



# *RENAL MODULE*

MBBS Year-2 (Academic Year 2019-2020)

*KMU Central Curriculum Committee*

*Khyber Medical University, Phase V, Hayatabad | Peshawar*

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## List of Themes

<b>Theme No.</b>	<b>Theme Name</b>	<b>Duration</b>
1	Flank Pain /Loin Pain	1 week
3	Scanty Urine /Urinary retention and Edema	1 week
2	Urinary Incontinence	1 week

## Theme-1 Loin pain/ Flank Pain

Subject	Topic	Learning objectives
<b>Gross anatomy</b>	1. Overview of the urinary system	1. List and describe the main components of the urinary system
	2. Kidneys	2. Discuss the location, anatomical structure, and relations of right and left kidneys to other abdominal organs 3. Discuss the gross morphological composition of kidneys <ul style="list-style-type: none"> <li>• Capsule</li> <li>• Pericapsular adipose tissue</li> <li>• Cortex</li> <li>• Medulla</li> <li>• Pelvis</li> <li>• Hilum</li> <li>• Vascular system within kidneys</li> <li>• Arterial supply</li> <li>• Venous drainage</li> <li>• Lymphatic's</li> <li>• Innervation</li> </ul> 4. Enumerate the various coverings of the kidney 5. Explain the clinical significance of coverings of the kidneys 6. Describe the structures entering and leaving the hilum of kidney and their relations
	3. Posterior abdominal wall	7. Describe the general features of lumbar vertebrae
		8. Describe the special features of lumbar vertebrae
		9. Enlist the muscles of posterior abdominal wall. Describe their origin, insertion, nerve supply and actions
		10. Explain the course and relations of Abdominal Aorta
		11. Enumerate and elaborate the paired branches of abdominal aorta
		12. Discuss the formation of inferior vena cava

<b>Embryology</b>	4. Development of the urinary system	13. Trace the embryological origins and development of the urinary system
	5. Congenital anomalies of the urinary system	14. List and describe the common congenital anomalies of kidney and ureter.
<b>Histology</b>	6. Kidney	15. Describe the parenchyma of kidney 16. Enlist different components of uriniferous tubules 17. Describe Histological features of the various components of Nephron 18. Describe the histological features of renal corpuscle 19. Describe filtration barrier 20. Describe the parts of collecting tubules 21. Describe the microscopic anatomy of collecting duct 22. Enlist the components of juxtaglomerular apparatus
<b>Physiology</b>	7. Physiological Anatomy Of the kidneys and Overview of its Functions	23. States major functions of the kidneys & brief physiological anatomy of kidney.
		24. Define the components of the nephron and their interrelationships: renal corpuscle, glomerulus, nephron, and collecting-duct system.
		25. Draw the relationship between glomerulus, Bowman's capsule, and the proximal tubule.
		26. Describe the 3 layers separating the lumen of the glomerular capillaries and Bowman's space; defines podocytes, foot processes, and slit diaphragms.
		27. Define glomerular mesangial cells and states their functions and

		location within the glomerulus. Detail of renal vessels & Pressure within them. Describe, in general terms, the differences among superficial cortical, midcortical, and juxtamedullary nephrons.
		28. List the individual tubular segments in order; states the segments that comprise the proximal tubule, Henle's loop, and the collecting-duct system; defines principal cells and intercalated cells.
		29. Define juxtaglomerular apparatus and describes its 3 cell types; states the function of the granular cells.
		30. Define the basic renal processes: glomerular filtration, tubular reabsorption, and tubular secretion
	8.Glomerular Filtration: Determinants and Equation	31. Describe how molecular size and electrical charge determine filterability of plasma solutes; states how protein binding of a low-molecular-weight substance influences its filterability.
		32. State the formula for the determinants of glomerular filtration rate, and states, in qualitative terms why the net filtration pressure is positive.
		33. Define filtration coefficient and states how mesangial cells might alter the filtration coefficient; states the reason glomerular filtration rate is so large relative to filtration across other capillaries in the body.
		34. Describe how arterial pressure, afferent arteriolar resistance, and efferent arteriolar resistance influence glomerular capillary pressure.
		35. Describe how changes in renal plasma flow influence average glomerular capillary oncotic pressure.

