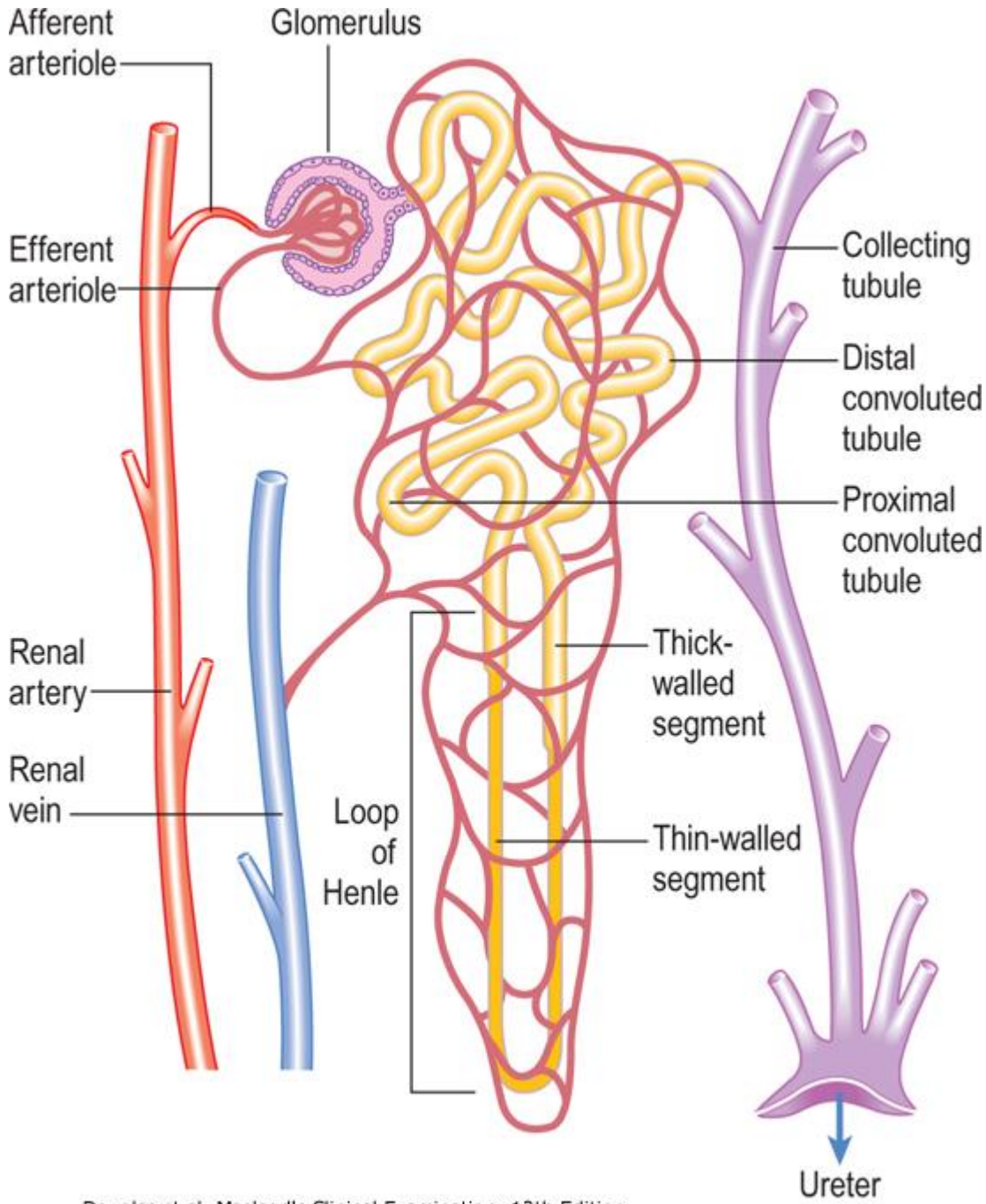
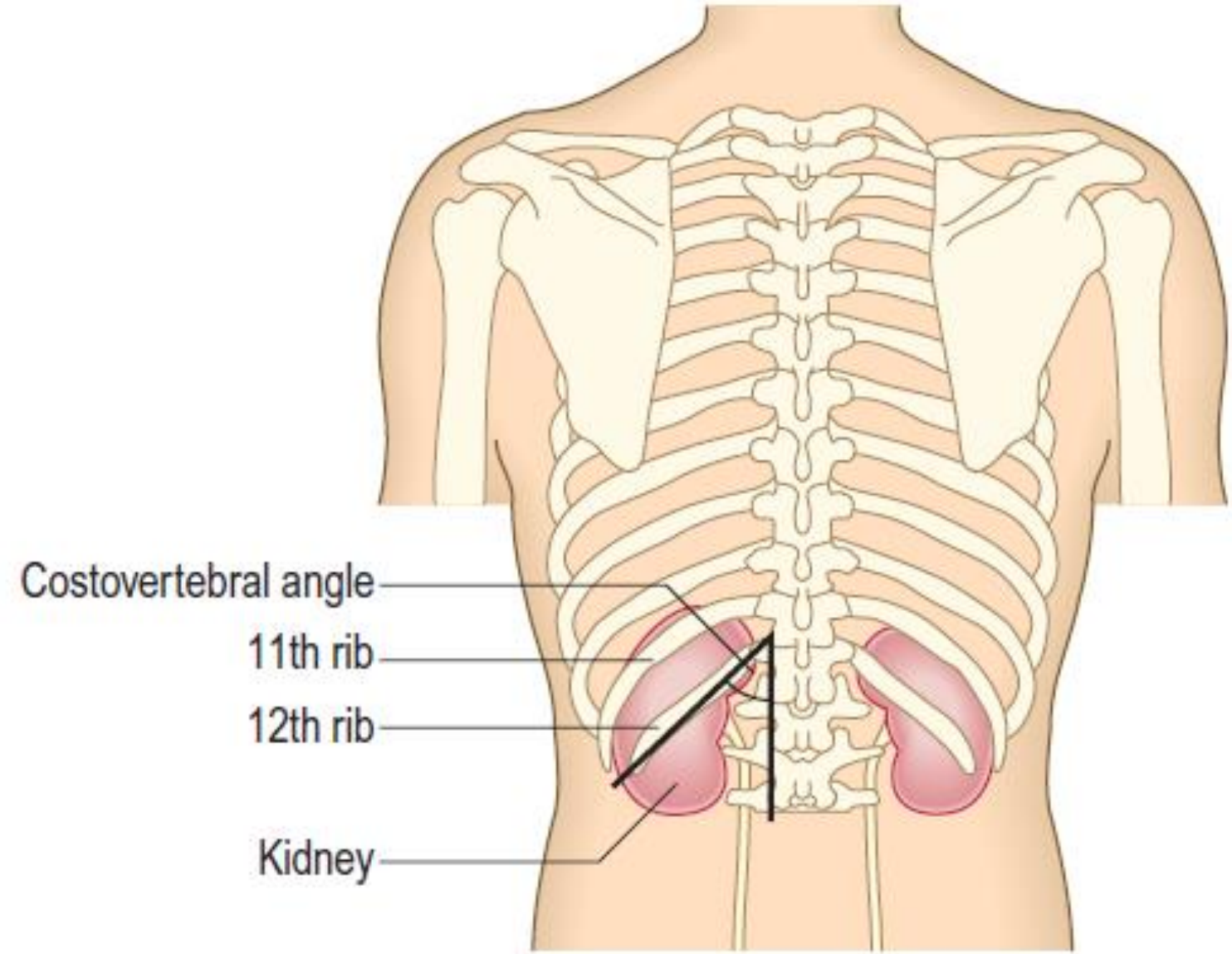
The Renal System

Anatomy

- Retroperitoneal , T12–L3 level and are 11–14 cm long.
- The right kidney lies 1.5 cm lower → **liver**.
- The kidneys move downwards during inspiration as the lungs expand.
- kidneys receive ~25% of cardiac output.
- Each kidney contains about one million nephrons.



