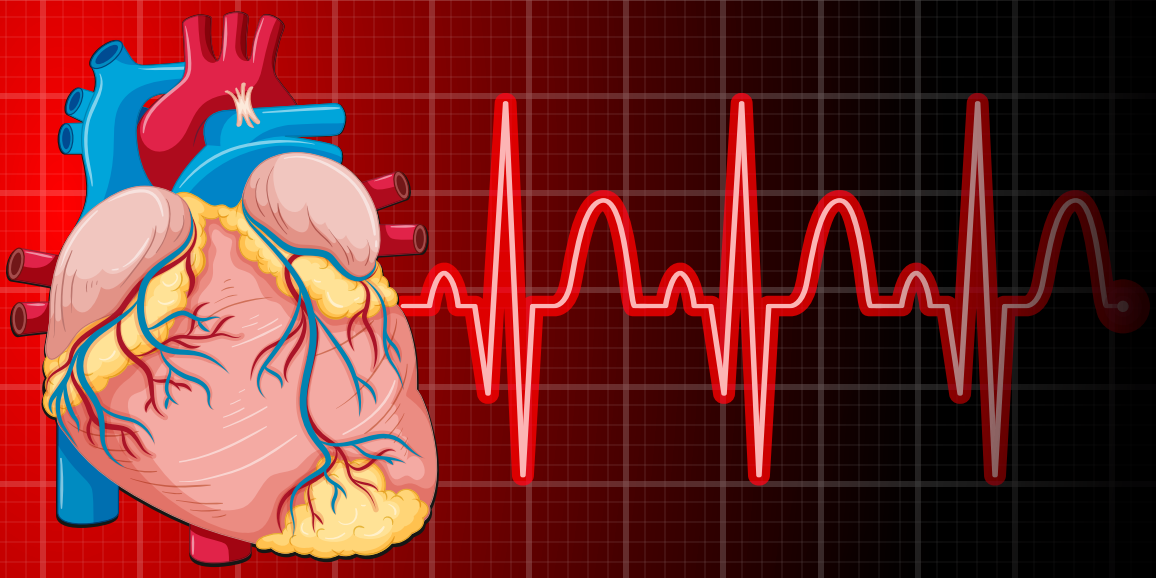
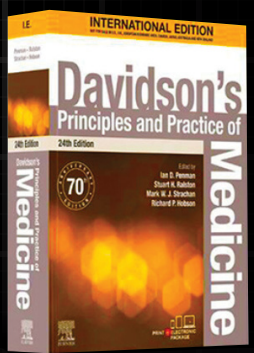
Quick Review

DAVIDSON TABLES & CHARTS CARDIOLOGY

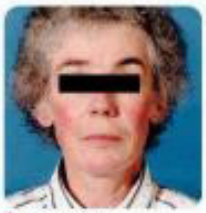




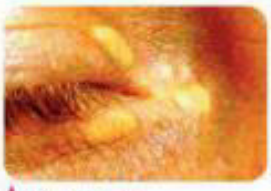
SK+F

Clinical examination of the cardiovascular system

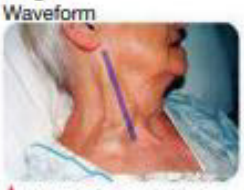
6 Face, mouth and eyes
Pallor
Central cyanosis
Dental caries
Fundi (retinopathy)
Stigmata of hyperlipidaemia and thyroid disease


Malar flush


Poor oral hygiene in a patient with infective endocarditis


Xanthelasma

5 Jugular venous pulse
(see opposite)
Height
Waveform


Jugular venous pulse

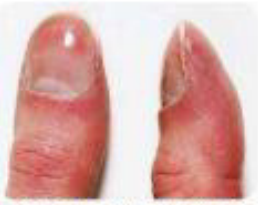
4 Carotid pulses
Volume
Character
Bruits
(see opposite)

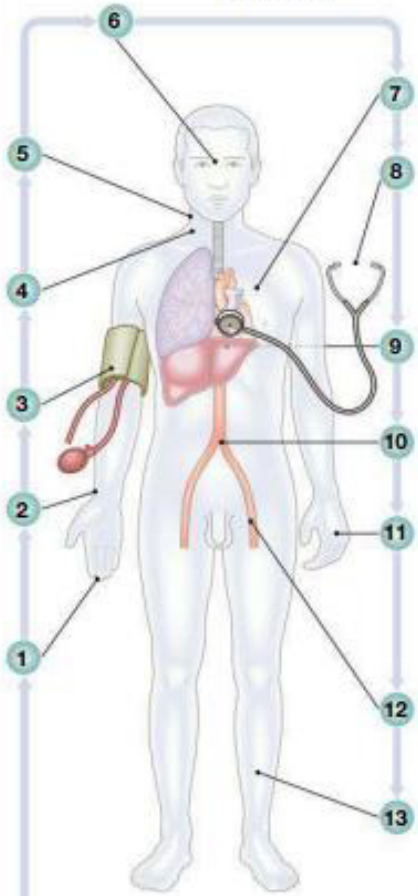
3 Blood pressure

2 Radial pulse
Rate
Rhythm

1 Hands
Clubbing
Splinter haemorrhages and other stigmata of infective endocarditis


Splinter haemorrhage


Cyanosis and clubbing in a patient with complex cyanotic congenital heart disease



Observation
Symptoms and well-being
- Breathlessness
- Distress etc.

Body habitus
- Body mass (obesity, cachexia)
- Marfan and other syndromes

Tissue perfusion
- Skin temperature
- Sweating
- Urine output

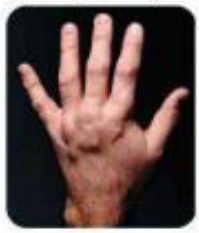
7 Precordium
Inspect
Palpate
(see opposite)

8 Auscultation
(see opposite)

9 Back
Lung crepitations
Sacral oedema

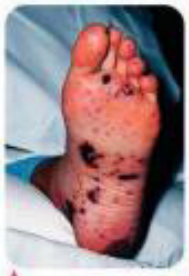
10 Abdomen
Hepatomegaly
Ascites
Aortic aneurysm
Bruits

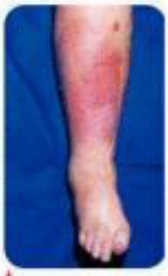
11 Tendon xanthomas
(hyperlipidaemia)



12 Femoral pulses
Radio-femoral delay
Bruits

13 Legs
Peripheral pulses
Oedema


Vasculitis in a patient with infective endocarditis

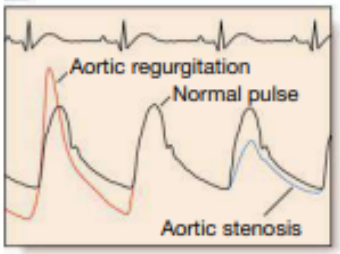

Peripheral oedema in a patient with congestive cardiac failure

Insets (Splinter haemorrhage, jugular venous pulse, malar flush, tendon xanthomas) From Newby D, Grubb N. Cardiology: an illustrated colour text. Edinburgh: Churchill Livingstone, Elsevier Ltd; 2005.

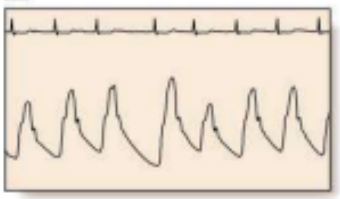
4 Examination of the arterial pulse

- The character of the pulse is determined by stroke volume and arterial compliance, and is best assessed by palpating a major artery, such as the carotid or brachial artery.
- Aortic regurgitation, anaemia, sepsis and other causes of a large stroke volume typically produce a bounding pulse with a high amplitude and wide pulse pressure (panel A).
- Aortic stenosis impedes ventricular emptying. If severe, it causes a slow-rising, weak and delayed pulse (panel A).
- Sinus rhythm produces a pulse that is regular in time and volume. Arrhythmias may cause irregularity. Atrial fibrillation produces a pulse that is irregular in time and volume (panel B).

A



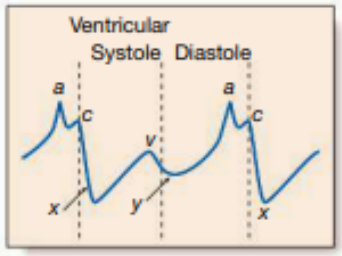
B



5 Examination of the jugular venous pulse

The internal jugular vein, superior vena cava and right atrium are in continuity, so the height of the jugular venous pulsation reflects right atrial pressure. When the patient is placed at 45°, with the head supported and turned to the left, the jugular venous pulse is visible along the line of the sternocleidomastoid muscle (see opposite). In health it is normally just visible above the clavicle.

- The height of the jugular venous pulse is determined by right atrial pressure and is therefore elevated in right heart failure and reduced in hypovolaemia.
- If the jugular venous pulse is not easily seen, it may be exposed by applying firm pressure over the abdomen.
- In sinus rhythm, the two venous peaks, the *a* and *v* waves, approximate to atrial and ventricular systole, respectively.
- The *x* descent reflects atrial relaxation and apical displacement of the tricuspid valve ring. The *y* descent reflects atrial emptying early in diastole. These signs are subtle.
- Tricuspid regurgitation produces giant *v* waves that coincide with ventricular systole.



i Distinguishing venous/arterial pulsation in the neck

- The venous pulse has two peaks in each cardiac cycle; the arterial pulse has one peak.
- The height of the venous pulse varies with respiration (falls on inspiration) and position.
- Abdominal compression causes the venous pulse to rise.
- The venous pulse is not easily palpable and can be occluded with light pressure.

7 Palpation of the precordium

Technique

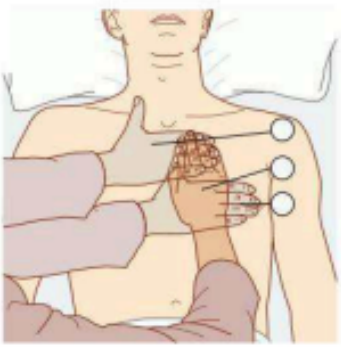
- Place fingertips over apex (1) to assess for position and character. Place heel of hand over left sternal border (2) for a parasternal heave or 'lift'. Assess for thrills in all areas, including the aortic and pulmonary areas (3). Normal position is the 5th or 6th intercostal space, at the mid-clavicular line.

Common abnormalities of the apex beat

- Volume overload, such as mitral or aortic regurgitation: displaced, thrusting
- Pressure overload, such as aortic stenosis, hypertension: discrete, heaving
- Dyskinetic, such as left ventricular aneurysm: displaced, incoordinate

Other abnormalities

- Palpable S1 (tapping apex beat: mitral stenosis)
- Palpable P2 (severe pulmonary hypertension)
- Left parasternal heave or 'lift' felt by heel of hand (right ventricular hypertrophy)
- Palpable thrill (aortic stenosis)



8 Auscultation of the heart

- Use the diaphragm to examine at the apex, lower left sternal border (tricuspid area) and upper left (pulmonary area) and right (aortic area) sternal borders.
- Use the bell to examine low-pitched noises, particularly at the apex for the mid-diastolic murmur of mitral stenosis.
- Time the sounds and murmurs by feeling the carotid pulse; the first heart sound (S1) just precedes the upstroke of the pulse and the second heart sound (S2) is out of step with it. If present, a third heart sound (S3) immediately follows S2, and a fourth heart sound (S4) just precedes S1. Systolic murmurs are synchronous with the pulse.
- Listen for radiation of systolic murmurs, over the base of the neck (aortic stenosis) and in the axilla (mitral incompetence).
- Listen over the left sternal border with the patient sitting forward (aortic incompetence), then at the apex with the patient rolled on to the left side (mitral stenosis).

16.1 Haemodynamic effects of respiration

	Inspiration	Expiration
Jugular venous pressure	Falls	Rises
Blood pressure	Falls (up to 10 mmHg)	Rises
Heart rate	Accelerates	Slows
Second heart sound	Splits*	Fuses*

*Inspiration prolongs right ventricular ejection, delaying P_2, and shortens left ventricular ejection, bringing forward A_2; expiration produces the opposite effects.

