems** *West Publishing Company*, New York. 7th edition.



Additional reading

- Ganong's **Review of Medical Physiology**. *Lange Medical Publications* McGraw Hill
- Guyton, A.C., **Textbook of Medical Physiology**, Saunders, Philadelphia

Pathology

Recommended reading

- Finlayson, C. J., & Newell, B. A. (2009). **Pathology at a Glance**. Wiley-Blackwell. (*pre-lecture reading*)
- Kumar, Vinay, Abul K. Abbas, and Jon C. Aster, eds. **Robbins basic pathology**. *Elsevier Health Sciences*, 2012.

Clinical skills

Recommended reading

- **Macleod's Clinical Examination**. Edited by Douglas *et al.* 2009, 12th edition. Published by Churchill Livingstone, Elsevier. **The Cardiovascular system, pages: 106-151**

Community Medicine

Recommended reading

- Somerville, M., Kumaran, K., & Anderson, R. (2012). **Public health and epidemiology at a glance** (Vol. 72). John Wiley & Sons. (*pre-lecture reading*)
- Iliyas M *et al*, eds. **Public Health and Community Medicine**. *Time publishers*, 2007 7th edition.

Additional reading

- Park, K (2005) **Park's textbook of Preventive and Social Medicine**, 2007. *Bhanot Publication* 29th edition.
- Community Medicine for all, by Brigadier Iqbal Ahmed.
- Epidemiology by Hennekens.

Male and female students should refer to the main university library (or ask librarian) for interactive materials available in the form of Compact Discs (CDs).

Note: You are requested to read the latest edition available.

All students are informed to come prepared for the lectures after reading the "at a glance" series mentioned in the recommended books. After the lectures, students are suggested to read the recommended textbook. The faculty members will provide the page numbers for the topics covered at the end of the lecture or an activity.



Module 6: Urinary system

Medical Education Department

Module 6 team:

Anatomy

Prof. Dr. Zaheer Memon
Dr. Shaukat Memon
Dr Syna Amir
Dr. Aftab Abbasi
Dr. Jahanzeb

Physiology

Prof. Dr. Navaid Kazi
Dr. Haji Khan Koharo
Dr Abroo Kazi
Dr. Yaar Mohammad Nizamani

Biochemistry

Prof. Dr. Maria Kazi
Dr. Hina Khanzada
Dr. Ruby
Dr. Sheeraz

Medical Education

Dr Kabir Dherwani

Year coordinator

Dr. Yaar Mohamad Nizamani

Timetable

Available online

Academic Calendar 2020

Available online