Douglas et al: Macleod's Clinical Examination, 12th Edition.


Costovertebral angle
11th rib
12th rib
Kidney

Function

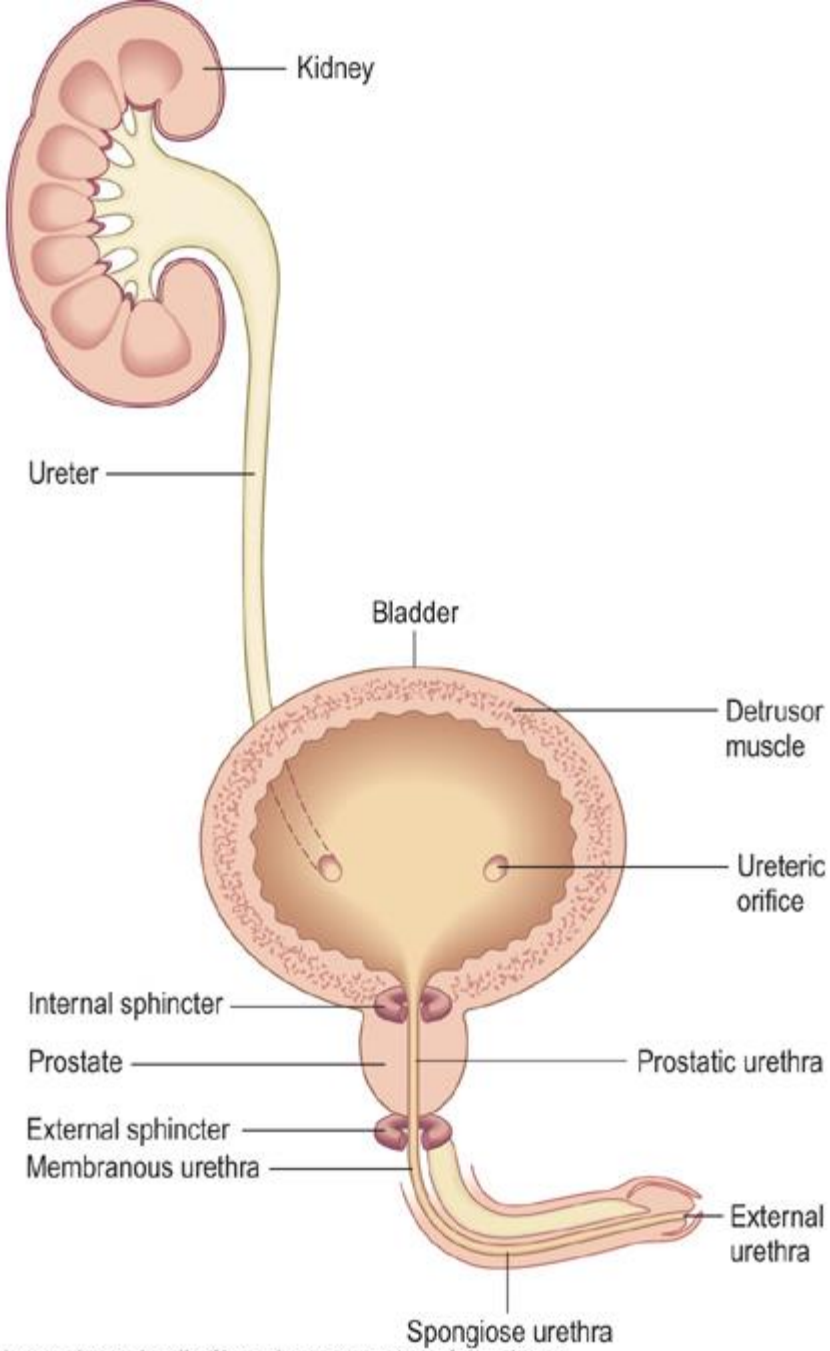
- **excretion** of waste products of metabolism
- maintaining salt, **water and electrolyte** homeostasis
- regulating **blood pressure** via the renin–angiotensin system
- **endocrine** functions related to **erythropoiesis** and **vitamin D** metabolism.

The **bladder** → reservoir. As it fills, it rises out of the pelvis in the midline towards the umbilicus.

The bladder wall contracts under parasympathetic control, allowing urine to pass through the urethra (micturition).

The conscious desire to micturate occurs when the bladder holds ~ **250–350** ml of urine.

Renal capsule and ureter are innervated by t8- l2 nerve root



Douglas et al: Macleod's Clinical Examination, 12th Edition.

Anatomy

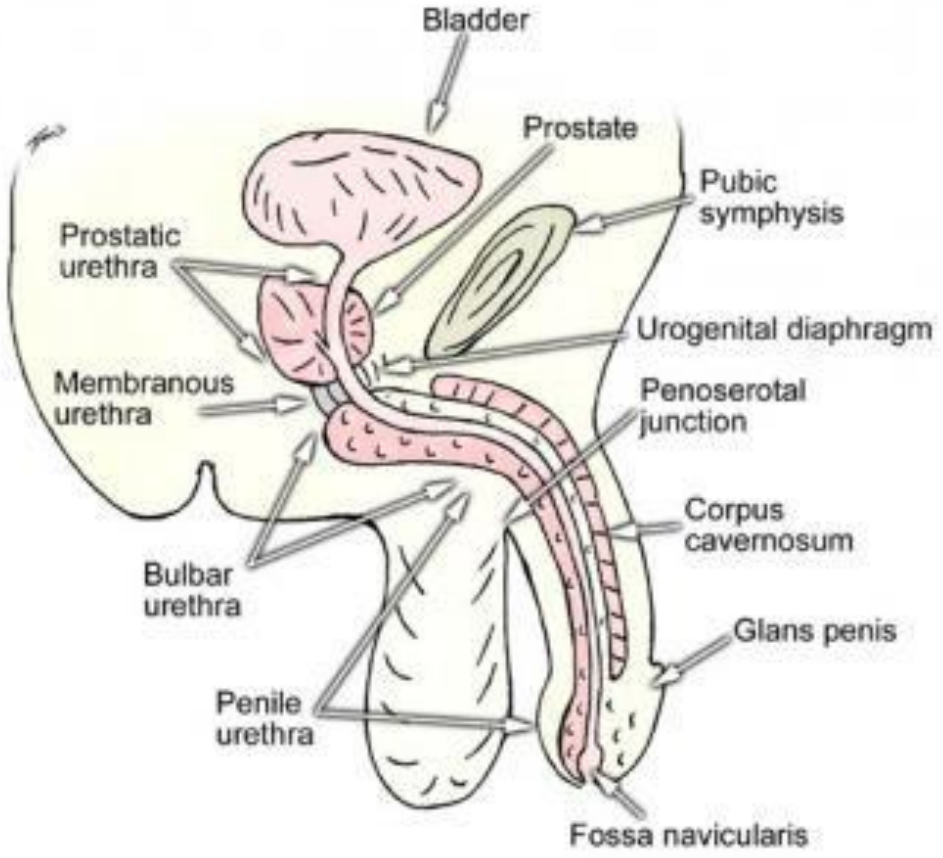
The male urethra runs from the bladder to the tip of the penis:

1. Prostatic urethra
2. Membranous
3. Bulbar
4. penile

- **The female urethra is much shorter.**

Two muscular rings acting as valves (sphincters) control micturition:

- The **internal sphincter** is at the bladder neck and is involuntary.
- The **external sphincter** surrounds the membranous s2-4



Symptoms and Definitions

- Severe renal disease may be **asymptomatic**, or have **nonspecific** symptoms, such as tiredness or breathlessness from renal failure or associated anemia. poor appetite, sleep disturbance, etc...

- **Growth retardation** is common with CKD in childhood.

- Detection often follows incidental testing of blood and urine.