16.2 How to read a 12-lead electrocardiogram: examination sequence

Rhythm strip (lead II)	To determine heart rate and rhythm
Cardiac axis	Normal if QRS complexes +ve in leads I and II
P-wave shape	Tall P waves denote right atrial enlargement (P pulmonale) and notched P waves denote left atrial enlargement (P mitrale)
PR interval	Normal = 0.12–0.20 sec. Prolongation denotes impaired atrioventricular nodal conduction. A short PR interval occurs in Wolff–Parkinson–White syndrome
QRS duration	If > 0.12 sec, ventricular conduction is abnormal (left or right bundle branch block)
QRS amplitude	Large QRS complexes occur in slim young patients and in patients with left ventricular hypertrophy
Q waves	May signify previous myocardial infarction
ST segment	ST elevation may signify myocardial infarction, pericarditis or left ventricular aneurysm; ST depression may signify ischaemia or infarction
T waves	T-wave inversion has many causes, including myocardial ischaemia or infarction, and electrolyte disturbances
QT interval	Normal < 0.44 sec (male), 0.46 sec (female) corrected for heart rate. QT prolongation may occur with congenital long QT syndrome, low K^+, Mg^{2+} or Ca^{2+}, and some drugs (see Box 16.28)
ECG conventions	Depolarisation towards electrode: +ve deflection Depolarisation away from electrode: −ve deflection Sensitivity: 10 mm = 1 mV Paper speed: 25 mm per sec Each large (5 mm) square = 0.2 sec Each small (1 mm) square = 0.04 sec Heart rate = 1500/RR interval (mm) (i.e. 300 ÷ number of large squares between beats)

16.3 Exercise testing

Indications

- To confirm the diagnosis of angina
- To evaluate stable angina
- To assess prognosis following myocardial infarction
- To assess outcome after coronary revascularisation, e.g. coronary angioplasty
- To diagnose and evaluate the treatment of exercise-induced arrhythmias

High-risk findings

- Low threshold for ischaemia (within stage 1 or 2 of the Bruce Protocol)
- Fall in blood pressure on exercise
- Widespread, marked or prolonged ischaemic ECG changes
- Exercise-induced arrhythmia

16.4 Common indications for echocardiography

- Assessment of left ventricular function
- Diagnosis and quantification of severity of valve disease
- Identification of vegetations in endocarditis
- Identification of structural heart disease in atrial fibrillation, cardiomyopathies or congenital heart disease
- Detection of pericardial effusion
- Identification of structural heart disease or intracardiac thrombus in systemic embolism

16.5 New York Heart Association (NYHA) functional classification

Class I

- No limitation during ordinary activity

Class II

- Slight limitation during ordinary activity

Class III

- Marked limitation of normal activities without symptoms at rest

Class IV

- Unable to undertake physical activity without symptoms; symptoms may be present at rest

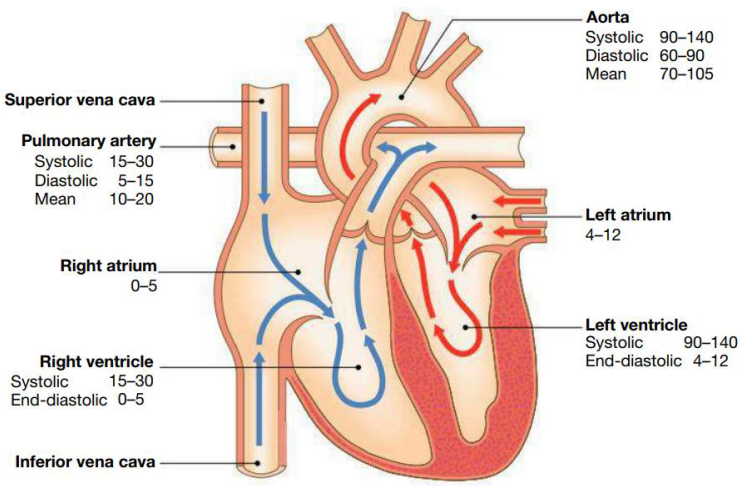


Fig. 16.1 Direction of blood flow through the heart. The blue arrows show deoxygenated blood moving through the right heart to the lungs. The red arrows show oxygenated blood moving from the lungs to the systemic circulation. The normal pressures are shown for each chamber in mmHg.

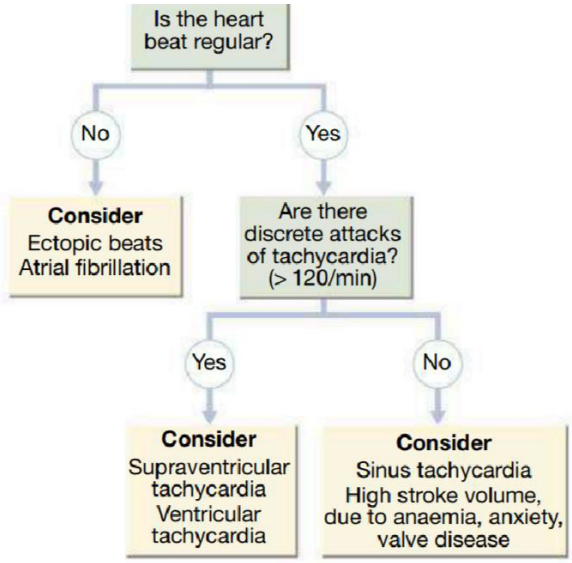


Fig. 16.18 **A simple approach to the diagnosis of palpitation.**

16.7 Causes of sudden arrhythmic death

Coronary artery disease (85%)

- Myocardial ischaemia
- Acute myocardial infarction
- Prior myocardial infarction with myocardial scarring

Structural heart disease (10%)

- Aortic stenosis
- Hypertrophic cardiomyopathy
- Dilated cardiomyopathy
- Arrhythmogenic right ventricular cardiomyopathy
- Congenital heart disease

No structural heart disease (5%)

- Long QT syndrome
- Brugada syndrome
- Wolff–Parkinson–White syndrome
- Adverse drug reactions (torsades de pointes)
- Severe electrolyte abnormalities

16.6 How to evaluate palpitation

- Is the palpitation continuous or intermittent?
- Is the heart beat regular or irregular?
- What is the approximate heart rate?
- Do symptoms occur in discrete attacks?
  Is the onset abrupt? How do attacks terminate?
- Are there any associated symptoms?
  Chest pain, lightheadedness, polyuria (a feature of supraventricular tachycardia)
- Are there any precipitating factors, such as exercise or alcohol excess?
- Is there a history of structural heart disease, such as coronary artery disease or valvular heart disease?

16.9 Features of a benign or innocent heart murmur

- Soft
- Mid-systolic
- Heard at left sternal border
- No radiation
- No other cardiac abnormalities

16.8 Normal and abnormal heart sounds

Sound	Timing	Characteristics	Mechanisms	Variable features
First heart sound (S1)	Onset of systole	Usually single or narrowly split	Closure of mitral and tricuspid valves	Loud: hyperdynamic circulation (anaemia, pregnancy, thyrotoxicosis); mitral stenosis Soft: heart failure; mitral regurgitation
Second heart sound (S2)	End of systole	Split on inspiration Single on expiration	Closure of aortic and pulmonary valve A_2 first P_2 second	Fixed wide splitting with atrial septal defect Wide but variable splitting with delayed right heart emptying (right bundle branch block) Reversed splitting due to delayed left heart emptying (left bundle branch block)
Third heart sound (S3)	Early in diastole, just after S2	Low pitch, often heard as 'gallop'	From ventricular wall due to abrupt cessation of rapid filling	Physiological: young people, pregnancy Pathological: heart failure, mitral regurgitation
Fourth heart sound (S4)	End of diastole, just before S1	Low pitch	Ventricular origin (stiff ventricle and augmented atrial contraction) related to atrial filling	Absent in atrial fibrillation A feature of severe left ventricular hypertrophy
Systolic clicks	Early or mid-systole	Brief, high-intensity sound	Valvular aortic stenosis Valvular pulmonary stenosis Floppy mitral valve Prosthetic heart sounds from opening and closing of normally functioning mechanical valves	Click may be lost when stenotic valve becomes thickened or calcified Prosthetic clicks lost when valve obstructed by thrombus or vegetations
Opening snap (OS)	Early in diastole	High pitch, brief duration	Opening of stenosed leaflets of mitral valve Prosthetic heart sounds	Moves closer to S2 as mitral stenosis becomes more severe. May be absent in calcific mitral stenosis

16.10 How to assess a heart murmur

When does it occur?

- Time the murmur using heart sounds, carotid pulse and the apex beat. Is it systolic or diastolic?
- Does the murmur extend throughout systole or diastole or is it confined to a shorter part of the cardiac cycle?

How loud is it?

- Grade 1: very soft (audible only in ideal conditions)
- Grade 2: soft
- Grade 3: moderate
- Grade 4: loud with associated thrill
- Grade 5: very loud
- Grade 6: heard without stethoscope

Note: Diastolic murmurs are very rarely above grade 4

Where is it heard best?

- Listen over the apex and base of the heart, including the aortic and pulmonary areas

Where does it radiate?

- Listen at the neck, axilla or back

What does it sound like?

- Pitch is determined by flow (high pitch indicates high-velocity flow)
- Is the intensity constant or variable?

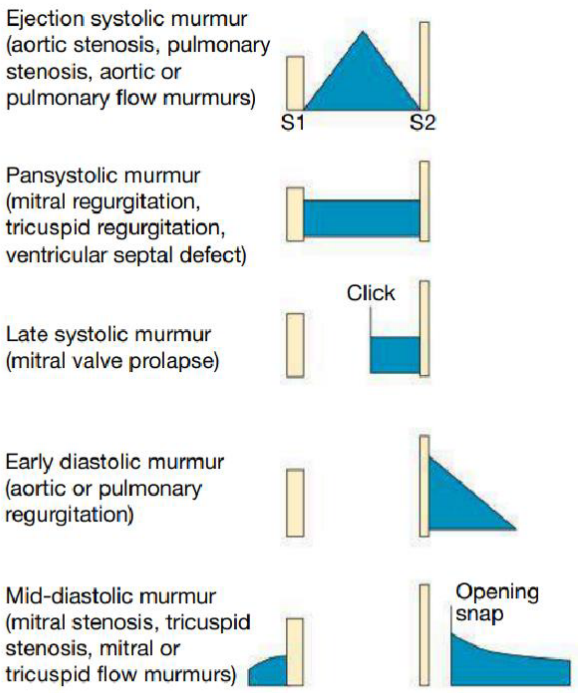


Fig. 16.21 The timing and pattern of cardiac murmurs.

i 16.11 Features of some common systolic murmurs

Condition	Timing and duration	Quality	Location and radiation	Associated features
Aortic stenosis	Mid-systolic	Loud, rasping	Base and left sternal border, radiating to suprasternal notch and carotids	Single second heart sound Ejection click (in young patients) Slow-rising pulse Left ventricular hypertrophy (pressure overload)
Mitral regurgitation	Pansystolic	Blowing	Apex, radiating to axilla	Soft first heart sound Third heart sound Left ventricular hypertrophy (volume overload)
Ventricular septal defect	Pansystolic	Harsh	Lower left sternal border, radiating to whole precordium	Thrill Biventricular hypertrophy
Benign	Mid-systolic	Soft	Left sternal border, no radiation	No other signs of heart disease

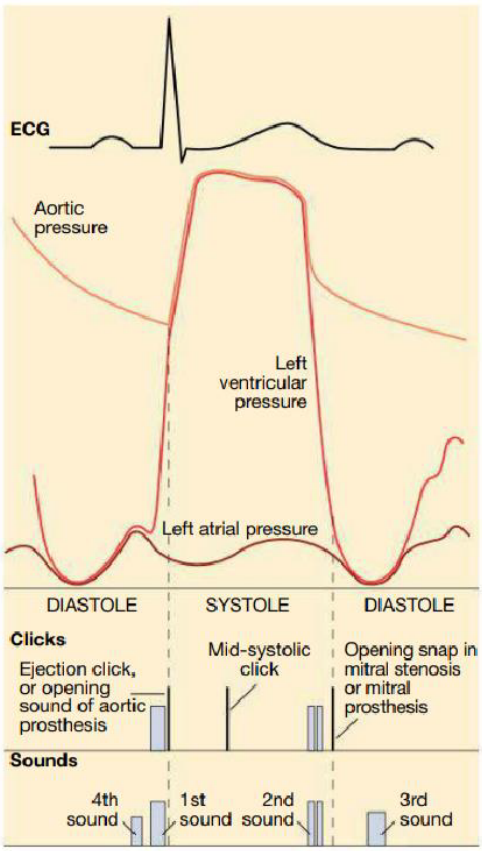


Fig. 16.20 The relationship of the cardiac cycle to the ECG, the left ventricular pressure wave and the position of heart sounds.

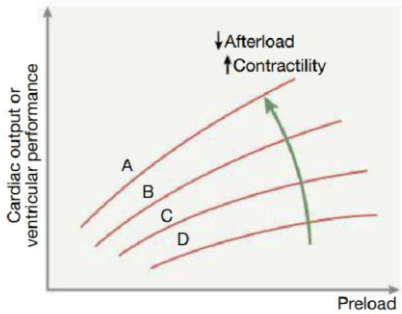


Fig. 16.22 **Starling's Law.** Normal (A), mild (B), moderate (C) and severe (D) heart failure. Ventricular performance is related to the degree of myocardial stretching. An increase in preload (end-diastolic volume, end-diastolic pressure, filling pressure or atrial pressure) will therefore enhance function; however, overstretching causes marked deterioration. In heart failure, the curve moves to the right and becomes flatter. An increase in myocardial contractility or a reduction in afterload will shift the curve upwards and to the left (green arrow).