		36. State the Starling forces involved in capillary filtration.
		37. State how changes in each Starling force affect glomerular filtration rate
	9.Nervous & Hormonal Control of Renal Circulation	38. Define renal blood flow, renal plasma flow, glomerular filtration rate, and filtration fraction, and gives normal values.
		39. State the formula relating flow, pressure, and resistance in an organ.
		40. Describe sympathetic nerve supply of renal vessels & hormones affecting renal vessels
		41. Describe the effects of changes in afferent and efferent arteriolar resistances on renal blood flow
	10.Auto regulation of GFR and renal blood flow	42. Define auto regulation of renal blood flow and glomerular filtration rate
		43. Describe the myogenic and tubuloglomerular feedback mechanisms of auto regulation.
	11.Review of Transport Mechanisms across the Cell Membrane(Active and Passive transport)	44. Define and state the major characteristics of diffusion, facilitated diffusion, primary active transport, secondary active transport (including symport and antiport) and endocytosis.
		45. Define osmolality and osmolarity, and states why osmolarity is commonly used to approximate osmolality.
		46. Describe what is meant by the expression "water follows the osmoles."
		47. Describe qualitatively the forces that determine movement of reabsorbed fluid from the interstitium into peritubular capillaries.
		48. Compare the Starling forces governing glomerular filtration with those governing peritubular capillary absorption.

		49. Compare and contrasts the concepts of $T_m$ and gradient-limited transport.
		50. Describe 3 processes that can produce bidirectional transport of a substance in a single tubular segment; states the consequences of pump-leak systems.
		51. Contrast "tight" and "leaky" epithelia.
<b>Biochemistry</b>	12. Acid-base balance & imbalance	52. Study the sources of Hydrogen Ion, pH & Anion Gap
		53. Describe Buffer Systems operating in the Body 54. Carbonic acid, protein, and phosphate buffer 55. Transporting acid and mitigating pH changes
		56. Describe Respiratory Regulation of Acid Base Balance
		57. Describe Renal Regulation of Acid Base Balance
		58. Describe Disorders of Acid Base Balance: their causes, mechanisms and compensations of Respiratory Acidosis & Alkalosis and Metabolic Acidosis & Alkalosis
<b>Pathology</b>	13. Smoky urine	59. List the common kidney symptoms 60. Discuss the pathophysiology of renal infections 61. Describe Symptoms associated with renal pathology 62. Classify renal diseases 63. Explain Pathophysiology of renal infections 64. Describe Treatment of chronic pyelonephritis
	14. Renal disorders	65. Define the terms Nephrotic syndrome, nephritic syndrome, Azotemia. 66. Enlist the Causes types of renal stones.



		67. Enlist the causes and describe the pathogenesis of urinary tract infection.
	15. Systemic disease affecting kidneys	68. Explain how systemic diseases can affect renal function 69. Systemic diseases affecting renal function - Diabetes - Cardiovascular disorders (hypertension, CHF) - Immunological disorders (SLE, glomerulonephritis) - Cancers (myeloma) - Hematological disorders (sickle cell anemia, HUS)

### Practical

<b>Anatomy</b>	16. Surface anatomy of the urinary system and radiology		70. Identify the gross anatomic features the kidneys, renal pelvis, ureter, urinary bladder and urethra 71. locate renal angle 72. Perform renal punch and its clinical significance 73. Develop Understanding of KUB 74. Identify different parts of urinary system on IVU
<b>Biochemistry</b>	17. Titrable acidity of urine		75. Find out PH of urine

## Theme-2 Edema and Urinary retention/ Scanty Urine

<b>Anatomy</b>	18.Ureters	76. Describe the gross anatomy of ureters
		77. Describe the relations of right ureter in males and females
		78. Describe the relations of left ureter in males and females
		79. Highlight the clinical significance of relations of right and left ureters in both sexes
		80. Discuss constrictions in ureter and their clinical relevance.
	19.Urinary bladder	81. Describe the gross structure of urinary bladder
		82. Discuss the Ligaments/supports.
		83. Discuss the blood supply and nerve supply of urinary bladder
		84. Discuss the relations of urinary bladder in males
	20.Prostate gland	85. Discuss the relations of urinary bladder in females
		86. Describe the structure of prostate gland
		87. Describe Lobes, capsule, relations and structures within prostate.
		88. Discuss the common problems resulting from abnormal growth of the prostate. Relate the symptoms to structures
	21.Urethra	89. Describe the gross anatomy of urethra
		90. Enlist the differences between male and female urethra
<b>Embryology</b>	22.Development of the urinary system (Kidney and Ureter)	91. Enlist the stages of development of kidneys
		92. Describe the formation of pronephric, mesonephric and metanephric kidneys
		93. Enumerate the derivatives of metanephricblastema and describe their development
		94. Enumerate the derivatives of metanephric diverticulum/ureteric bud
		95. Describe the changes in position and blood supply of kidneys during development
		96. Enlist the various types of developmental anomalies of kidneys along with their embryological causes
		97. Enlist the various types of developmental anomalies of ureters along with their embryological causes