- **Dysuria:** (voiding pain) is pain during or immediately after passing urine, often described as a ‘burning’ sensation felt at the urethral meatus.
- Ask about : associated symptoms(cystitis) /systemic symptoms(pyelonephritis)/ urine outflow obstruction symptoms/ sexual contacts
- Prostatitis may cause perineal and rectal pain at the same time.

Ureteric colic (‘renal colic’)

- **S**ite – unilateral, in the renal angle and flank area
- **O**nset – sudden
- **C**haracter – usually very severe and sustained, may vary cyclically in intensity
- **R**adiation – may radiate to the iliac fossa, the groin and the genitalia/ testes
- **A**ssociated features – patient is usually **restless** and nauseated, and often vomits
- **T**iming – may last for several hours.
- **E**xacerbating/relieving factors – analgesia
- **S**everity –often very severe .
- **S**imilar – distinguish from intestinal colic or biliary pain, appendicitis, torsion of an ovarian cyst, ruptured ectopic pregnancy.

Loin Pain

- **Renal angle** or **loin pain** is due to stretching of the renal capsule or renal pelvis → infection, inflammation or mechanical obstruction.
- **Constant** loin pain, with systemic upset, fever, rigors and pain on voiding, suggests upper UTI (acute pyelonephritis).
- **Chronic dull**, loin discomfort may occur with chronic renal infection and scarring from vesicoureteric reflux, adult polycystic kidney disease (APKD) or chronic urinary tract obstruction.

Voiding symptoms

Lower urinary tract symptoms may be:

- during the storage phase of micturition
- during the voiding phase of micturition
- incontinence

Storage symptoms

- **Frequency** is a desire to pass urine more often than usual >6times/day
- **Urgency** – a sudden strong need to pass urine.

Urgency is due to either overactivity in the detrusor muscle or abnormal stretch receptor activity from the bladder (sensory urgency).

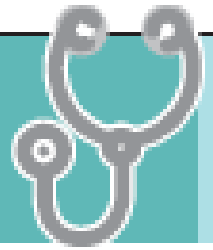
- **Nocturia** – waking one or more at night to void.

Storage symptoms are usually associated with bladder, prostate or urethral problems, e.g. **lower urinary tract infection**, **tumour, urinary stones or obstruction from prostatic enlargement**, or are a consequence of neurological disease.

Voiding phase symptoms

- **Hesitancy** is difficulty or delay in initiating urine flow.
- **Dribbling** and **incomplete** emptying are caused by bladder neck obstruction, but if they are associated with storage symptoms, may indicate abnormal detrusor function.
- **Poor stream**
- In men over 40 this is commonly due **to bladder outlet obstruction** by prostatic enlargement.

- In women these symptoms suggest urethral obstruction from stenosis or in association with genital prolapse.



9.2 Features of bladder outlet obstruction due to prostatic hyperplasia

- Slow flow
- Hesitancy
- Incomplete emptying (the need to pass urine again within a few minutes of micturition)
- Dribbling after micturition
- Frequency and nocturia (due to incomplete bladder emptying)
- A palpable bladder

Incontinence

- **urge incontinence** : Involuntary release of urine may occur with a need to void , occurs when the detrusor is overactive.
- **stress incontinence** : result from an increase in intra-abdominal pressure, occurs in women due to weakness of the pelvic floor, usually following childbirth.
- **mixed incontinence**: combination of both
- **Enuresis** is incontinence during sleep, and common in childhood. In adults it suggests bladder outlet obstruction or abnormalities of the wakening mechanism.

9.6 Causes of urinary incontinence

- Pelvic floor weakness following childbirth
- Pelvic surgery or radiotherapy
- Detrusor overactivity
- Bladder outlet obstruction
- Urinary tract infection
- Degenerative brain diseases and stroke
- Neurological diseases, e.g. multiple sclerosis
- Spinal cord damage

9.11 Urinary incontinence: points to cover in the history

- Age at onset and frequency of wetting
- Occurrence during sleep (enuresis)
- Any other urinary symptoms
- Provocative factors, e.g. coughing, sneezing, exercising
- Past medical, obstetric and surgical histories
- Number of pads used. Are they damp, wet or soaked?
- Impact on daily living

Abnormalities in urine volume and composition

- Healthy adults produce 2–3 litres of urine per day, equivalent to their fluid intake minus insensible fluid losses through the skin and respiratory tract (500– 800 ml/day).

Polyuria

- Polyuria is an abnormally large volume of urine, and is most commonly due to excessive fluid intake.

>3 L /day

- psychogenic polydipsia
- Polyuria also occurs when the kidneys cannot concentrate urine:

1. extrarenal, e.g. diuretic drugs; DM, DI, Addison's disease.
2. Renal causes : nephrogenic diabetes insipidus

Oliguria

- **<500 ml/day.** It may be appropriate with a very low fluid intake or mechanical obstruction , but may also indicate loss of kidney function.
- The minimum urine volume needed to excrete the daily solute load varies with diet, physical activity and metabolic rate, but is at least 500 ml/day.
- Acute renal failure is usually associated with oliguria .

Anuria

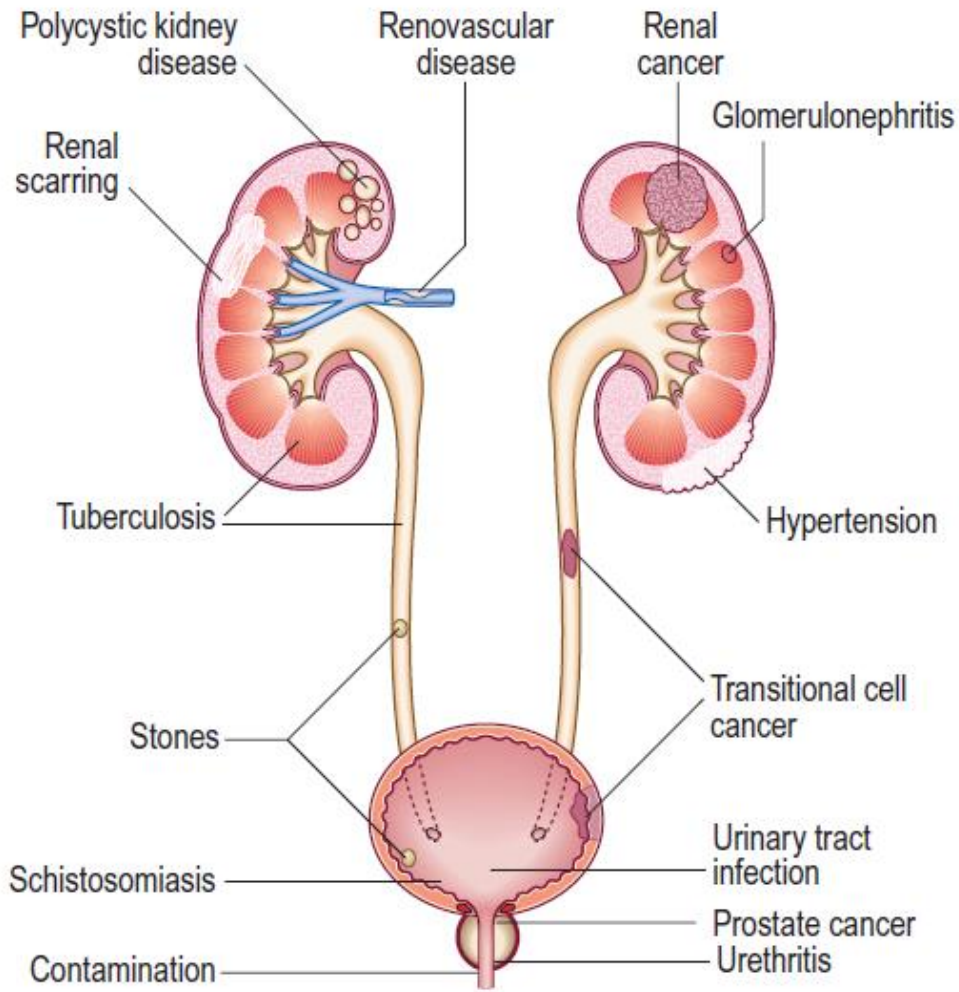
- Anuria is the total absence of urine production. **< 50 per day**
- **Exclude urinary tract obstruction**, which may be lower (bladder neck or urethral obstruction causing acute urinary retention) or upper, e.g. a ureteric stone in a patient with a single functioning kidney.