16.12 Mechanisms of heart failure

Cause	Examples	Features
Reduced ventricular contractility	Myocardial infarction (segmental dysfunction)	In coronary artery disease, 'akinetic' or 'dyskinetic' segments contract poorly and may impede the function of normal segments by distorting their contraction and relaxation patterns
	Myocarditis/cardiomyopathy (global dysfunction)	Progressive ventricular dilatation
Ventricular outflow obstruction (pressure overload)	Hypertension, aortic stenosis (left heart failure) Pulmonary hypertension, pulmonary valve stenosis (right heart failure)	Initially, concentric ventricular hypertrophy allows the ventricle to maintain a normal output by generating a high systolic pressure. Later, secondary changes in the myocardium and increasing obstruction lead to failure with ventricular dilatation and rapid clinical deterioration
Ventricular inflow obstruction	Mitral stenosis, tricuspid stenosis	Small, vigorous ventricle; dilated, hypertrophied atrium. Atrial fibrillation is common and often causes marked deterioration because ventricular filling depends heavily on atrial contraction
Ventricular volume overload	Left ventricular volume overload (mitral or aortic regurgitation) Ventricular septal defect Right ventricular volume overload (atrial septal defect) Increased metabolic demand (high output)	Dilatation and hypertrophy allow the ventricle to generate a high stroke volume and help to maintain a normal cardiac output. However, secondary changes in the myocardium lead to impaired contractility and worsening heart failure
Arrhythmia	Atrial fibrillation	Tachycardia does not allow for adequate filling of the heart, resulting in reduced cardiac output and back pressure
	Tachycardia	Prolonged tachycardia causes myocardial fatigue
	Complete heart block	Bradycardia limits cardiac output, even if stroke volume is normal
Diastolic dysfunction	Constrictive pericarditis	Marked fluid retention and peripheral oedema, ascites, pleural effusions and elevated jugular veins
	Restrictive cardiomyopathy	Bi-atrial enlargement (restrictive filling pattern and high atrial pressures). Atrial fibrillation may cause deterioration
	Left ventricular hypertrophy and fibrosis	Good systolic function but poor diastolic filling
	Cardiac tamponade	Hypotension, elevated jugular veins, pulsus paradoxus, poor urine output

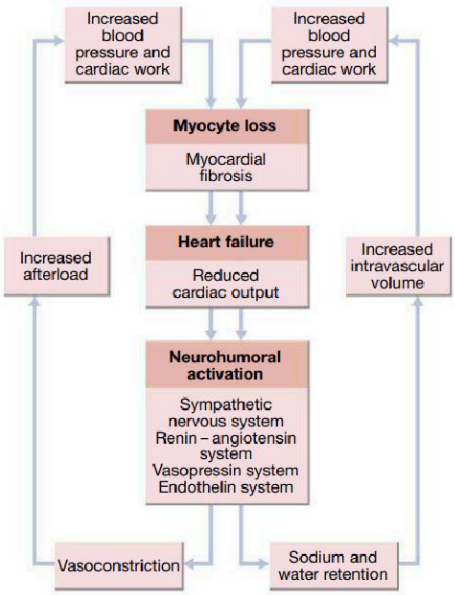


Fig. 16.23 Neurohumoral activation and compensatory mechanisms in heart failure. There is a vicious circle in progressive heart failure.

16.13 Factors that may precipitate or aggravate heart failure in pre-existing heart disease

- Myocardial ischaemia or infarction
- Intercurrent illness
- Arrhythmia
- Inappropriate reduction of therapy
- Administration of a drug with negative inotropic (β-blocker) or fluid-retaining properties (non-steroidal anti-inflammatory drugs, glucocorticoids)
- Pulmonary embolism
- Conditions associated with increased metabolic demand (pregnancy, thyrotoxicosis, anaemia)
- Intravenous fluid overload

16.14 Differential diagnosis of peripheral oedema

- Cardiac failure: right or combined left and right heart failure, pericardial constriction, cardiomyopathy
- Chronic venous insufficiency: varicose veins
- Hypoalbuminaemia: nephrotic syndrome, liver disease, protein-losing enteropathy; often widespread, can affect arms and face
- Drugs:
  - Sodium retention: fludrocortisone, non-steroidal anti-inflammatory drugs
  - Increasing capillary permeability: nifedipine, amlodipine
- Idiopathic: women > men
- Chronic lymphatic obstruction

16.15 Management of acute pulmonary oedema

Action	Effect
Sit the patient up	Reduces preload
Give high-flow oxygen	Corrects hypoxia
Ensure continuous positive airway pressure (CPAP) of 5–10 mmHg by tight-fitting mask	Reduces preload and pulmonary capillary hydraulic gradient
Administer nitrates:* IV glyceryl trinitrate (10–200 µg/min) Buccal glyceryl trinitrate 2–5 mg	Reduces preload and afterload
Administer a loop diuretic: Furosemide (50–100 mg IV)	Combats fluid overload

*The dose of nitrate should be titrated upwards every 10 minutes until there is an improvement or systolic blood pressure is <110 mmHg.
(IV = intravenous)

16.16 General measures for the management of heart failure

Education

- Explanation of nature of disease, treatment and self-help strategies

Diet

- Good general nutrition and weight reduction for the obese
- Avoidance of high-salt foods and added salt, especially for patients with severe congestive heart failure

Alcohol

- Moderation or elimination of alcohol consumption; alcohol-induced cardiomyopathy requires abstinence

Smoking

- Cessation

Exercise

- Regular moderate aerobic exercise within limits of symptoms

Vaccination

- Consideration of influenza and pneumococcal vaccination

16.17 Congestive cardiac failure in old age

- **Incidence**: rises with age and affects 5%–10% of those in their eighties.
- **Common causes**: coronary artery disease, hypertension and calcific degenerative valvular disease.
- **Diastolic dysfunction**: often prominent, particularly in those with a history of hypertension.
- **ACE inhibitors and ARBs**: improve symptoms and mortality but are more frequently associated with postural hypotension and renal impairment than in younger patients.
- **Loop diuretics**: usually required but may be poorly tolerated in those with urinary incontinence and men with prostate enlargement.

16.18 Dosages of ACE inhibitors, angiotensin receptor blockers, β-blockers and neprilysin inhibitors in heart failure

	Starting dose	Target dose
ACE inhibitors		
Enalapril	2.5 mg twice daily	10 mg twice daily
Lisinopril	2.5 mg daily	20 mg daily
Ramipril	1.25 mg daily	10 mg daily
Angiotensin receptor blockers		
Losartan	25 mg daily	100 mg daily
Candesartan	4 mg daily	32 mg daily
Valsartan	40 mg daily	160 mg daily
β-blockers		
Bisoprolol	1.25 mg daily	10 mg daily
Metoprolol	25 mg twice daily	100 mg twice daily
Carvedilol	3.125 mg twice daily	25 mg twice daily
Neprilysin inhibitor-ARB		
Sacubitril–valsartan	24/26 mg twice daily	97/103 mg twice daily

16.19 Some pathological causes of sinus bradycardia and tachycardia

Sinus bradycardia

- Myocardial infarction
- Sinus node disease (sick sinus syndrome)
- Hypothermia
- Hypothyroidism
- Cholestatic jaundice
- Raised intracranial pressure
- Drugs (β-blockers, digoxin, verapamil)

Sinus tachycardia

- Anxiety
- Fever
- Anaemia
- Heart failure
- Thyrotoxicosis
- Phaeochromocytoma
- Drugs (β-agonists)

16.20 Common features of sinoatrial disease

- Sinus bradycardia
- Sinoatrial block (sinus arrest)
- Paroxysmal atrial fibrillation
- Paroxysmal atrial tachycardia
- Atrioventricular block

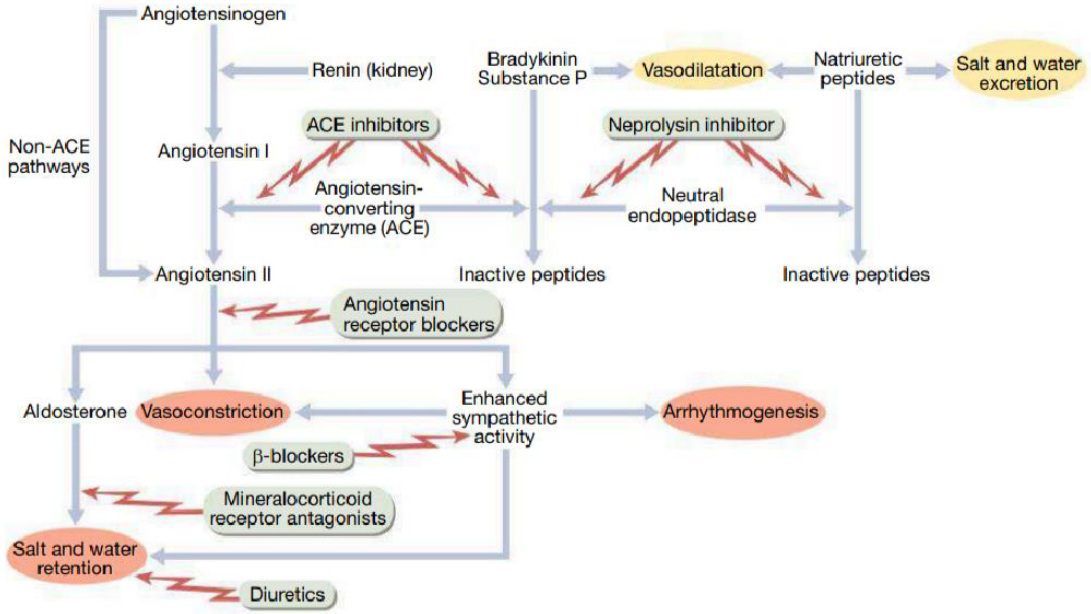


Fig. 16.27 Neurohumoral activation of the renin–angiotensin and sympathetic nervous systems have adverse (red) effects on the cardiovascular system which are counterbalanced by beneficial effects of endogenous natriuretic and vasoactive peptide systems (yellow). Heart failure treatments are targeted at inhibiting the detrimental pathways and enhancing the beneficial compensatory systems.

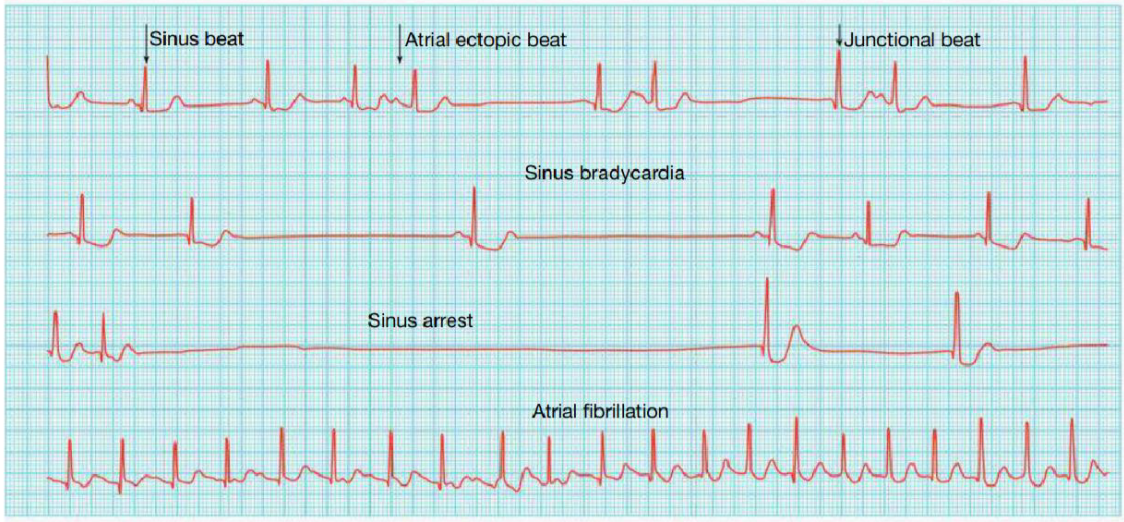


Fig. 16.30 Sinoatrial disease (sick sinus syndrome). A continuous rhythm strip from a 24-hour ECG tape recording illustrating periods of sinus rhythm, atrial ectopics, junctional beats, sinus bradycardia, sinus arrest and paroxysmal atrial fibrillation.

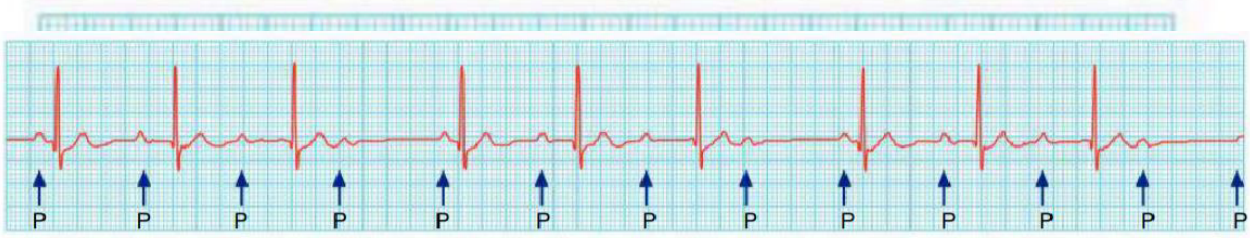


Fig. 16.32 Second-degree atrioventricular block (Mobitz type I – the Wenckebach phenomenon). The PR interval progressively increases until a P wave is not conducted. The cycle then repeats itself. In this example, conduction is at a ratio of 4:3, leading to groupings of three ventricular complexes in a row.