	23.(Bladder and urethra)	<p>98. Describe the development of bladder</p> <p>99. Discuss the developmental anomalies of bladder</p> <p>100. Describe the development of male urethra</p> <p>101. Describe the development of prostate and bulbourethral glands</p> <p>102. Describe the development of female urethra</p> <p>103. Discuss the developmental anomalies of male and female urethra</p>
	24. Prostate gland	104. Describe Embryological development of prostate gland
	25. Congenital anomalies of the urinary system	105. List and describe the common congenital anomalies of of bladder and urethra.
<b>Histology</b>	26. Ureter	106. Describe the microscopic anatomy of ureter
	27. Bladder	107. Describe the histological features of urinary bladder
	28. Prostate	108. Describe the microscopic structure of prostate
	29. Urethra	109. Discuss the microscopic structure of male and female urethra
<b>Physiology</b>	30. Body fluid compartments	<p>110. List the body fluid compartments</p> <p>111. Recall the volumes of body fluid compartments</p> <p>112. Discuss the interplay in fluid volumes between different fluid compartments</p> <p>113. Describes principles of osmosis and osmotic pressure</p> <p>114. Discuss the interplay between various pressures</p> <p>115. Discuss principles of edema</p> <ul style="list-style-type: none"> <li>• Intracellular fluid compartment</li> <li>• Extracellular fluid compartment</li> <li>• Intravascular fluids</li> <li>• Blood</li> <li>• Plasma</li> <li>• Interstitial fluid</li> <li>• Constituents of intra- and extracellular fluid compartments</li> <li>• Calculating fluid volumes</li> <li>• Osmosis and osmotic fluid regulation</li> </ul>

	<p>31. Reabsorption /Secretion along Different Parts of the Nephron</p>	<p>116. List approximate percentages of sodium reabsorbed in major tubular segments.</p> <p>117. List approximate percentages of water reabsorbed in major tubular segments.</p> <p>118. Define the term <i>iso-osmotic volume</i> reabsorption.</p> <p>119. Describe proximal tubule sodium reabsorption, including the functions of the apical membrane sodium entry mechanisms and the basolateral sodium-potassium-adenosine triphosphatase.</p> <p>120. Explain why chloride reabsorption is coupled with sodium reabsorption, and lists the major pathways of proximal tubule chloride reabsorption.</p> <p>121. State the maximum and minimum values of urine osmolality.</p> <p>122. Define osmotic diuresis and water diuresis.</p> <p>123. Explain why there is an obligatory water loss.</p> <p>124. Describe the handling of sodium by the descending and ascending limbs, distal tubule, and collecting-duct system.</p> <p>125. Describe the role of sodium-potassium-2 chloride symporters in the thick ascending limb.</p> <p>126. Describe the handling of water by descending and ascending limbs, distal tubule, and collecting-duct system</p>
	<p>32.mechanisms of regulation of tubular reabsorption</p>	<p>127. Discuss the mechanisms of regulation of tubular reabsorption</p> <ul style="list-style-type: none"> <li>•Reabsorption and secretion by the renal tubules</li> <li>•Active and passive transport mechanisms</li> <li>•Mechanism of reabsorption of specific substances (eg. Water, electrolytes)</li> <li>•Reabsorption and secretion in different parts of the tubules</li> <li>•Glomerular balance</li> <li>•Peritubular and renal interstitial fluid physical forces</li> <li>•Effect of arterial pressure on urine output</li> <li>•Hormonal control of tubular reabsorption</li> <li>•Aldosterone</li> <li>•Angiotensin-II</li> <li>•ADH</li> <li>•Parathyroid hormone</li> <li>•Nervous regulation of tubular reabsorption</li> </ul>