Pneumaturia

- passing gas bubbles in the urine, is rare.
- It may be associated with faecuria, when faeces are voided. It suggests a fistula between the bladder and the colon, from a diverticular abscess, cancer or Crohn’s disease.

Haematuria

- Non-visible haematuria occurs in renal or urinary tract disease, especially if associated with proteinuria, hypertension, raised serum creatinine or reduced estimated glomerular filtration rate.
- **Visible haematuria** may be due to urinary tract infection with its associated symptoms but should be investigated, if **painless**→ cancer of the kidney, bladder or prostate.
- **Investigate all patients >40 years with haematuria** (visible or non-visible).
- contamination of the urine by blood from the female genital tract during **menstruation**.
- Free haemoglobin in the urine due to haemolysis, myoglobin in rhabdomyolysis and other abnormalities of urine colour may mimic haematuria
- Ask about : loin pain ,lower urinary symptoms, family hx


Polycystic kidney disease
Renovascular disease
Renal cancer
Glomerulonephritis
Renal scarring
Tuberculosis
Hypertension
Stones
Transitional cell cancer
Urinary tract infection
Schistosomiasis
Prostate cancer
Urethritis
Contamination

9.7 Abnormalities of urine colour

Orange-brown

- Conjugated bilirubin
- Rhubarb, senna
- Concentrated normal urine, e.g. very low fluid intake
- Drugs: sulfasalazine

Red-brown

- Blood, myoglobin, free haemoglobin, porphyrins
- Beetroot, blackberries
- Drugs: rifampicin, rifabutin, clofazimine, entacapone

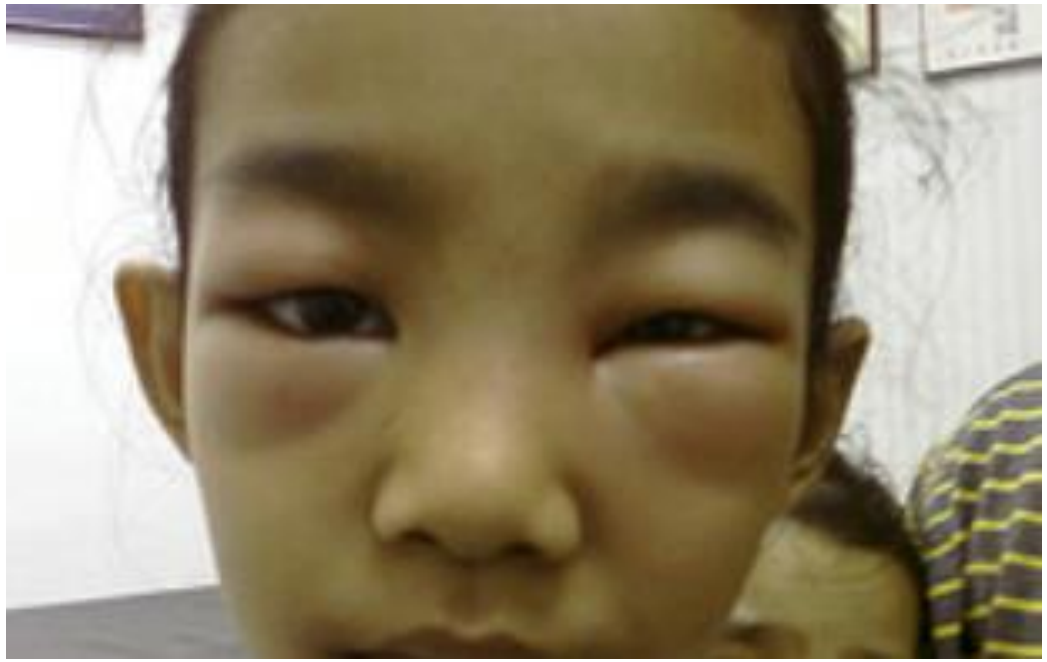
Brown-black

- Conjugated bilirubin
- Drugs: L-dopa, metronidazole, nitrofurantoin, chloroquine, primaquine
- Homogentisic acid (in alkaptonuria or ochronosis)

Blue-green

- Drugs/dyes, e.g. propofol, fluorescein, triamterene


Kidney Disease Symptoms
www.kidney-symptom.com



Proteinuria

- Proteinuria is excess protein in urine and indicates kidney disease.
- It is usually asymptomatic and detected by urinalysis
- most commonly glomerulonephritis or diabetic nephropathy.
- **>3.5 g/ day in adults or 1g/ m2/day in children → nephrotic syndrome**
- **More than 150 mg/day (Except children and pregnancy; 300 mg/d)**
- Proteinuria may occur in normal patients with febrile illness. Orthostatic proteinuria is proteinuria <1 g/l which disappears when lying down
- Severe proteinuria may produce frothy urine. May reduce the plasma oncotic pressure, the patient develops generalised oedema
- Ask about : wt loss , ankle swelling , sob , abdominal swelling

9.9 Causes of proteinuria

Renal disease

- Glomerulonephritis
- Diabetes mellitus
- Amyloidosis
- Systemic lupus erythematosus
- Drugs, e.g. gold, penicillamine
- Malignancy, e.g. myeloma
- Infection

Non-renal disease

- Fever
- Severe exertion
- Severe hypertension
- Burns
- Heart failure
- Orthostatic proteinuria*

*Occurs when a patient is upright but not lying down; the first morning sample will not show proteinuria.

9.10 Causes of transient proteinuria

- Cold exposure
- Vigorous exercise
- Febrile illness
- Abdominal surgery
- Heart failure

ACUTE KIDNEY INJURY

- Abrupt elevation in serum cr conc. Or a decrease in urine output
- It may have prerenal , renal and postrenal causes
- PRERENAL
- RENAL
- POSTRENAL

12.2 Causes of acute kidney injury

Prerenal

- Hypovolaemia (e.g. blood loss, diarrhoea, vomiting, diuresis, inadequate oral intake)
- Relative hypovolaemia (e.g. heart failure, nephrotic syndrome)
- Sepsis
- Drugs (e.g. antihypertensives, diuretics, non-steroidal anti-inflammatory drugs)
- Renal artery stenosis or occlusion
- Hepatorenal syndrome

Intrarenal

- Glomerular disease (e.g. systemic vasculitis, systemic lupus erythematosus, immunoglobulin A nephropathy)
- Interstitial nephritis (drug-induced)
- Acute tubular necrosis/injury (may follow a prerenal cause)
- Multiple myeloma
- Rhabdomyolysis
- Intrarenal crystal deposition (e.g. urate nephropathy, ethylene glycol poisoning)
- Thrombotic microangiopathy (e.g. haemolytic uraemic syndrome, scleroderma renal crisis)
- Accelerated-phase hypertension
- Cholesterol emboli

Postrenal

- Renal stones (in papilla, ureter or bladder)
- Papillary necrosis
- Ureteric or bladder transitional cell carcinoma
- Intra-abdominal or pelvic malignancy (e.g. cervical carcinoma)
- Retroperitoneal fibrosis
- Blood clot
- Bladder outflow obstruction (e.g. prostatic enlargement)
- Neurogenic bladder
- Urethral stricture
- Posterior urethral valves
- Iatrogenic (e.g. ureteric damage at surgery, blocked urethral catheter)

CHRONIC KIDNEY DISEASE

- Alteration in kidney function or structure for more than 3 months
- Look for underlying conditions that may explain the etiology of CKD:
- HTN , DM , VASCULAR D. (MI /PAD /STROKE) , HYPERLIPIDEMIA , EPISODES OF ACUTE GN , NEPHROTIC SYNDROME
- PROTEINUREA OR HAEMATUREA MAY SUGGEST A GLOMERULAR D,
- DETAILED FHX IS REQUIRED AS A NUMBER OF GENETIC DISEASES MAY PRESENT WITH CKD

END STAGE RENAL DISEASE AND URAEMIA

- Most commonly when the estimated GFR less than 10ml/min/1.73m2
- Poor conc , lethargy, anorexia ,n ,v pruritus , sob, pirephral edema
- Less commonly pericarditis and periphral neuropathy

DIALYSIS PATIENTS

- HAEMODIALYSIS : via arteriovenous fistula
- The fistula has an obvious thrill
- The most common problem here is infection

- PERITONEAL DIALYSIS :via a tunnelled catheter
- Infection is also common here

Past history

Ask about any previous history of renal system disease.