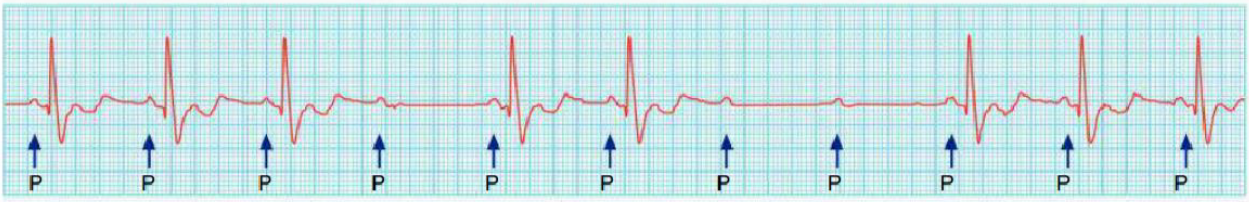


Fig. 16.33 Second-degree atrioventricular block (Mobitz type II). The PR interval of conducted beats is normal but some P waves are not conducted. The constant PR interval distinguishes this from the Wenckebach phenomenon.

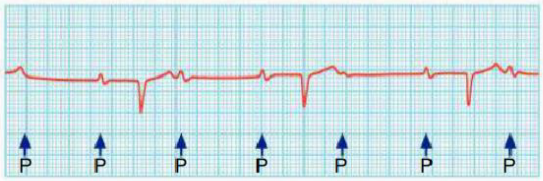


Fig. 16.34 Second-degree atrioventricular block with fixed 2:1 block. Alternate P waves are not conducted. This may be due to Mobitz type I or II block.

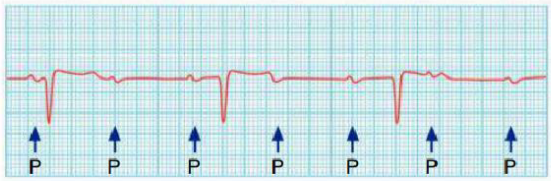


Fig. 16.35 Complete (third-degree) atrioventricular block. There is complete dissociation of atrial and ventricular complexes. The atrial rate is 80/min and the ventricular rate is 38/min.

16.21 Causes of complete atrioventricular block

Congenital
Acquired

- Idiopathic fibrosis
- Myocardial infarction/ischaemia
- Inflammation:
  - Infective endocarditis
  - Sarcoidosis
  - Chagas' disease
- Trauma
- Drugs:
  - Digoxin
  - β-blockers
  - Calcium antagonists

16.22 Common causes of bundle branch block

Right bundle branch block

- Normal variant
- Right ventricular hypertrophy or strain, e.g. pulmonary embolism
- Congenital heart disease, e.g. atrial septal defect
- Coronary artery disease

Left bundle branch block

- Coronary artery disease
- Hypertension
- Aortic valve disease
- Cardiomyopathy

16.23 Common causes of atrial fibrillation

- Coronary artery disease (including acute MI)
- Valvular heart disease, especially rheumatic mitral valve disease
- Hypertension
- Sinoatrial disease
- Hyperthyroidism
- Alcohol
- Cardiomyopathy
- Congenital heart disease
- Chest infection
- Pulmonary embolism
- Pericardial disease
- Idiopathic (lone atrial fibrillation)

16.24 Atrial fibrillation in old age

- **Prevalence**: rises with age, reaching 9% in those over 80 years.
- **Symptoms**: sometimes asymptomatic but often accompanied by diastolic heart failure.
- **Hyperthyroidism**: atrial fibrillation may emerge as the dominant feature of otherwise silent or occult hyperthyroidism.
- **Cardioversion**: followed by high rates (~70% at 1 year) of recurrent atrial fibrillation.
- **Stroke**: atrial fibrillation is an important cause of cerebral embolism, found in 15% of all stroke patients and 2%–8% of those with transient ischaemic attacks (TIAs).
- **Anticoagulation**: although the risk of thromboembolism rises, the hazards of anticoagulation also become greater with age because of increased comorbidity, particularly cognitive impairment and falls.
- **Direct oral anticoagulants**: alternatives to warfarin. No blood monitoring is required, there are fewer drug interactions, and fixed dosing may aid adherence. Renal impairment affects dosing, for example apixaban dose is reduced from 5 mg twice daily to 2.5 mg twice daily if two or more of the following apply: serum creatinine more than 132 µmol/L, age 80 years or greater, weight 60 kg or less.
- **Warfarin**: in those over 75 years, care should be taken to maintain an INR (International Normalised Ratio) below 3.0 because of the increased risk of intracranial haemorrhage.

16.25 CHA_2DS_2-VASc stroke risk scoring system for non-valvular atrial fibrillation

	Parameter	Score
C	Congestive heart failure	1 point
H	Hypertension history	1 point
A_2	Age ≥ 75 years	2 points
D	Diabetes mellitus	1 point
S_2	Previous stroke or transient ischaemic attack (TIA)	2 points
V	Vascular disease	1 point
A	Age 65–74 years	1 point
Sc	Sex category female	1 point
	Maximum total score	9 points

Annual stroke risk

0 points = 0% (no prophylaxis required)
1 point = 1.3% (oral anticoagulant recommended in males only)
2+ points = > 2.2% (oral anticoagulant recommended)

From European Society of Cardiology clinical practice guidelines: atrial fibrillation (management of) 2010 and focused update (2012). Eur Heart J 2012; 33:2719–2747.

16.27 Features more in keeping with ventricular tachycardia

- History of myocardial infarction
- Atrioventricular dissociation (pathognomonic)
- Capture/fusion beats (pathognomonic; see Fig. 16.40)
- Extreme left axis deviation
- Very broad QRS complexes (> 140 msecs)
- No response to carotid sinus massage or intravenous adenosine

16.26 HAS-BLED bleeding risk scoring system for patients receiving oral anticoagulation

	Parameter	Score
H	Hypertension; current systolic blood pressure > 160 mmHg	1 point
A	Abnormal liver function (cirrhosis OR bilirubin > twice upper limit of reference range or transaminases > three times upper limit of reference range)	1 point
	Abnormal renal function (creatinine > 200 µmol/L (2.26 mg/dL))	1 point
S	Stroke history	1 point
B	Bleeding: prior major event	1 point
L	Labile INR on warfarin	1 point
E	Elderly: age ≥ 65 years	1 point
D	Drugs:	
	Use of antiplatelet drug	1 point
	High alcohol consumption	1 point
	Maximum total score	9 points

HAS-BLED score of ≥ 3 points requires close patient monitoring

16.28 Causes of long QT interval and torsades de pointes

Bradycardia

- Bradycardia potentiates other factors that cause torsades de pointes

Electrolyte disturbance

- Hypokalaemia
- Hypomagnesaemia
- Hypocalcaemia

Drugs*

- Disopyramide, flecainide and other class Ia, Ic anti-arrhythmic drugs (Box 16.29 and Fig. 16.49)
- Sotalol, amiodarone and other class III anti-arrhythmic drugs
- Amitriptyline and other tricyclic antidepressants
- Chlorpromazine and other phenothiazines
- Erythromycin and other macrolides
- Hydroxychloroquine and chloroquine

Congenital syndromes

- Long QT1: gene affected *KCNQ1*: K^+ channel, 30%–35%
- Long QT2: gene affected *HERG*: K^+ channel, 25%–30%
- Long QT3: gene affected *SCN5A*: Na^+ channel, 5%–10%
- Long QT4–12: rare; various genes implicated

*Many other drugs that are not shown can be associated with prolongation of the QT interval. See www.crediblemeds.org for a complete list.

16.29 Classification of anti-arrhythmic drugs by effect on the intracellular action potential*

Class I: membrane-stabilising agents (sodium channel blockers)

(a) Block Na^+ channel and prolong action potential
- Quinidine, disopyramide

(b) Block Na^+ channel and shorten action potential
- Lidocaine, mexiletine

(c) Block Na^+ channel with no effect on action potential
- Flecainide, propafenone

Class II: β-adrenoceptor antagonists (β-blockers)

- Atenolol, bisoprolol, metoprolol

Class III: drugs whose main effect is to prolong the action potential

- Amiodarone, dronedarone, sotalol

Class IV: slow calcium channel blockers

- Verapamil, diltiazem

*Some drugs such as digoxin, ivabradine and adenosine have no place in this classification, while others such as amiodarone have properties in more than one class.

16.30 Uses, dosage and side-effects of anti-arrhythmic drugs

Drug	Main uses	Route	Dosage (adult)	Important side-effects
Class I				
Disopyramide	Prevention and treatment of atrial and ventricular tachyarrhythmias	IV	2 mg/kg at 30 mg/min, then 0.4 mg/kg/hr (max 800 mg/day)	Myocardial depression, hypotension, dry mouth, urinary retention
Lidocaine	Treatment and short-term prevention of VT and VF	Oral	300–800 mg daily in divided dosage	Myocardial depression, delirium, convulsions
		IV	Bolus 50–100 mg, 4 mg/min for 30 mins, then 2 mg/min for 2 hrs, then 1 mg/min for 24 hrs	
Mexiletine	Prevention and treatment of ventricular tachyarrhythmias	IV	Loading dose: 100–250 mg at 25 mg/min, then 250 mg in 1 hr, then 250 mg in 2 hrs Maintenance therapy: 0.5 mg/min	Myocardial depression, gastrointestinal irritation, delirium, dizziness, tremor, nystagmus, ataxia
		Oral	167–500 mg daily	
Flecainide	Prevention and treatment of atrial and ventricular tachyarrhythmias	IV	2 mg/kg over 10 mins, then if required 1.5 mg/kg/hr for 1 hr, then 0.1 mg/kg/hr	Myocardial depression, dizziness
		Oral	50–150 mg twice daily	
Propafenone	Prevention and treatment of atrial and ventricular tachyarrhythmias	Oral	150 mg 3 times daily for 1 week, then 300 mg twice daily	Myocardial depression, dizziness
Class II				
Atenolol	Treatment and prevention of SVT and AF, prevention of VEs and exercise-induced VF	IV	2.5 mg at 1 mg/min, repeated at 5-min intervals (max 10 mg)	Myocardial depression, bradycardia, bronchospasm, fatigue, depression, nightmares, cold peripheries
		Oral	25–100 mg daily	
Bisoprolol		Oral	2.5–10 mg daily	
Metoprolol		IV	5 mg over 2 mins to a maximum of 15 mg	
Class III				
Amiodarone	Serious or resistant atrial and ventricular tachyarrhythmias	IV	5 mg/kg over 20–120 mins, then up to 15 mg/kg/24 hrs	Photosentivity skin discoloration, corneal deposits, thyroid dysfunction, alveolitis, nausea and vomiting, hepatotoxicity, peripheral neuropathy, torsades de pointes; potentiates digoxin and warfarin
		Oral	Initially 600–1200 mg/day, then 100–400 mg daily	
Dronedarone	Paroxysmal atrial fibrillation	Oral	400 mg twice daily	Renal and hepatic dysfunction requiring regular blood monitoring
Sotatol*	AF, rarely ventricular tachyarrhythmias	IV	10–20 mg slowly	Can cause torsade de pointes
		Oral	40–160 mg twice daily	
Class IV				
Verapamil	Treatment of SVT, control of AF	IV	5–10 mg over 30 secs	Myocardial depression, hypotension, bradycardia, constipation
		Oral	40–120 mg 3 times daily or 240 mg SR daily	
Other				
Atropine	Treatment of bradycardia and/or hypotension due to vagal over-activity (see Box 16.32)	IV	0.6–3 mg	Dry mouth, thirst, blurred vision, atrial and ventricular extrasystoles
Adenosine	Treatment of SVT, aid to diagnosis in unidentified tachycardia	IV	3 mg over 2 secs, followed if necessary by 6 mg, then 12 mg at intervals of 1–2 mins	Flushing, dyspnoea, chest pain Avoid in asthma
Digoxin	Rate control of AF	IV	Loading dose: 0.5–1 mg (total), 0.5 mg over 30 mins, then 0.25–0.5 mg after 4–6 hrs	Gastrointestinal disturbance, xanthopasia, arrhythmias
		Oral	0.5 mg repeated after 6 hrs, then 0.0625–0.25 mg daily	

*Sotalol also has class II activity as a β-blocker.
(AF = atrial fibrillation; IV = intravenous; SR = sustained-release formulation; SVT = supraventricular tachycardia; VE = ventricular ectopic; VF = ventricular fibrillation; VT = ventricular tachycardia)

16.31 Anti-arrhythmic drugs: principles of use

Anti-arrhythmic drugs are potentially toxic and should be used carefully according to the following principles:

- Many arrhythmias are benign and do not require specific treatment
- Precipitating or causal factors should be corrected if possible:
  - Alcohol excess
  - Myocardial ischaemia
  - Hyperthyroidism
  - Acidosis
  - Hypokalaemia
  - Hypomagnesaemia
- If drug therapy is required, it is best to use as few drugs as possible
- In difficult cases, programmed electrical stimulation (electrophysiological study) may help to identify the optimum therapy
- When managing life-threatening arrhythmias, it is essential to ensure that prophylactic treatment is effective. Ambulatory monitoring and exercise testing may be of value
- Patients on long-term anti-arrhythmic drugs should be reviewed regularly and attempts made to withdraw therapy if the factors that precipitated the arrhythmias are no longer operative
- For patients with recurrent supraventricular tachycardia or atrial flutter, radiofrequency ablation is the treatment of choice

16.32 Response to intravenous adenosine

Arrhythmia	Response
Supraventricular tachycardia	Termination
Atrial fibrillation, atrial flutter, atrial tachycardia	Transient atrioventricular block
Ventricular tachycardia	No effect