	<p>33. Concept Of Renal Clearance</p>	<p>128. Define the terms clearance and metabolic clearance rate, and differentiates between general clearance and renal clearance.</p> <p>129. List the information required for clearance calculation</p> <p>130. State the criteria that must be met for a substance so that its clearance can be used as a measure of glomerular filtration rate; states which substances are used to measure glomerular filtration rate and effective renal plasma flow.</p> <p>131. Predict whether a substance undergoes net reabsorption or net secretion by comparing its clearance with that of inulin or by comparing its rate of filtration with its rate of excretion.</p> <p>132. Calculate net rate of reabsorption or secretion for any substance.</p> <p>133. Calculate fractional excretion of any substance.</p> <p>134. Describe how to estimate glomerular filtration rate from <math>C_{Cr}</math> and describes the limitations.</p> <p>135. Describe how to use plasma concentrations of urea and creatinine as indicators of changes in glomerular filtration rate.</p>
	<p>34. Mechanism of diluted urine formation</p>	<p>136. Describe the process of "separating salt from water" and how this permits excretion of either concentrated or dilute urine.</p> <p>137. Describe how antidiuretic hormone affects water reabsorption.</p> <p>138. Describe the characteristics of the medullary osmotic gradient.</p> <p>139. Explain the role of the thick ascending limb, urea recycling, and medullary blood flow in generating the medullary osmotic gradient.</p> <p>140. State why the medullary osmotic gradient is partially "washed out" during a water diuresis</p> <p>141. Describe the origin of antidiuretic hormone and the 2 major reflex controls of its secretion; define diabetes insipidus; state the effect of antidiuretic hormone on arterioles.</p> <p>142. Distinguish between the reflex changes that occur when an individual has suffered iso-osmotic fluid loss because of diarrhoea as opposed to a pure</p>

		<p>water loss (ie, solute-water loss as opposed to pure-water loss).</p> <p>143. Describe the control of thirst.</p> <p>144. Describe the pathways by which sodium and water excretion are altered in response to sweating, diarrhoea, haemorrhage, high-salt diet, and low-salt diet.</p>
	35.Mechanism of concentrated urine formation	145. Discuss the mechanism of concentrated urine formation.
	36. Renal regulation of Potassium	<p>146. State the normal balance and distribution of potassium within different body compartments, including cells and extracellular fluid.</p> <p>147. Describe how potassium moves between cells and the extracellular fluid, and how, on a short-term basis, the movement protects the extracellular fluid from large changes in potassium concentration.</p> <p>148. Describe how plasma levels of potassium do not always reflect the status of total-body potassium.</p> <p>149. State generalizations about renal potassium handling for persons on high- or low-potassium diets.</p> <p>150. State the relative amounts of potassium reabsorbed by the proximal tubule and thick ascending limb of Henle's loop regardless of the state of potassium intake.</p> <p>151. Describe how the cortical collecting duct can manifest net secretion or reabsorption; describes the role of principal cells and intercalated cells in these processes.</p> <p>152. List the 3 inputs that control the rate of potassium secretion by the cortical collecting duct.</p> <p>153. Describe the mechanism by which changes in potassium balance influence aldosterone secretion.</p> <p>154. State the effects of most diuretic drugs and osmotic diuretics on potassium excretion.</p> <p>155. Describe the association between perturbations in acid-base status and the plasma potassium level</p>
	37.The prostate	156. Discuss the physiological functions of the prostate
	38.physiochemical aspects	157. Discuss the physiochemical aspects (Diffusion, Adsorption, Viscosity, Colloid Osmotic pressure and role of Albumin in regulation of Osmotic pressure)