- **hypertension** (which may cause or result from renal disease)
- **diabetes mellitus** (associated with diabetic nephropathy and renovascular disease)
- vascular disease at other sites (which makes renovascular disease more likely)
- past history of urinary tract stones or surgery
- renal disease
- **recurrent infections** (particularly urinary infection which may be associated with renal scarring, and upper respiratory infections which may be associated with glomerulonephritis and/or vasculitis)
- **anaemia** (which may be due to CKD).

Drug history

- **Drugs which accumulate in renal failure**, such as digoxin, lithium, aminoglycosides, opioids and water soluble beta-blockers, e.g. atenolol.
- **Drugs which may affect renal function** include angiotensin-converting enzyme inhibitors, angiotensin receptor antagonists and NSAIDs.
- Aminoglycosides, amphotericin, lithium, ciclosporin, tacrolimus and, in overdose, paracetamol are **toxic to normal kidneys.**

Family history

- The most common inherited conditions are APKD (autosomal dominant) and Alport's syndrome (X-linked dominant) .
- APKD is associated with subarachnoid haemorrhage from intracranial berry aneurysms;
- Alport's syndrome is associated with high-tone sensorineural deafness.

9.12 Some hereditary and congenital conditions affecting the kidneys and urinary tract

Name	Principal findings	Commonly associated abnormalities	Most common form of inheritance
Adult polycystic kidney disease	Bilateral enlarged kidneys, sometimes massive, with nodular surface	Liver cysts Intracranial berry aneurysms Mitral or aortic valve abnormalities	Autosomal dominant
Alport's syndrome	Haematuria, proteinuria, renal failure	Nerve deafness Lens and retinal abnormalities	X-linked dominant
Medullary sponge kidney	Tubular dilatation; renal stones	Other congenital abnormalities, e.g. hemihypertrophy, cardiac valve abnormalities, Marfan's syndrome	Congenital, rarely familial
Nail–patella syndrome	Proteinuria Renal failure (30%)	Nail dysplasia, patellar dysplasia or aplasia	Autosomal dominant
Cystinosis	Tubular dysfunction; renal failure	Rickets, growth retardation, retinal depigmentation and visual impairment	Autosomal recessive
Tuberous sclerosis complex	Renal cysts Renal angiolipomata	Seizures, mental retardation, facial angiofibromata, retinal lesions	Autosomal dominant
Prune-belly syndrome	Dilated bladder and urinary tract; urinary infection and renal failure	Absent abdominal wall musculature	Sporadic mutation

Social history

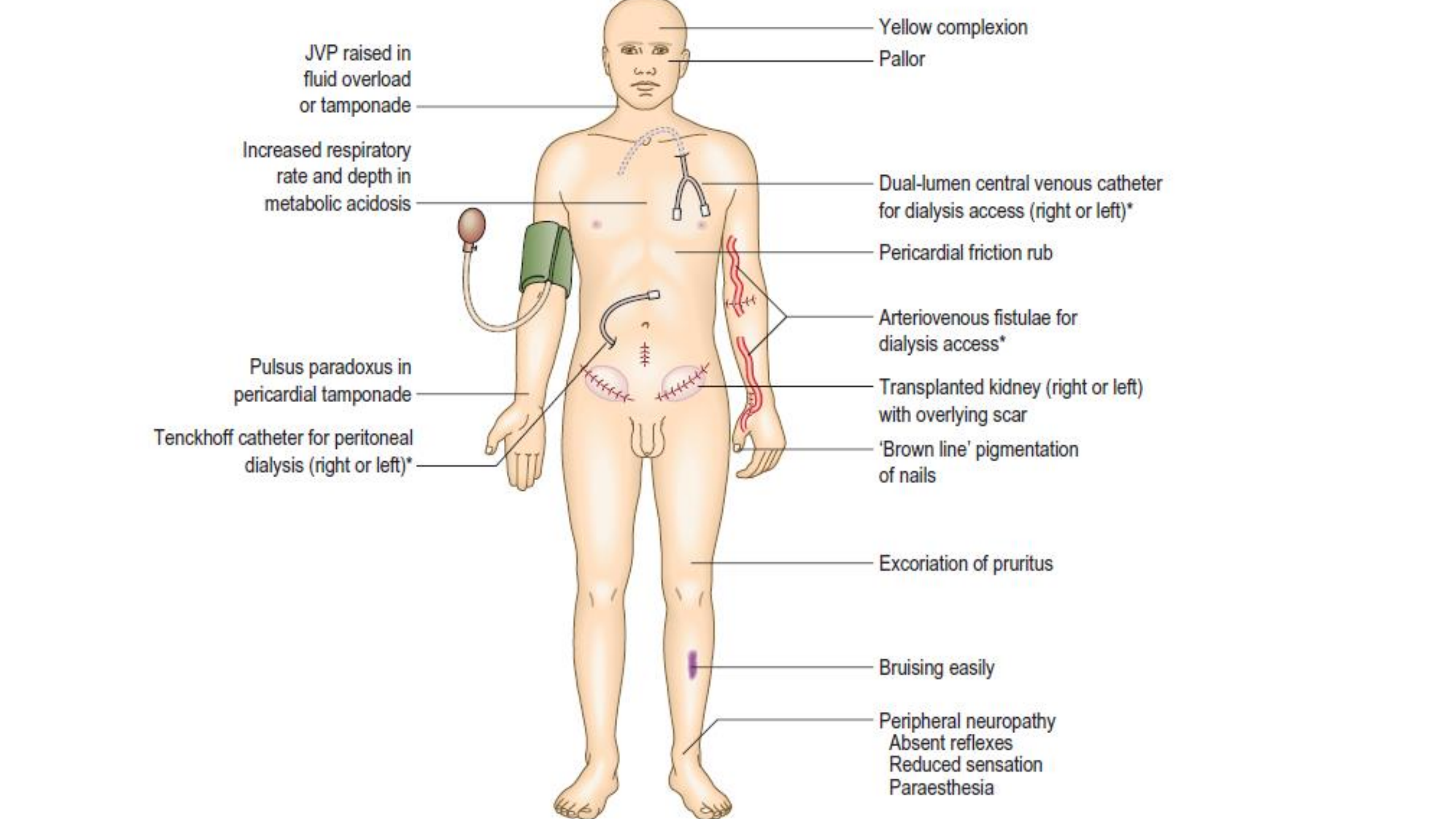
- **End-stage renal disease** requiring dialysis and/or transplantation has major implications for lifestyle, employment and relationships. Similarly
- **incontinence** has major implications for daily living.
- **Smoking**.
- Take a dietary history in patients with renal stones and patients with CKD.