16.33 Digoxin toxicity

Extracardiac manifestations

- Anorexia, nausea, vomiting
- Diarrhoea
- Altered colour vision (xanthopsia)

Cardiac manifestations

- Bradycardia
- Multiple ventricular ectopics
- Ventricular bigeminy (alternate ventricular ectopics)
- Atrial tachycardia (with variable block)
- Ventricular tachycardia
- Ventricular fibrillation

16.34 International generic pacemaker code

Chamber paced	Chamber sensed	Response to sensing
O = none	O = none	O = none
A = atrium	A = atrium	T = triggered
V = ventricle	V = ventricle	I = inhibited
D = both	D = both	D = both

16.35 Key indications for implantable cardiac defibrillator therapy

Primary prevention

- After myocardial infarction, if the left ventricular ejection fraction is < 30%
- Mild to moderate symptomatic heart failure on optimal drug therapy, with left ventricular ejection fraction < 35%
- Some patients with inherited cardiac conditions (long QT syndrome, cardiomyopathy)

Secondary prevention

- Survivors of ventricular fibrillation or ventricular tachycardia cardiac arrest not having a transient or reversible cause
- Ventricular tachycardia with haemodynamic compromise or significant left ventricular impairment (left ventricular ejection fraction < 35%)

16.36 Coronary artery disease: clinical manifestations and pathology

Clinical problem	Pathology
Stable angina	Ischaemia due to fixed atheromatous stenosis of one or more coronary arteries
Unstable angina	Ischaemia caused by dynamic complete or partial obstruction of a coronary artery due to plaque rupture or erosion with superimposed thrombosis
Myocardial infarction (type 1)	Myocardial necrosis caused by acute occlusion of a coronary artery due to plaque rupture or erosion with superimposed thrombosis
Myocardial infarction (type 2)	Supply demand imbalance where blood flow cannot meet the needs of the myocardium. This may be caused by fixed atheromatous obstruction with high myocardial demand for blood
Heart failure	Myocardial dysfunction due to infarction or ischaemia
Arrhythmia	Altered conduction due to ischaemia or infarction
Sudden death	Ventricular arrhythmia, asystole or massive myocardial infarction

16.37 Population-based strategies to prevent coronary disease

- Do not smoke
- Take regular exercise (minimum of 20 mins, three times per week)
- Maintain an 'ideal' body weight
- Eat a mixed diet rich in fresh fruit and vegetables
- Aim to get no more than 10% of energy intake from saturated fat

16.38 Factors influencing myocardial oxygen supply and demand

Oxygen demand: cardiac work

- Heart rate
- Blood pressure
- Myocardial contractility
- Left ventricular hypertrophy
- Valve disease

Oxygen supply: coronary blood flow*

- Duration of diastole
- Coronary perfusion pressure (aortic diastolic minus coronary sinus or right atrial diastolic pressure)
- Coronary vasomotor tone
- Oxygenation:
  - Haemoglobin
  - Oxygen saturation

*Coronary blood flow occurs mainly in diastole.

16.39 Classification of angina pectoris and chest pain

Three characteristic features of angina

1. Constricting discomfort in the centre of the chest, or in the neck, shoulders, jaw or arms
2. Precipitated by physical exertion
3. Relieved by rest (or GTN) within 5 minutes

Classification

- **Typical angina**: All three features
- **Atypical angina**: Two features
- **Non-anginal chest pain**: One or no features

NICE classification

- **Possible angina**: Typical angina, atypical angina or non-anginal chest pain with an abnormal resting 12-lead ECG
- **Non-anginal chest pain**: Non-anginal chest pain with a normal resting 12-lead ECG

(ECG = electrocardiogram; GTN = glyceryl trinitrate; NICE = National Institute for Health and Care Excellence)

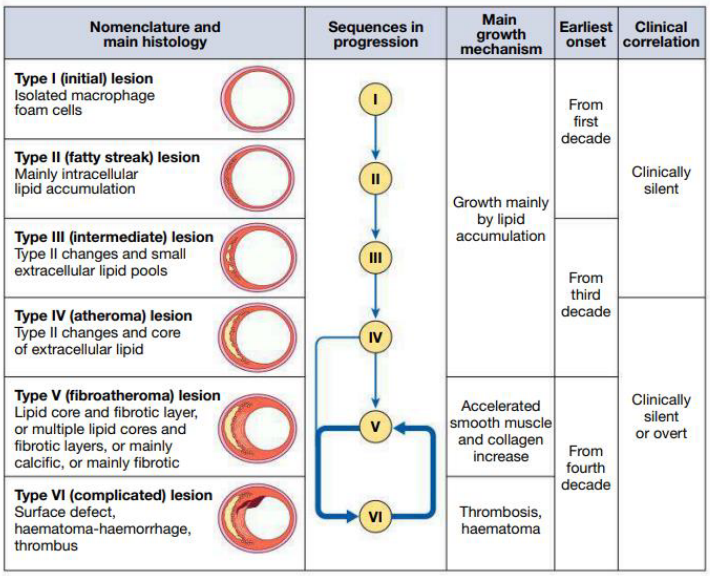


Fig. 16.53 The six stages of atherosclerosis: American Heart Association classification. *From Stary HC, Chandler B, Dinsmore RE, et al. A definition of advanced types of atherosclerotic lesions and a histological classification of atherosclerosis. Circulation 1995; 92:1355–1374. © 1995 American Heart Association.*

16.40 Canadian Cardiovascular Society (CCS) angina score

Class I

- Angina only during strenuous or prolonged physical activity

Class II

- Slight limitation, with angina only during vigorous physical activity

Class III

- Moderate limitation where symptoms occur with everyday activities

Class IV

- Inability to perform any activity without angina or angina at rest, i.e. severe limitation

16.41 Risk stratification in patients with stable angina[1]

High risk	Low risk
Recent-onset symptoms (< 6 months)	Long-standing symptoms
Class II to IV symptoms†	Class I symptoms[2]
Diabetes mellitus	
Comorbidity	
Post-infarct angina	Predictable exertional angina
Ischaemia at low workload	Ischaemia only at high workload
Left main or three-vessel disease	Single-vessel or two-vessel disease
Poor left ventricular function	Good left ventricular function

[1]Patients may fall between these two categories. [2]Canadian Cardiovascular Society Classification.

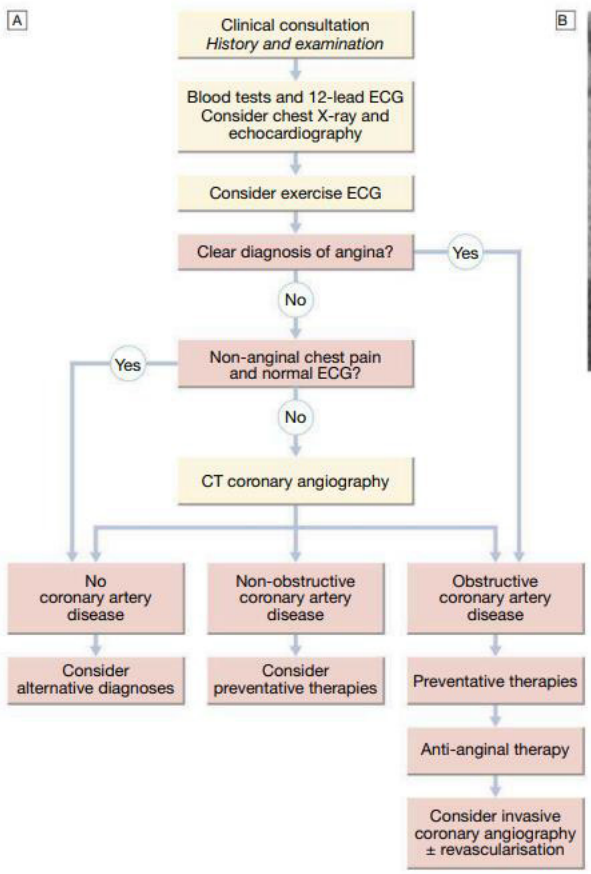
16.42 Advice to patients with stable angina

- Do not smoke
- Aim for an ideal body weight
- Take regular exercise (exercise up to, but not beyond, the point of chest discomfort is beneficial and may promote collateral vessels)
- Avoid severe unaccustomed exertion, and vigorous exercise after a heavy meal or in very cold weather
- Take sublingual nitrate before undertaking exertion that may induce angina

16.43 Duration of action of some nitrate preparations

Preparation	Peak action	Duration of action
Sublingual GTN	4–8 mins	10–30 mins
Buccal GTN	4–10 mins	30–300 mins
Transdermal GTN	1–3 hrs	Up to 24 hrs
Oral isosorbide dinitrate	45–120 mins	2–6 hrs
Oral isosorbide mononitrate	45–120 mins	6–10 hrs

(GTN = glyceryl trinitrate)



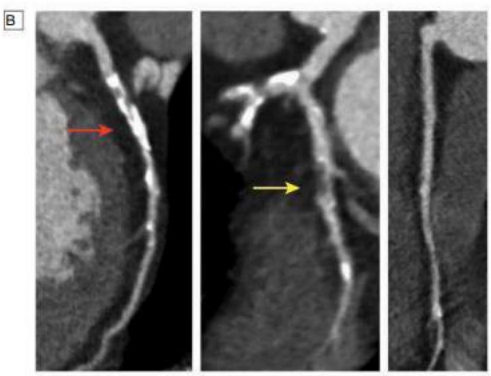


Fig. 16.54 A A scheme for the investigation and treatment of stable angina on effort. This scheme is best adopted for patients without prior known coronary artery disease and possible angina. For patients with known coronary artery disease, further stress imaging (echocardiography, radionuclide perfusion or magnetic resonance perfusion) rather than computed tomography coronary angiography is recommended. B An example CT coronary angiogram showing coronary artery disease in all three vessels with evidence of 'soft' lipid-rich plaque (yellow arrow) and extensive calcified coronary atheroma (red arrow).

16.44 Calcium channel antagonists used for the treatment of angina

Drug	Dose	Feature
Nifedipine	5–20 mg 3 times daily*	May cause marked tachycardia
Nicardipine	20–40 mg 3 times daily	May cause less myocardial depression than the other calcium antagonists
Amlodipine	2.5–10 mg daily	Long-acting
Verapamil	40–80 mg 3 times daily*	Commonly causes constipation; useful anti-arrhythmic properties
Diltiazem	60–120 mg 3 times daily*	Similar anti-arrhythmic properties to verapamil

*Once- or twice-daily sustained-release preparations are available.

16.45 Comparison of percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG)

	PCI	CABG
Death	< 0.5%	< 1.5%
Myocardial infarction*	2%	10%
Hospital stay	6–18 hrs	5–8 days
Return to work	2–5 days	6–12 weeks
Recurrent angina	15%–20% at 6 months	10% at 1 year
Repeat revascularisation	10%–20% at 2 years	2% at 2 years
Neurological complications	Rare	Common (see text)
Other complications	Emergency CABG Vascular damage related to access site	Diffuse myocardial damage Infection (chest, wound) Wound pain

*Defined as CK-MB > 2× normal

16.46 Angina in old age

- **Incidence**: coronary artery disease increases in old age and affects women almost as often as men.
- **Comorbid conditions**: anaemia and thyroid disease are common and may worsen angina.
- **Calcific aortic stenosis**: common and should be sought in all older people with angina.
- **Atypical presentations**: when myocardial ischaemia occurs, age-related changes in myocardial compliance and diastolic relaxation can cause the presentation to be with symptoms of heart failure, such as breathlessness, rather than with chest discomfort.
- **Angioplasty and coronary artery bypass surgery**: provide symptomatic relief, although with increased procedure-related morbidity and mortality. Outcome is determined by the number of diseased vessels, severity of cardiac dysfunction and the number of concomitant diseases, as much as by age itself.

16.48 Criteria for diagnosis of a previously unrecognised myocardial infarction

- Abnormal Q waves with or without symptoms in the absence of non-ischaemic causes
- Imaging evidence of loss of viable myocardium in a pattern consistent with ischaemic aetiology
- Patho-anatomical findings of a prior MI

Adapted from Thygesen K, Alpert JS, Jaffe AS, et al. Fourth universal definition of myocardial infarction. Eur Heart J 2019; 40: 237–269.