	<p>39.Regulation of extracellular fluid osmolality and sodium concentration</p>	<p>158. Discuss the homeostatic function of the kidneys          159. Explain the mechanism by which kidneys are able to form diluted or concentrated urine          160. Describe Mechanism of formation of dilute urine          161. Describe Mechanism of formation of concentrated urine          162. Describe requirements for excreting a concentrated urine          163. Describe the counter-current mechanism          164. Describe Role of distal tubules and collecting ducts          165. Describe Quantifying urine concentration and dilution          166. Describe Disorders of urine concentration ability</p>
	<p>40.Regulation of extracellular fluid osmolarity and sodium concentration-2</p>	<p>167. Discuss the homeostatic function of the kidneys          168. Discuss the principles of osmoregulation by the kidneys          169. Explain how the body regulated the osmolarity of fluid compartments          170. Describe Control of extracellular fluid osmolarity and sodium concentration          171. Describe Osmoreceptor-ADH feedback system          172. Describe Role of thirst in controlling extracellular fluid osmolarity and concentration          173. Describe Salt-appetite mechanism and Integrated response to sodium intake</p>
	<p>41.Regulation of concentration of potassium, calcium, phosphate and magnesium</p>	<p>174. Discuss the mechanisms of regulation of concentrations of various ions in the body          175. Describe the processes occurring at cellular level to maintain/excrete various ions in the kidneys          -Regulation of potassium          --Regulation of calcium          -Regulation of phosphate          -Regulation of magnesium</p>

	42.Short and Long term control of Blood pressure by Kidneys	<p>176. Describe the 3 temporal domains of blood pressure control and the major mechanisms associated with them.</p> <p>177. Describe the relationship between renin and angiotensin II.</p> <p>178. Describe the 3 detectors that can alter renin secretion.</p> <p>179. Define pressure natriuresis and diuresis.</p> <p>180. Define tubuloglomerular feedback and describe the mechanism for tubuloglomerular feedback and auto regulation of glomerular filtration rate</p>
<b>Biochemistry</b>	43.Renal control of Calcium & Phosphorus	181. State the normal total plasma calcium concentration and the fraction that is free.
		182. Describe the distribution of calcium between bone and extracellular fluid and the role of bone in regulating extracellular calcium.
		183. Describe and compare osteocytes osteolysis and bone remodelling.
		184. Describe renal handling of phosphate.
		185. Describe how parathyroid hormone changes renal phosphate excretion.
	44.constituents of urine	186. Describe the normal and abnormal constituents of urine
<b>General Surgery/urology</b>	45.Urinary retention	187. Describe the etiology, and management of urinary retention
		188. Describe the etiology, clinical features and treatment of Benign prostatic hyperplasia
<b>Pathology</b>	46.Renal failure	<p>189. Enlist the causes of Renal failure/ uraemia and abnormalities related to micturition including incontinence</p> <p>190. Discuss the causes and pathophysiology of Chronic Renal failure</p>
	47.Urinary stones	191. Describe the pathophysiology of Urinary stones
	48.Glomerular diseases	192. Describe the etiology and pathogenesis of glomerulonephritis
	49.Classification of kidney disorders	193. Classify kidney disorders according to etiology, site of dysfunction and type of dysfunction - Acute/ chronic



		<ul style="list-style-type: none"> <li>-Infectious</li> <li>-Immunological</li> <li>-Neoplastic</li> <li>-Vascular/interstitial /parenchymal</li> <li>- Primary/systemic</li> </ul>
	50.Nephrotic syndrome	194. Describe Nephrotic syndrome and its etiology
<b>Pharmacology</b>	51.Nephrotoxic drugs	195. Describe the mechanism of drug excretion
		196. Enlist nephrotoxic drugs
		197. Describe the mechanism of action of diuretic drugs
	52.Drugs acting on the renal system (in NW module it's in theme of Scanty Urine)	198. Classify diuretics
<b>Community Medicine/Public Health</b>	53.Quality of life in problems of prostate	<p>199. Discuss quality of life issues in patients with prostate problems</p> <p>200. Overview of the concept of quality of life (QoL)</p> <p>201. Discuss the significance of quality of life in disease and treatment settings</p> <p>202. Discuss quality of life issues in geriatric population</p>
<b>Practical</b>		
<b>Physiology</b>	54.Intake output chart maintenance in bed ridden patients	203. Maintain Intake output chart maintenance in bed ridden patients
	55.Catheter insertion	204. Perform insertion of catheter on dummy