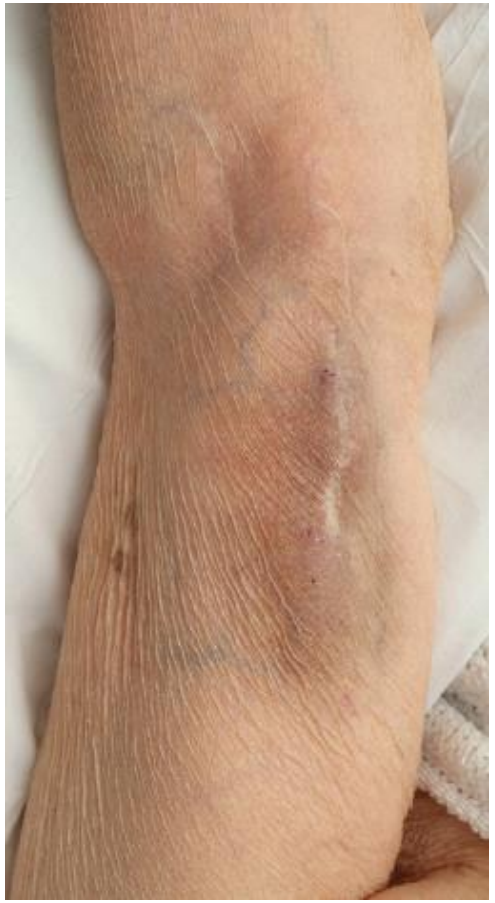
Occupational history

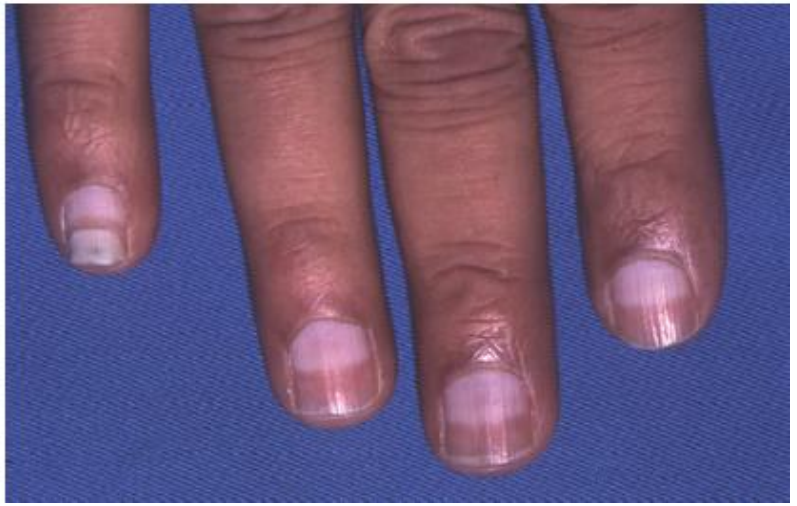
- Exposure to organic solvents may cause glomerulonephritis.
- **Aniline dye** and **rubber** workers have an increased incidence of urothelial cancer.
- Long term exposure to lead and cadmium may cause renal damage.

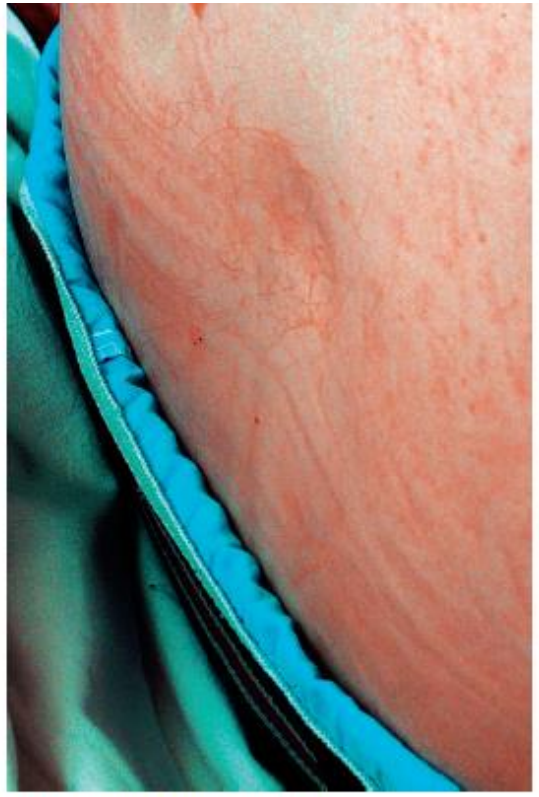
THE PHYSICAL EXAMINATION

- Physical examination may be normal, even with significant kidney disease

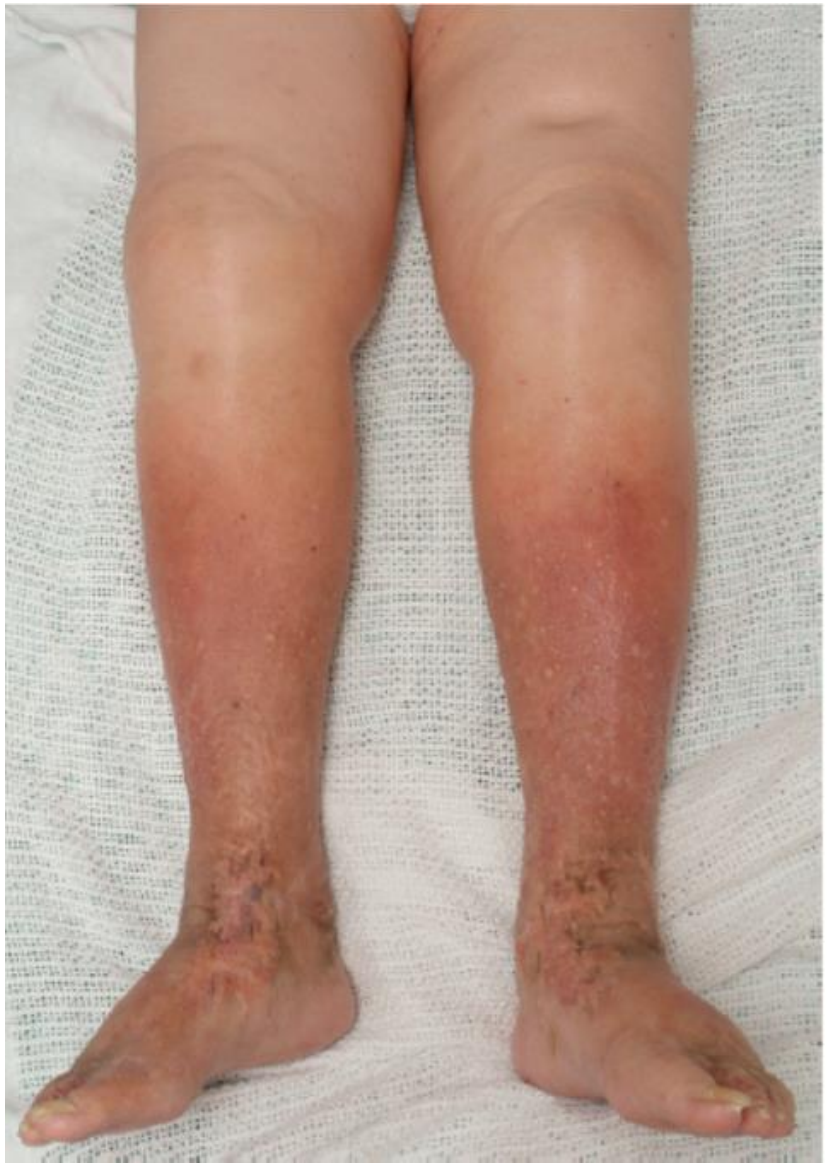

Yellow complexion
Pallor
JVP raised in fluid overload or tamponade
Increased respiratory rate and depth in metabolic acidosis
Dual-lumen central venous catheter for dialysis access (right or left)*
Pericardial friction rub
Arteriovenous fistulae for dialysis access*
Pulsus paradoxus in pericardial tamponade
Transplanted kidney (right or left) with overlying scar
Tenckhoff catheter for peritoneal dialysis (right or left)*
'Brown line' pigmentation of nails
Excoriation of pruritus
Bruising easily
Peripheral neuropathy
Absent reflexes
Reduced sensation
Paraesthesia







Sacral oedema showing pitting.