16.47 Classification and criteria for diagnosis of acute myocardial infarction

Criteria for acute myocardial infarction

The term acute myocardial infarction (MI) should be used when there is acute myocardial injury with clinical evidence of acute myocardial ischaemia and with detection of a rise and/or fall of cardiac troponin values with at least one value above the 99th centile upper reference limit and at least one of the following:

- Symptoms of myocardial ischaemia
- New ischaemic ECG changes
- Development of pathological Q waves
- Imaging evidence of new loss of viable myocardium or new regional wall motion abnormality in a pattern consistent with an ischaemic aetiology
- Identification of a coronary thrombus by angiography or autopsy

Classification of acute myocardial infarction

- **Type 1 MI:** Acute atherothrombosis in the artery supplying the infarcted myocardium
- **Type 2 MI:** An imbalance between myocardial oxygen supply and demand unrelated to acute atherothrombosis
- **Type 3 MI:** Cardiac death in patients with symptoms suggestive of myocardial ischaemia and presumed new ischaemic ECG changes before cardiac troponin values become available or abnormal
- **Type 4 MI:** MI caused during percutaneous coronary intervention (PCI; type 4a). Other types include stent thrombosis (type 4b) and restenosis (type 4c) and consistent with type 1 MI
- **Type 5 MI:** MI caused during coronary artery bypass grafting

Coronary procedure-related MI ≤ 48 hours after the index procedure is arbitrarily defined by an elevation of cardiac troponin values > 5× for type 4a MI and > 10× for type 5 MI of the 99th centile upper reference limit in patients with normal baseline values together with at least one of the following:

- New ischaemic ECG changes (this criterion is related to type 4a MI only)
- Development of new pathological Q waves
- Imaging evidence of loss of viable myocardium that is presumed to be new and consistent with an ischaemic aetiology
- Angiographic findings consistent with a procedural flow-limiting complication such as coronary dissection, occlusion of a major epicardial artery or graft, side-branch occlusion-thrombus, disruption of collateral flow or distal embolisation

Adapted from Thygesen K, Alpert JS, Jaffe AS, et al. Fourth universal definition of myocardial infarction. Eur Heart J 2019; 40: 237–269.

16.49 Clinical features of acute coronary syndromes

Symptoms

- Prolonged cardiac pain: chest, throat, arms, epigastrium or back
- Anxiety and fear of impending death
- Nausea and vomiting
- Breathlessness
- Collapse/syncope

Physical signs

Signs of sympathetic activation

- Pallor
- Sweating
- Tachycardia

Signs of vagal activation

- Vomiting
- Bradycardia

Signs of impaired myocardial function

- Hypotension, oliguria, cold peripheries
- Narrow pulse pressure
- Raised jugular venous pressure
- Third heart sound
- Quiet first heart sound
- Diffuse apical impulse
- Lung crepitations

Low-grade fever

16.50 Common arrhythmias in acute coronary syndrome

- Ventricular fibrillation
- Ventricular tachycardia
- Accelerated idioventricular rhythm
- Ventricular ectopics
- Atrial fibrillation
- Sinus bradycardia (particularly after inferior myocardial infarction)
- Atrioventricular block

1. Find points for each predictive factor

Killip class	Points	SBP (mmHg)	Points	Heart rate (beats/min)	Points	Age (years)	Points	Serum creatinine level (μmol/L)	Points
I	0	≤ 80	58	≤ 50	0	≤ 30	0	0–34	1
II	20	80–99	53	50–69	3	30–39	8	35–70	4
III	39	100–119	43	70–89	9	40–49	25	71–105	7
IV	59	120–139	34	90–109	15	50–59	41	106–140	10
		140–159	24	110–149	24	60–69	58	141–176	13
		160–199	10	150–199	38	70–79	75	177–353	21
		≥ 200	0	≥ 200	46	80–89	91	≥ 354	28
						≥ 90	100		

Other risk factors	Points
Cardiac arrest at admission	39
ST-segment deviation	28
Elevated cardiac biomarker concentrations	14

2. Sum points for all predictive factors

Killip class	+	SBP	+	Heart rate	+	Age	+	Creatinine level	+	Cardiac arrest at admission	+	ST-segment deviation	+	Elevated cardiac biomarker concentrations	=	Total points

3. Look up risk corresponding to total points

Total points	≤ 60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	≥ 250
Probability of in-hospital death (%)	≤ 0.2	0.3	0.4	0.6	0.8	1.1	1.6	2.1	2.9	3.9	5.4	7.3	9.8	13	18	23	29	36	44	≥ 52

Examples

A patient has Killip class II, SBP of 99 mmHg, heart rate of 100 beats/min, is 65 years of age, has a serum creatinine level of 76 μmol/L, did not have a cardiac arrest at admission but did have ST-segment deviation and elevated cardiac troponin. His score would be: 20 + 53 + 15 + 58 + 7 + 0 + 28 + 14 = 195. This gives about a 16% risk of having an in-hospital death.

Similarly, a patient with Killip class I, SBP of 80 mmHg, heart rate of 60 beats/min, who is 55 years of age, has a serum creatinine level of 30 μmol/L, and no risk factors would have the following score: 0 + 58 + 3 + 41 + 1 = 103. This gives about a 0.9% risk of having an in-hospital death.

Fig. 16.61 Risk stratification in the acute coronary syndrome: the GRACE score. Killip class refers to a categorisation of the severity of heart failure based on easily obtained clinical signs. The main clinical features are as follows: class I = no heart failure; class II = crackles audible halfway up the chest; class III = crackles heard in all the lung fields; class IV = cardiogenic shock. To convert creatinine in μmol/L to mg/dL, divide by 88.4. (SBP = systolic blood pressure) *From Scottish Intercollegiate Guidelines Network (SIGN) Guideline no. 93 – Acute coronary syndromes; updated February 2013.*

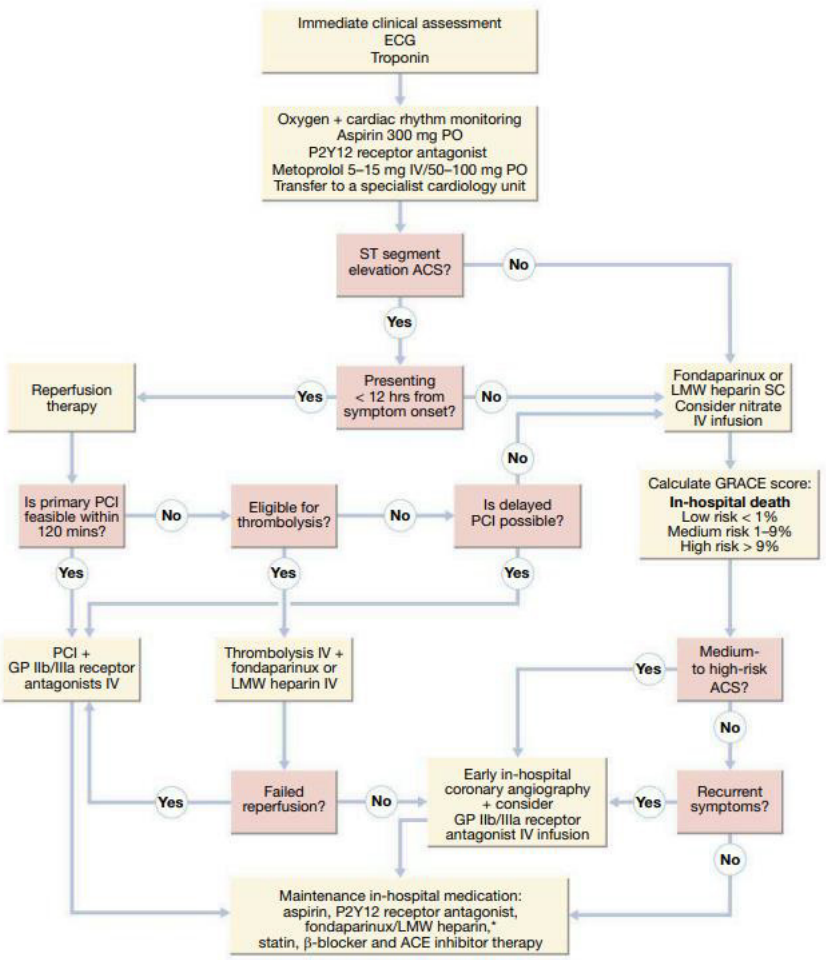


Fig. 16.69 Summary of treatment for acute coronary syndrome (ACS). *Not required following PCI. For details of the GRACE score, see Fig. 16.61. (ACE = angiotensin-converting enzyme; ECG = electrocardiogram; GP = glycoprotein; IV = intravenous; LMW = low-molecular-weight; PCI = percutaneous coronary intervention; PO = by mouth; SC = subcutaneous) *Adapted from Scottish Intercollegiate Guidelines Network (SIGN) Guideline no. 93 – Acute coronary syndromes, February 2007 and updated in SIGN 148, April 2016.*

16.51 Late management of myocardial infarction

Risk stratification and further investigation

See text for details

Lifestyle modification

- Diet (weight control, lipid-lowering, 'Mediterranean diet')
- Cessation of smoking
- Regular exercise

Secondary prevention drug therapy

- Antiplatelet therapy (aspirin and/or clopidogrel)
- β-blocker
- ACE inhibitor/ARB
- Statin
- Additional therapy for control of diabetes and hypertension
- Mineralocorticoid receptor antagonist

Rehabilitation

Devices

- Implantable cardiac defibrillator (high-risk patients)

(ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker)

16.52 Relative contraindications to thrombolytic therapy

- Active internal bleeding
- Previous subarachnoid or intracerebral haemorrhage
- Uncontrolled hypertension
- Recent surgery (within 1 month)
- Recent trauma (including traumatic resuscitation)
- High probability of active peptic ulcer
- Pregnancy

16.53 Myocardial infarction in old age

- **Atypical presentation**: often with anorexia, fatigue, weakness, delirium or falls rather than chest pain.
- **Case fatality**: rises steeply. Hospital mortality exceeds 25% in those over 75 years old, which is five times greater than that seen in those aged less than 55 years.
- **Survival benefit of treatments**: not influenced by age. The absolute benefit of evidence-based treatments may therefore be greatest in older people.
- **Hazards of treatments**: rise with age (for example, increased risk of intracerebral bleeding after thrombolysis) and are due partly to increased comorbidity.
- **Quality of evidence**: older patients, particularly those with significant comorbidity, were under-represented in many of the randomised controlled clinical trials that helped to establish the treatment of myocardial infarction. The balance of risk and benefit for many treatments, such as thrombolysis and primary percutaneous transluminal coronary angiography, in frail older people is uncertain.

16.54 Major risk factors for cardiac complications of non-cardiac surgery

- Recent (< 6 months) myocardial infarction or unstable angina
- Severe coronary artery disease: left main stem or three-vessel disease
- Severe stable angina on effort
- Severe left ventricular dysfunction
- Severe valvular heart disease (especially aortic stenosis)

16.57 Symptoms *and* signs of acute limb ischaemia

Symptoms/signs	Comment
Pain **Pallor** **Pulselessness**	May be absent in complete acute ischaemia, and can be present in chronic ischaemia
Perishing cold	Unreliable, as the ischaemic limb takes on the ambient temperature
Paraesthesia **Paralysis**	Important features of impending irreversible ischaemia

16.55 Factors influencing the clinical manifestations of peripheral arterial disease (PAD)

Anatomical site

Cerebral circulation

- TIA, amaurosis fugax, vertebrobasilar insufficiency

Renal arteries

- Hypertension and renal failure

Mesenteric arteries

- Mesenteric angina, acute intestinal ischaemia

Limbs (legs >> arms)

- Intermittent claudication, critical limb ischaemia, acute limb ischaemia

Collateral supply

- In a patient with a complete circle of Willis, occlusion of one carotid artery may be asymptomatic
- In a patient without cross-circulation, stroke is likely

Speed of onset

- Where PAD develops slowly, a collateral supply will develop
- Sudden occlusion of a previously normal artery is likely to cause severe distal ischaemia

Mechanism of injury

Haemodynamic

- Plaque must reduce arterial diameter by 70% ('critical stenosis') to reduce flow and pressure at rest. On exertion a moderate stenosis may become 'critical'. This mechanism tends to have a relatively benign course due to collateralisation

Thrombotic

- Occlusion of a long-standing critical stenosis may be asymptomatic due to collateralisation. However, acute rupture and thrombosis of a non-haemodynamically significant plaque usually has severe consequences

Atheroembolic

- Symptoms depend on embolic load and size
- Carotid (TIA, amaurosis fugax or stroke) and peripheral arterial (blue toe/finger syndrome) plaque are common examples

Thromboembolic

- Usually secondary to atrial fibrillation
- The consequences are usually dramatic, as the thrombus load is often large and occludes a major, previously healthy, non-collateralised artery suddenly and completely

(TIA = transient ischaemic attack)

16.56 Peripheral vascular disease in diabetes

Feature	Difficulty
Arterial calcification	Spuriously high ABPI due to incompressible ankle vessels. Inability to clamp arteries for the purposes of bypass surgery. Resistant to angioplasty
Immunocompromise	Prone to rapidly spreading cellulitis, gangrene and osteomyelitis
Multisystem arterial disease	Coronary and cerebral arterial disease increase the risks of intervention
Distal disease	Diabetic vascular disease has a predilection for the calf vessels. Although vessels in the foot are often spared, performing a satisfactory bypass or angioplasty to these small vessels is a technical challenge
Sensory neuropathy	Even severe ischaemia and/or tissue loss may be completely painless. Diabetic patients often present late with extensive destruction of the foot. Loss of proprioception leads to abnormal pressure loads and worsens joint destruction (Charcot joints)
Motor neuropathy	Weakness of the long and short flexors and extensors leads to abnormal foot architecture, abnormal pressure loads, callus formation and ulceration
Autonomic neuropathy	Leads to a dry foot deficient in sweat that normally lubricates the skin and is antibacterial. Scaling and fissuring create a portal of entry for bacteria. Abnormal blood flow in the bones of the ankle and foot may also contribute to osteopenia and bony collapse

(ABPI = ankle–brachial pressure index)