<b>Biochemistry</b>	56.Urine analysis	205. Determine the normal/abnormal constituents in the urine  -Urine sugar -Amino acids -Proteins -Hemoglobin -Uric acid -Urea -Creatinine and chloride -Calcium and phosphate -Ammonia -Ketone bodies -Benzidine test for blood in urine
<h3>Theme-3 Urinary incontinence</h3>		
<b>Anatomy</b>	57.The Perineum	206. Define the pelvis and the perineum Discuss the openings in the pelvis and what passes through them  207. List and describe the contents of the urogenital triangle -Contents of the male urogenital triangle -Urethral injuries  208. Injury to the perineum in childhood
<b>Physiology</b>	58.Urinary bladder and micturition	209. Describe the functional anatomy of urinary bladder  210. Explain the mechanism of micturition 211. Explain the micturition reflex and relate structures of the bladder with function 212. Explain basal cystometrogram 213. Describe the nervous control of bladder functions
	59.Urinary incontinence	214. Discuss the causes, symptoms and management of patients with urinary incontinence, urgency, frequency, burning micturition etc  215. Causes of urinary incontinence, urgency, frequency, burning micturition

		<p>216. Terms related to urinary obstruction and incontinence</p> <p>217. Describe Clinical presentation of continence disorders</p> <p>218. Explain General management of incontinence</p>
<b>Biochemistry</b>	60. Water balance/metabolism	<p>219. Mechanism &amp; regulation of Water balance</p> <p>220. Disorders of water balance, such as dehydration &amp; over hydration</p> <p>221. Electrolytes (intracellular &amp; extracellular cations) &amp; its metabolism</p> <p>222. Disorders of electrolyte metabolism</p>
<b>Radiology</b>	61. Radiological diagnosis of urinary pathologies	<p>223. Identify and describe the various anatomic landmarks of the renal system on radiographs</p> <p>224. Discuss special radiological tests to determine renal function and pathologies</p> <p>225. Describe normal radiographs of abdomen and pelvis</p> <p>226. Describe special radiological tests to show renal pathology and function</p> <p>227. Abdominal ultrasound</p>
<b>Clinical (Nephrology/ Medicine)</b>	62. Dialysis	<p>228. Describe the types, indications and the process of dialysis for kidney disease</p> <p>229. Describe Types of dialysis                      -Peritoneal dialysis                      -Hemodialysis                      -Hemofiltration                      -Haemodiafiltration                      -Intestinal dialysis                      -indications for dialysis</p> <p>230. Discuss disorders of acid-base balance, electrolyte abnormalities uremia or fluid overload resulting from acute and chronic renal failure, and intoxication</p> <p>231. Describe The process of hemodialysis and peritoneal dialysis</p> <p>232. Describe Dialyzable substances</p>
Clinical (Nephrology/ Medicine)	63. Patient with excessive urination	<p>233. Discuss the disorders associated with urine concentrating ability</p> <p>234. Plan a line of investigation and management in renal disorders</p>

		<p>235. Disorders of renal concentration ability</p> <p>236. Comparison of excessive urine volume with increased frequency of micturition</p> <p>237. Describe the mechanism of secretion and action of ADH</p> <p>238. Describe Urine concentrating ability of the various parts of the nephron Proximal convoluted tubule Descending limb of loop of Henle Ascending limb of loop of Henle Collecting system</p>
Clinical (Nephrology/ Medicine)	64. Patient with continuous dribbling of urine	<p>239. Discuss the causes of urinary incontinence</p> <p>240. Discuss the significance of radiological investigations in cases of urinary incontinence in children</p> <p>241. Define and describe Enuresis, its causes and treatment</p> <p>242. Describe Causes of urinary incontinence</p> <p>243. Describe the micturition reflex</p> <p>244. Discuss Tests for investigating urinary incontinence</p>
<b>Pathology</b>	65. common pathologies of perineal region	<p>245. List and define the common pathologies of the perineal region</p> <p>246. Describe Urethral infection</p>
<b>Practical</b>		
<b>Anatomy</b>	66. surface anatomy of the perineum and radiology	<p>247. Identification of the various structures forming the perineum on models</p> <p>248. Identify the radiographic landmarks of the perineum</p>
	67. Histologic examination urinary system	<p>249. Identify the characteristic microscopic features of the urinary system</p> <ul style="list-style-type: none"> <li>-Kidney</li> <li>-Ureter</li> <li>-Urinary bladder</li> <li>-Urethra</li> </ul>

<b>Biochemistry</b>	68.Creatinine in urine	250. Estimation of creatinine in 24 hour urine sample
<b>Physiology</b>	69.Arterial blood-gas analysis	251. Arterial blood sampling 252. Analysis and interpretation of arterial blood gases