Examination sequence

Assess the patient's **general appearance** and conscious level.

- Look for fatigue, pallor, breathlessness, uraemic complexion, cushingoid appearance and hirsutism.
- Measure the temperature + vs (bp(+ postural) , hr
- Look at the eyes for anaemia.fundoscopy
- Note any bruising or excoriation.
- Examine the hands for nail changes, vasculitic rash
- Look for a coarse flapping tremor
- Smell the patient's breath for uraemic fetor.
- Assess **hydration** by checking skin turgor, eyeball tone, JVP and presence of oedema , dry mucus membrane , weight assessment , fluid balance chart

Abdominal examination

Inspection

■ Look for **distension** (from the enlarged kidneys of APKD,ascites ,and suprapubically from bladder distension.

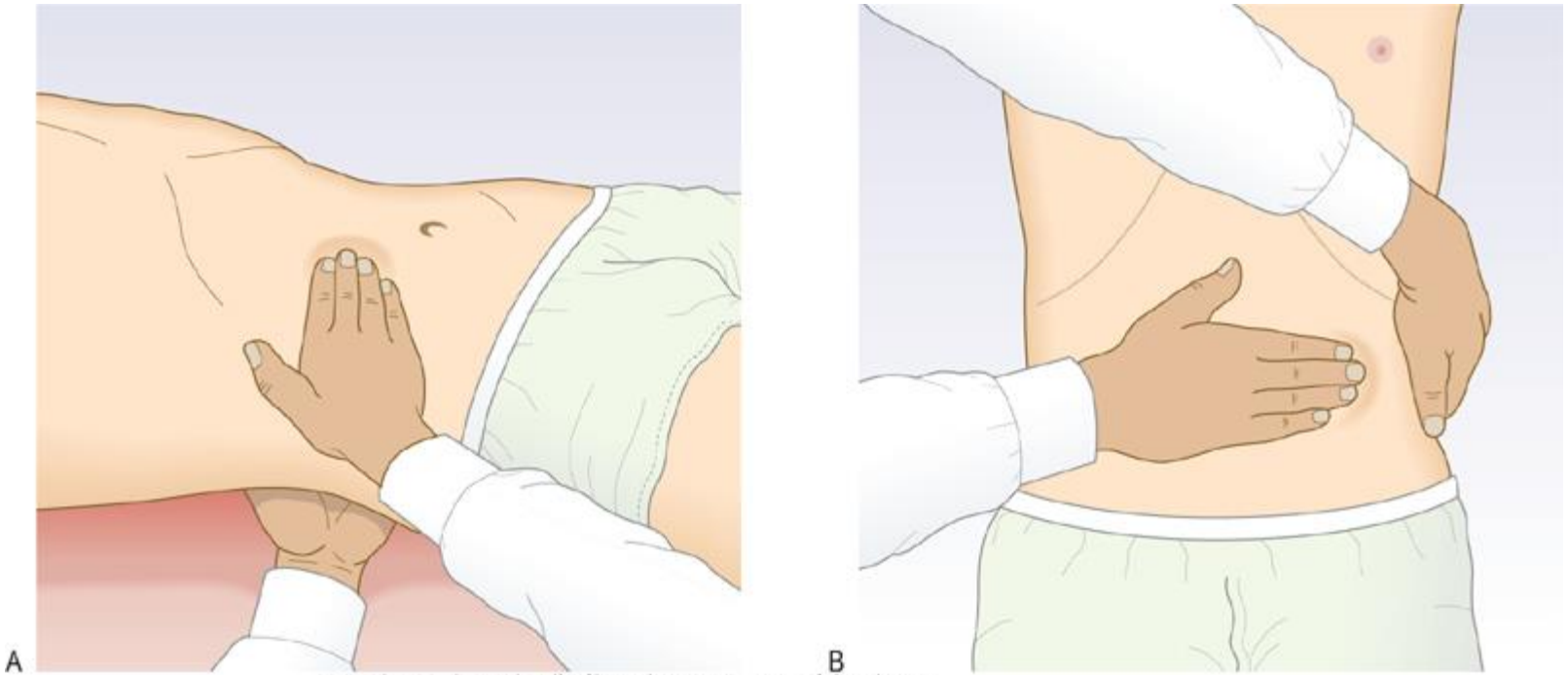
■ Look in the loins for **scars** of renal tract surgery and in the iliac

fossa for those of transplant surgery.

▪ You may see a catheter for peritoneal dialysis or small scars left by one in the midline and hypochondrium.

Palpation

- palpate the kidneys.
- If the kidney is palpable, assess its size, surface and consistency.
- Ask the patient to sit up. Palpate the renal angle



•Use the fingers of your right hand. Start in the right lower quadrant and palpate each area systematically A distended bladder is felt as a smooth firm mass arising from the pelvis which disappears after urethral catheterization. Polycystic kidneys have a distinctive nodular surface.

•

To detect lesser degrees of kidney enlargement, place your left hand behind the patient's back below the lower ribs and your right index finger against the 12th rib . Firmly, but gently, push your hands together as the patient breathes out. Ask the patient to breathe in deeply; feel for the lower pole of the kidney moving down between your hands. If this happens, gently push the kidney back and forwards between your two hands to demonstrate its mobility. This is ballotting, and confirms that this structure is the kidney.

•

Ask the patient to sit up. Palpate the renal angle firmly but gently. If this does not cause the patient discomfort, firmly (but with moderate force only!) strike the renal angle once with the ulnar aspect of your closed fist after warning the patient what to expect

Percussion

Percussion of the kidneys is unhelpful.

Enlarged kidney >> resonant

- **Percuss for the bladder** over a resonant area in the upper abdomen in the midline and then down towards the symphysis pubis.
- Test for **ascites**, which may be found in nephrotic syndrome or in patients having peritoneal dialysis.

Auscultation and...

- Auscultate for bruits arising from the **renal arteries**.
- Test for **ascites**, which may be found in nephrotic syndrome or in patients having peritoneal dialysis.
- In men examine the external genitalia and perform a **rectal examination to assess the prostate for benign or malignant change**.

Cardiovascular examination

Examination sequence

- Measure the pulse and blood pressure
- Assess the JVP
- Palpate the apex beat.
- Auscultate for:
  - Quiet heart sound
  - a mid-systolic ‘flow’ murmur
  - third or fourth heart sounds
  - pericardial friction rub.
- Look for pitting oedema in the ankles, the sacrum, and the back of the thighs in recumbent patients