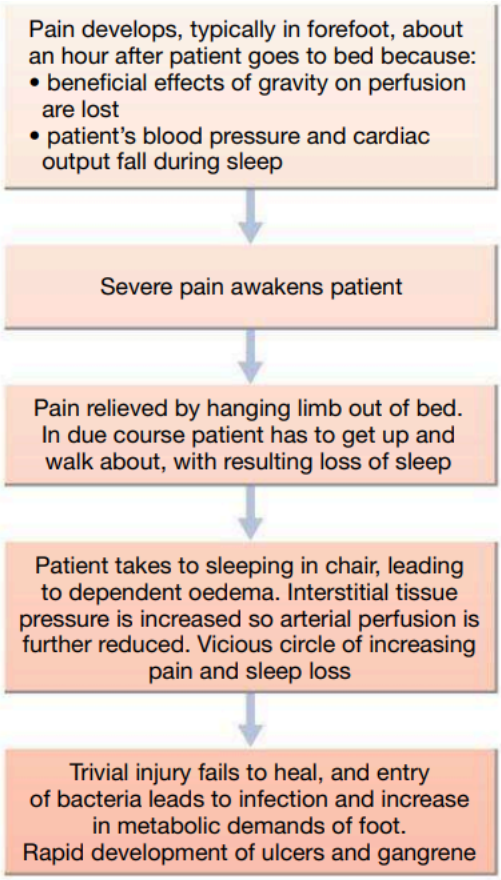


Fig. 16.70 **Progressive night pain and the development of tissue loss.**

16.58 Distinguishing features of embolism and thrombosis in peripheral arteries

Clinical features	Embolism	Thrombosis
Severity	Complete (no collaterals)	Incomplete (collaterals)
Onset	Seconds or minutes	Hours or days
Limb	Leg 3:1 arm	Leg 10:1 arm
Multiple sites	Up to 15%	Rare
Embolic source	Present (usually atrial fibrillation)	Absent
Previous claudication	Absent	Present
Palpation of artery	Soft, tender	Hard, calcified
Bruits	Absent	Present
Contralateral leg pulses	Present	Absent
Diagnosis	Clinical	Angiography
Treatment	Embolectomy, warfarin	Medical, bypass, thrombolysis
Prognosis	Loss of life > loss of limb	Loss of limb > loss of life

16.59 Clinical features of chronic lower limb ischaemia

- Pulses: diminished or absent
- Bruits: denote turbulent flow but bear no relationship to the severity of the underlying disease
- Reduced skin temperature
- Pallor on elevation and rubor on dependency (Buerger's sign)
- Superficial veins that fill sluggishly and empty ('gutter') on minimal elevation
- Muscle-wasting
- Skin and nails: dry, thin and brittle
- Loss of hair

Box 16.60 Medical therapy for peripheral arterial disease

- Smoking cessation
- Regular exercise (30 mins of walking, three times per week)
- Antiplatelet agent (aspirin 75 mg or clopidogrel 75 mg daily)
- Consider low-dose factor Xa inhibitor (rivaroxaban 2.5 mg twice daily)
- Reduction of cholesterol: statins
- Diet and weight loss
- Diagnosis and treatment of diabetes mellitus
- Diagnosis and treatment of associated conditions:
  - Hypertension
  - Anaemia
  - Heart failure

16.61 Atherosclerotic vascular disease in old age

- **Prevalence**: related almost exponentially to age in developed countries, although atherosclerosis is not considered part of the normal ageing process.
- **Statin therapy**: no role in the primary prevention of atherosclerotic disease in those over 75 years but reduces cardiovascular events in those with established vascular disease, albeit with no reduction in overall mortality.
- **Presentation in the frail**: frequently with advanced multisystem arterial disease, along with a host of other comorbidities.
- **Intervention in the frail**: in those with extensive disease and limited life expectancy, the risks of surgery may outweigh the benefits, and symptomatic care is all that should be offered.

16.62 Abdominal aortic aneurysm (AAA): common presentations

Incidental

- On physical examination, plain X-ray or, most commonly, abdominal ultrasound
- Even large AAAs can be difficult to feel, so many remain undetected until they rupture
- Studies are currently under way to determine whether screening will reduce the number of deaths from rupture

Pain

- In the central abdomen, back, loin, iliac fossa or groin

Thromboembolic complications

- Thrombus within the aneurysm sac may be a source of emboli to the lower limbs
- Less commonly, the aorta may undergo thrombotic occlusion

Compression

- Surrounding structures such as the duodenum (obstruction and vomiting) and the inferior vena cava (oedema and deep vein thrombosis)

Rupture

- Into the retroperitoneum, the peritoneal cavity or surrounding structures (most commonly the inferior vena cava, leading to an aortocaval fistula)

16.63 Risk factors for aortic dissection

- Hypertension (in 80%)
- Atherosclerosis
- Coarctation
- Genetic:
  - Marfan syndrome
  - Ehlers–Danlos syndrome
- Fibromuscular dysplasia
- Previous cardiac surgery:
  - CABG
  - Aortic valve replacement
- Pregnancy (usually third trimester)
- Trauma
- Iatrogenic:
  - Cardiac catheterisation
  - Intra-aortic balloon pumping

(CABG = coronary artery bypass grafting)

16.64 Definition of hypertension

Category	Systolic blood pressure (mmHg)	Diastolic blood pressure (mmHg)
Blood pressure		
Optimal	<120	<80
Normal	<130	85
High normal	130–139	85–89
Hypertension		
Grade 1 (mild)	140–159	90–99
Grade 2 (moderate)	160–179	100–109
Grade 3 (severe)	≥ 180	>110
Isolated systolic hypertension		
Grade 1	140–159	< 90
Grade 2	≥ 160	<90

16.65 Causes of secondary hypertension

Alcohol

Obesity

Pregnancy

Renal disease

- Parenchymal renal disease, particularly glomerulonephritis
- Renal vascular disease
- Polycystic kidney disease

Endocrine disease

- Phaeochromocytoma
- Cushing's syndrome
- Primary hyperaldosteronism (Conn syndrome)
- Glucocorticoid-suppressible hyperaldosteronism
- Hyperparathyroidism
- Acromegaly
- Primary hypothyroidism
- Thyrotoxicosis
- Congenital adrenal hyperplasia due to 11β-hydroxylase or 17α-hydroxylase deficiency
- Liddle syndrome
- 11β-hydroxysteroid dehydrogenase deficiency

Drugs

Coarctation of the aorta

16.66 Hypertensive retinopathy

Grade 1

- Arteriolar thickening, tortuosity and increased reflectiveness ('silver wiring')

Grade 2

- Grade 1 plus constriction of veins at arterial crossings ('arteriovenous nipping')

Grade 3

- Grade 2 plus evidence of retinal ischaemia (flame-shaped or blot haemorrhages and 'cotton wool' exudates)

Grade 4

- Grade 3 plus papilloedema

16.67 How to measure blood pressure

- Use a machine that has been validated, well maintained and properly calibrated
- Measure sitting BP routinely, with additional standing BP in older and diabetic patients and those with possible postural hypotension; rest the patient for 2 minutes
- Remove tight clothing from the arm
- Support the arm at the level of the heart
- Use a cuff of appropriate size (the bladder must encompass more than two-thirds of the arm)
- Lower the pressure slowly (2 mmHg per second)
- Read the BP to the nearest 2 mmHg
- Use phase V (disappearance of sounds) to measure diastolic BP
- Take two measurements at each visit

16.68 Investigation of hypertension

- Urinalysis for blood, protein and glucose
- Blood urea, electrolytes and creatinine
  Hypokalaemic alkalosis may indicate primary hyperaldosteronism but is usually due to diuretic therapy
- Blood glucose
- Serum total and HDL cholesterol
- Thyroid function tests
- 12-lead ECG (left ventricular hypertrophy, coronary artery disease)

(HDL = high-density lipoprotein)

16.69 Specialised investigation of hypertension

- Chest X-ray: to detect cardiomegaly, heart failure, coarctation of the aorta
- Ambulatory BP recording: to assess borderline or 'white coat' hypertension
- Echocardiogram: to detect or quantify left ventricular hypertrophy
- Renal ultrasound: to detect possible renal disease
- Renal angiography: to detect or confirm the presence of renal artery stenosis
- Urinary catecholamines: to detect possible phaeochromocytoma)
- Urinary cortisol and dexamethasone suppression test: to detect possible Cushing's syndrome
- Plasma renin activity and aldosterone: to detect possible primary aldosteronism

16.70 Hypertension in old age

- **Prevalence**: hypertension affects more than half of all people over the age of 60 years (including isolated systolic hypertension).
- **Risks**: hypertension is the most important risk factor for myocardial infarction, heart failure and stroke in older people.
- **Benefit of treatment**: absolute benefit from therapy is greatest in older people (at least up to age 80 years).
- **Target blood pressure**: targets may be relaxed in older people to 150/90 mmHg.
- **Tolerance of treatment**: antihypertensives are tolerated as well as in younger patients.
- **Drug of choice**: low-dose thiazides but, in the presence of coexistent disease such as gout or diabetes, other agents may be more appropriate.

16.71 Optimal target blood pressures[1]

Age	Clinic BP (mmHg)	Ambulatory or home BP (mmHg)[2]
<80 years	<140/90	<135/85
≥80 years	<150/90	< 140/85

[1]Both systolic and diastolic values should be attained. [2]Average BP during waking hours.

16.72 The influence of comorbidity on choice of antihypertensive drug therapy

Class of drug	Compelling indications	Possible indications	Caution	Compelling contraindications
α-blockers	Benign prostatic hypertrophy	–	Postural hypotension, heart failure[1]	Urinary incontinence
ACE inhibitors	Heart failure Left ventricular dysfunction, post-MI or established CAD Type 1 diabetic nephropathy Secondary stroke prevention[4]	Chronic renal disease[2] Type 2 diabetic nephropathy	Renal impairment[2] PAD[3]	Pregnancy Renovascular disease[2]
Angiotensin II receptor blockers	ACE inhibitor intolerance Type 2 diabetic nephropathy Hypertension with left ventricular hypertrophy Heart failure in ACE-intolerant patients, after MI	Left ventricular dysfunction after MI Intolerance of other antihypertensive drugs Proteinuric or chronic renal disease[2] Heart failure	Renal impairment[2] PAD[3]	Pregnancy
β-blockers	MI, angina Heart failure[5]	–	Heart failure[6] PAD Diabetes (except with CAD)	Asthma or chronic obstructive pulmonary disease Heart block
Calcium channel blockers (dihydropyridine)	Older patients, isolated systolic hypertension	Angina	–	–
Calcium channel blockers (rate-limiting)	Angina	Older patients	Combination with β-blockade	Atrioventricular block, heart failure
Thiazides or thiazide-like diuretics	Older patients, isolated systolic hypertension, heart failure, secondary stroke prevention	–	–	Gout[8]

[1]In heart failure when used as monotherapy. [2]ACE inhibitors or ARBs may be beneficial in chronic renal failure and renovascular disease but should be used with caution, close supervision and specialist advice when there is established and significant renal impairment. [3]Caution with ACE inhibitors and ARBs in PAD because of association with renovascular disease. [4]In combination with a thiazide or thiazide-like diuretic. [5]β-blockers are used increasingly to treat stable heart failure but may worsen acute heart failure. [6]Thiazides or thiazide-like diuretics may sometimes be necessary to control BP in people with a history of gout, ideally used in combination with allopurinol.
(ACE = angiotensin-converting enzyme; ARBs = angiotensin II receptor blockers; CAD = coronary artery disease; MI = myocardial infarction; PAD = peripheral arterial disease)

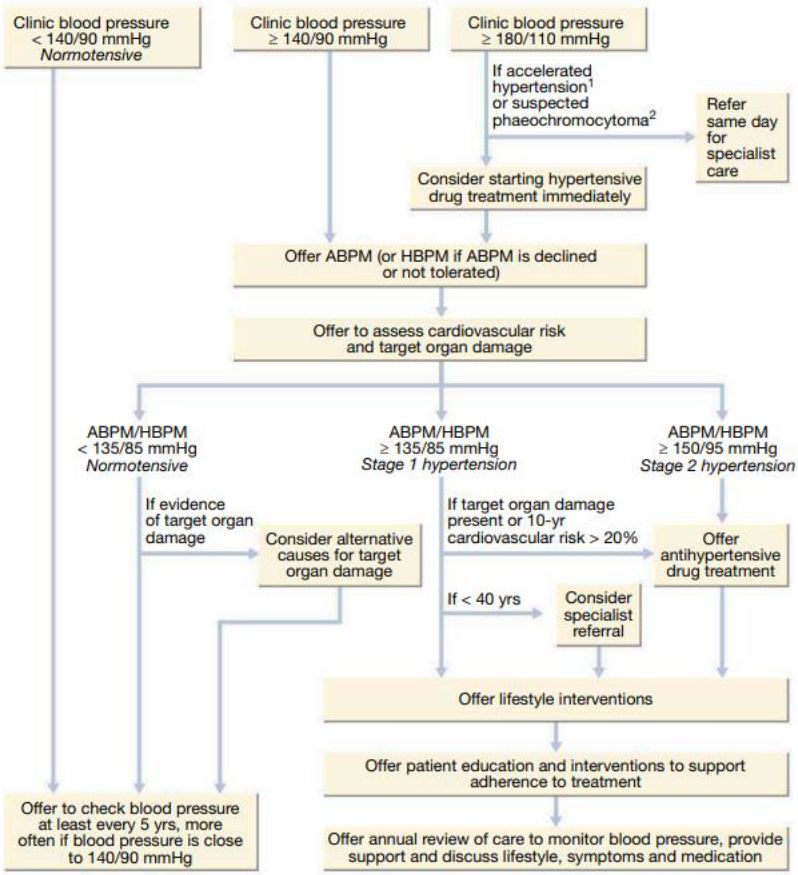


Fig. 16.76 Management of hypertension. [1]Signs of papilloedema or retinal haemorrhage. [2]Labile or postural hypotension, headache, palpitations, pallor and diaphoresis. (ABPM = ambulatory blood pressure monitoring; HBPM = home blood pressure monitoring). *Adapted from 2020 International Society of Hypertension Global Hypertension Practice Guidelines.*

16.73 Causes of acute valve failure

Aortic regurgitation

- Aortic dissection
- Infective endocarditis

Mitral regurgitation

- Papillary muscle rupture due to acute myocardial infarction
- Infective endocarditis
- Rupture of chordae due to myxomatous degeneration

Prosthetic valve failure

- Mechanical valves: fracture, jamming, thrombosis, dehiscence
- Biological valves: degeneration with cusp tear

16.74 Principal causes of valve disease

Valve regurgitation

- Congenital
- Acute rheumatic carditis
- Chronic rheumatic carditis
- Infective endocarditis
- Cardiac failure*
- Syphilitic aortitis
- Traumatic valve rupture
- Senile degeneration
- Damage to chordae and papillary muscles

Valve stenosis

- Congenital
- Rheumatic carditis
- Senile degeneration

*Causes dilatation of the valve ring.