Respiratory examination

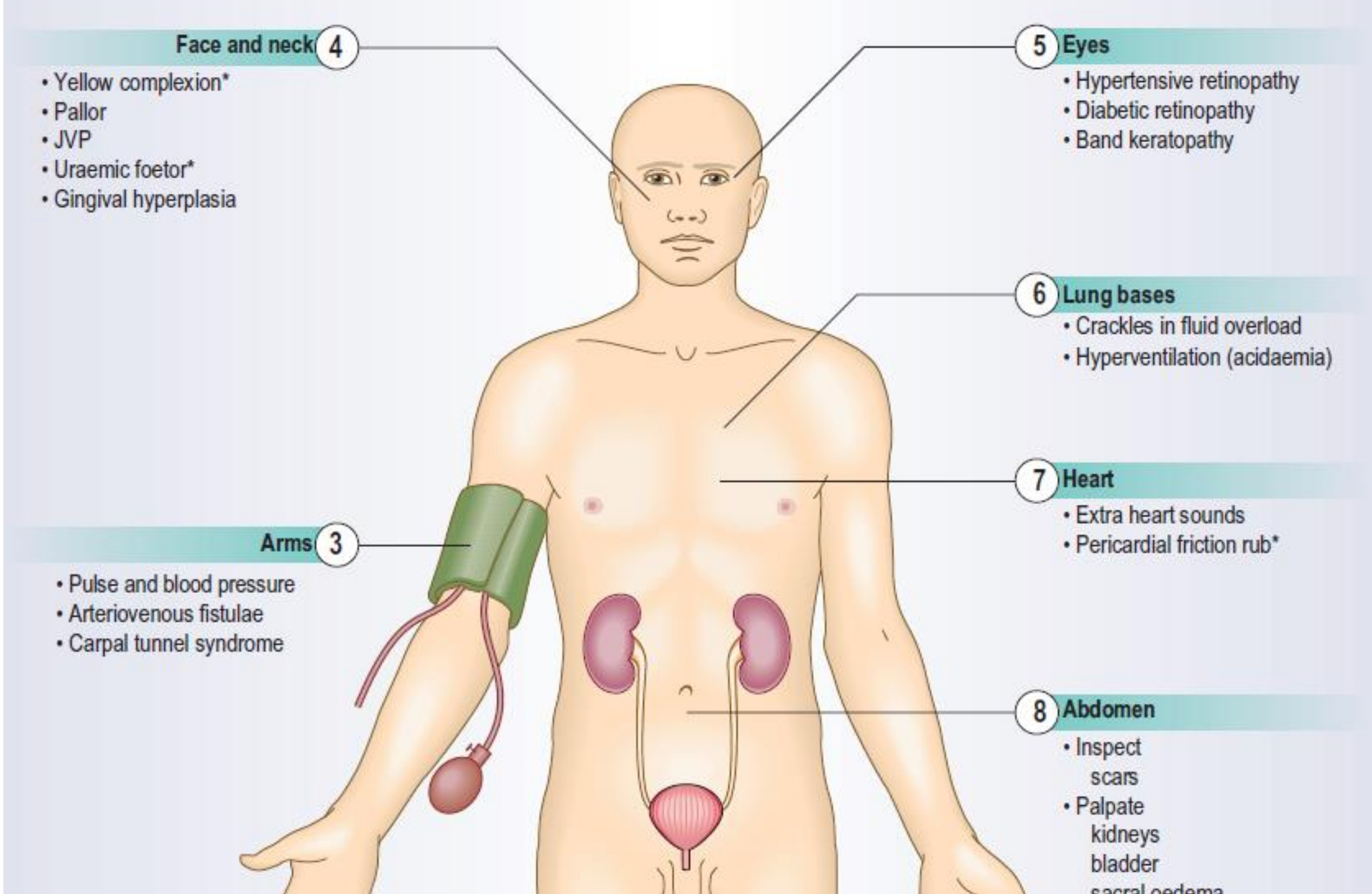
Measure the respiratory rate

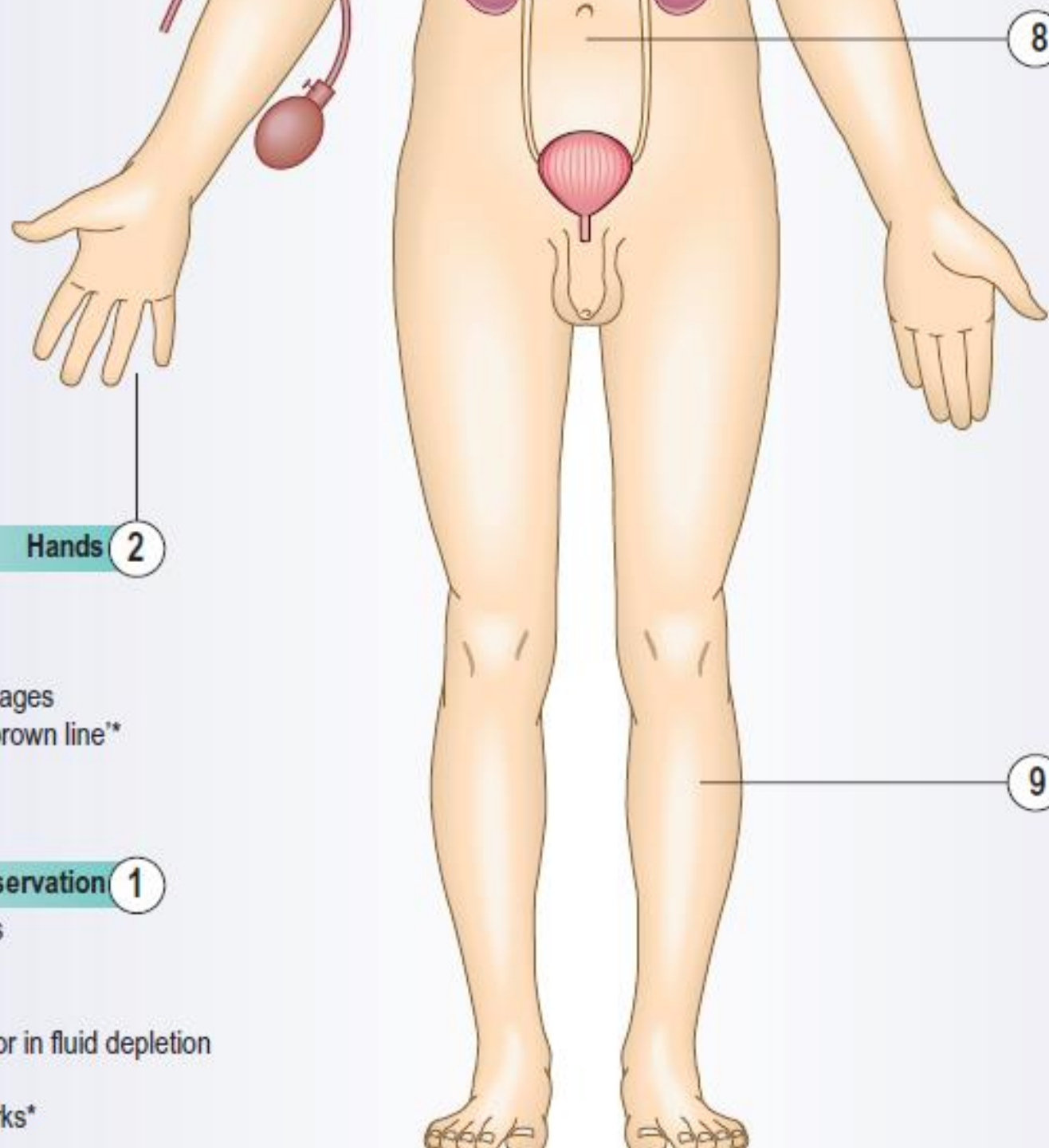
- Percuss the chest to detect **pleural effusions**.
- Auscultate for **bilateral basal lung crackles** indicating fluid overload or heart failure.

Nervous system

Assess level of **consciousness** .

- Test sensation and the tendon reflexes .
- Examine the optic fundi .
- Peripheral neuropathy (dm)


4 Face and neck
• Yellow complexion*
• Pallor
• JVP
• Uraemic foetor*
• Gingival hyperplasia
5 Eyes
• Hypertensive retinopathy
• Diabetic retinopathy
• Band keratopathy
6 Lung bases
• Crackles in fluid overload
• Hyperventilation (acidaemia)
7 Heart
• Extra heart sounds
• Pericardial friction rub*
3 Arms
• Pulse and blood pressure
• Arteriovenous fistulae
• Carpal tunnel syndrome
8 Abdomen
• Inspect
scars
• Palpate
kidneys
bladder
sacral oedema



8 Abdomen

- Inspect
  - scars
- Palpate
  - kidneys
  - bladder
  - sacral oedema
- Auscultate
  - renal arterial bruits
- Rectal examination
  - prostate enlargement

Hands 2

- Asterixis
- Nail features
  - Beau's lines
  - splinter haemorrhages
  - pigmentation – 'brown line'*
  - Muehrcke's lines

9 Legs

- Oedema
  - hypoproteinaemia
  - fluid overload
- Peripheral neuropathy*

General observation 1

- Pallor and tiredness
- Breathlessness
- Hydration
  - reduced skin turgor in fluid depletion
- Bruising*
- Itching, scratch marks*