16.79 Criteria for mitral valvuloplasty*

- Significant symptoms
- Isolated mitral stenosis
- No (or trivial) mitral regurgitation
- Mobile, non-calcified valve/subvalve apparatus on echo
- Left atrium free of thrombus

*For comprehensive guidelines on valvular heart disease, see www.acc.org.

16.75 Jones criteria for the diagnosis of rheumatic fever

Major manifestations

- Carditis
- Polyarthritis
- Chorea
- Erythema marginatum
- Subcutaneous nodules

Minor manifestations

- Fever
- Arthralgia
- Raised erythrocyte sedimentation rate or C-reactive protein
- Previous rheumatic fever
- Leucocytosis
- First-degree atrioventricular block

Plus

- Supporting evidence of preceding streptococcal infection: recent scarlet fever, raised antistreptolysin O or other streptococcal antibody titre, positive throat culture*

*Evidence of recent streptococcal infection is particularly important if there is only one major manifestation.

16.76 Investigations in acute rheumatic fever

Evidence of a systemic illness

- Leucocytosis, raised erythrocyte sedimentation rate and C-reactive protein

Evidence of preceding streptococcal infection

- Throat swab culture: group A β-haemolytic streptococci (also from family members and contacts)
- Antistreptolysin O antibodies (ASO titres): rising titres, or levels of > 200 U (adults) or > 300 U (children)

Evidence of carditis

- Chest X-ray: cardiomegaly; pulmonary congestion
- ECG: first- and, rarely, second-degree atrioventricular block; features of pericarditis; T-wave inversion; reduction in QRS voltages
- Echocardiography: cardiac dilatation and valve abnormalities

16.77 Clinical features of mitral stenosis

Clinical feature	Cause
Symptoms	
Breathlessness	Pulmonary congestion, low cardiac output
Fatigue	Low cardiac output
Oedema, ascites	Right heart failure
Palpitation	Atrial fibrillation
Haemoptysis	Pulmonary congestion
Cough	Pulmonary congestion
Chest pain	Pulmonary hypertension
Thromboembolism	Atrial stasis and atrial fibrillation
Signs	
Atrial fibrillation	Atrial dilatation
Mitral facies	Low cardiac output
Auscultation:	
Loud first heart sound, opening snap	Non-compliant, stenotic valve
Mid-diastolic murmur	
Crepitations	Left heart failure
Pulmonary oedema	
Pleural effusions	
Right ventricular heave, loud P_2	Pulmonary hypertension

16.78 Investigations in mitral stenosis

ECG

- Right ventricular hypertrophy: tall R waves in V_1–V_3
- P mitrale or atrial fibrillation

Chest X-ray

Enlarged left atrium and appendage — Signs of pulmonary venous congestion

Echo

- Thickened immobile cusps
- Reduced valve area
- Enlarged left atrium
- Reduced rate of diastolic filling of left ventricle

Doppler

- Pressure gradient across mitral valve
- Pulmonary artery pressure
- Left ventricular function

Cardiac catheterisation

- Coronary artery disease
- Pulmonary artery pressure
- Mitral stenosis and regurgitation

16.81 Clinical features of mitral regurgitation

Clinical feature	Cause
Symptoms	
Breathlessness	Pulmonary congestion
Fatigue	Low cardiac output
Oedema, ascites	Right heart failure
Palpitation	Atrial fibrillation
Signs	
Atrial fibrillation	Atrial dilatation
Displaced apex beat	Cardiomegaly
Auscultation:	
Apical pansystolic murmur	Regurgitation of blood from left ventricle to left atrium
Soft S1	Valve does not close properly
Apical S3	Rapid flow of blood into left ventricle
Crepitations	Left heart failure
Pulmonary oedema	
Pleural effusions	
Right ventricular heave	Pulmonary hypertension
Raised jugular venous pressure	Right heart failure
Oedema	Right heart failure

16.82 Investigations in mitral regurgitation

ECG

- P-mitrale
- Atrial fibrillation

Chest X-ray

- Enlarged left atrium
- Enlarged left ventricle
- Pulmonary venous congestion
- Pulmonary oedema (if acute)

Echo

- Dilated left atrium, left ventricle
- Dynamic left ventricle (unless myocardial dysfunction predominates)
- Structural abnormalities of mitral valve

Doppler

- Detects and quantifies regurgitation

Cardiac catheterisation

- Dilated left atrium, dilated left ventricle, mitral regurgitation
- Pulmonary hypertension
- Coexisting coronary artery disease

16.83 Medical management of mitral regurgitation

- Diuretics
- Vasodilators if hypertension is present
- Digoxin if atrial fibrillation is present
- Anticoagulants if atrial fibrillation is present

16.84 Causes of aortic stenosis

Infants, children, adolescents

- Congenital aortic stenosis
- Congenital subvalvular aortic stenosis
- Congenital supravalvular aortic stenosis

Young to middle-aged adults

- Calcification and fibrosis of congenitally bicuspid aortic valve
- Rheumatic aortic stenosis

Middle-aged to older adults

- Senile degenerative aortic stenosis
- Calcification of bicuspid valve
- Rheumatic aortic stenosis

16.85 Clinical features of aortic stenosis

Symptoms

- Mild or moderate stenosis: usually asymptomatic
- Exertional dyspnoea
- Angina
- Exertional syncope
- Sudden death
- Episodes of acute pulmonary oedema

Signs

- Ejection systolic murmur
- Slow-rising carotid pulse
- Heaving apex beat (left ventricular pressure overload)
- Narrow pulse pressure
- Signs of pulmonary venous congestion

16.86 Investigations in aortic stenosis

ECG

- Left ventricular hypertrophy
- Left bundle branch block

Chest X-ray

- May be normal; sometimes enlarged left ventricle and dilated ascending aorta on postero-anterior view, calcified valve on lateral view

Echo

- Calcified valve with restricted opening, hypertrophied left ventricle

Doppler

- Measurement of severity of stenosis
- Detection of associated aortic regurgitation

Cardiac catheterisation

- Mainly to identify associated coronary artery disease
- May be used to measure gradient between left ventricle and aorta

16.87 Aortic stenosis in old age

- **Incidence**: the most common form of valve disease affecting the very old.
- **Symptoms**: a common cause of syncope, angina and heart failure in the very old.
- **Signs**: because of increasing stiffening in the central arteries, low pulse pressure and a slow-rising pulse may not be present.
- **Transcatheter aortic valve implantation (TAVI)**: a good option in older individuals because less invasive than surgery.
- **Surgery**: can be successful in those aged 80 years or more in the absence of comorbidity, but with a higher operative mortality. The prognosis without surgery is poor once symptoms have developed.
- **Valve replacement type**: a biological valve is often preferable to a mechanical one because this obviates the need for anticoagulation, and the durability of biological valves usually exceeds the patient's anticipated life expectancy.

16.88 Causes of aortic regurgitation

Congenital

- Bicuspid valve or disproportionate cusps

Acquired

- Rheumatic disease
- Infective endocarditis
- Trauma
- Causes of aortic dilatation:
  - Marfan syndrome
  - Aneurysm
  - Aortic dissection
  - Syphilis
  - Ankylosing spondylitis

16.89 Clinical features of aortic regurgitation

Symptoms

Mild to moderate aortic regurgitation

- Often asymptomatic
- Palpitations

Severe aortic regurgitation

- Breathlessness
- Angina

Signs

Pulses

- Large-volume or 'collapsing' pulse
- Low diastolic and increased pulse pressure
- Bounding peripheral pulses
- Capillary pulsation in nail beds: Quincke's sign
- Femoral bruit ('pistol shot'): Duroziez's sign
- Head nodding with pulse: de Musset's sign

Murmurs

- Early diastolic murmur
- Systolic murmur (increased stroke volume)
- Austin Flint murmur (soft mid-diastolic)

Other signs

- Displaced, thrusting apex beat (volume overload)
- Pre-systolic impulse
- Third heart sound
- Fourth heart sound
- Crepitations (pulmonary venous congestion)

16.90 Investigations in aortic regurgitation

ECG

- Initially normal, later left ventricular hypertrophy and T-wave inversion

Chest X-ray

- Cardiac dilatation, maybe aortic dilatation
- Features of left heart failure

Echo

- Dilated left ventricle
- Hyperdynamic left ventricle
- Doppler detects reflux
- Fluttering anterior mitral leaflet

Cardiac catheterisation*

- Dilated left ventricle
- Aortic regurgitation
- Dilated aortic root

*Not always required.

16.91 Causes of tricuspid regurgitation

Primary

- Rheumatic heart disease
- Endocarditis, particularly in intravenous drug users
- Ebstein's congenital anomaly (see Box 16.102)

Secondary

- Right ventricular failure
- Right ventricular infarction
- Pulmonary hypertension, secondary to chronic pulmonary disease

16.92 Anticoagulation targets and prosthetic heart valves

Mechanical valves	Target INR
Ball and cage (e.g. Starr–Edwards) **Tilting disc** (e.g. Bjork–Shiley)	3.0–4.0
Bi-leaflet (e.g. St Jude)	2.5–3.0
Biological valves with atrial fibrillation	2.0–3.0

(INR = International Normalised Ratio)

16.93 Endocarditis in old age

- **Symptoms and signs**: may be non-specific, with delirium, weight loss, malaise and weakness, and the diagnosis may not be suspected.
- **Common causative organisms**: often enterococci (from the urinary tract) and *Streptococcus gallolyticus* subsp. *gallolyticus* (from a colonic source).
- **Morbidity and mortality**: much higher.

16.94 Microbiology of infective endocarditis

Pathogen	Of native valve (n = 280)	In injection drug users (n = 87)	Of prosthetic valve	
			Early (n = 15)	Late (n = 72)
Staphylococci	124 (44%)	60 (69%)	10 (67%)	33 (46%)
Staph. aureus	106 (38%)	60 (69%)	3 (20%)	15 (21%)
Coagulase-negative	18 (6%)	0	7 (47%)	18 (25%)
Streptococci	86 (31%)	7 (8%)	0	25 (35%)
Oral	59 (21%)	3 (3%)	0	19 (26%)
Others (non-enterococcal)	27 (10%)	4 (5%)	0	6 (8%)
***Enterococcus* spp.**	21 (8%)	2 (2%)	1 (7%)	5 (7%)
HACEK	12 (4%)	0	0	1 (1%)
Polymicrobial	6 (2%)	8 (9%)	0	1 (1%)
Other bacteria	12 (4%)	4 (5%)	0	2 (3%)
Fungi	3 (1%)	2 (2%)	0	0
Negative blood culture	16 (6%)	4 (5%)	4 (27%)	5 (7%)

HACEK = Haemophilus aphrophilus – now known as Aggregatibacter aphrophilus–Aggregatibacter actinomycetemcomitans; Cardiobacterium hominis; Eikenella corrodens; and Kingella kingae)
Adapted from Morellon P, Que YA. Infective endocarditis. Lancet 2004; 363:139–149.

16.95 Diagnosis of infective endocarditis*

Major criteria

Positive blood culture

- Typical organism from two cultures
- Persistent positive blood cultures taken > 12 hrs apart
- Three or more positive cultures taken over > 1 hr

Endocardial involvement

- Positive echocardiographic findings of vegetations
- New valvular regurgitation

Minor criteria

- Predisposing valvular or cardiac abnormality
- Intravenous drug misuse
- Pyrexia ≥ 38°C
- Embolic phenomenon
- Vasculitic phenomenon
- Blood cultures suggestive: organism grown but not achieving major criteria
- Suggestive echocardiographic findings

*Modified Duke criteria. Patients with two major, or one major and three minor, or five minor have definite endocarditis. Patients with one major and one minor, or three minor have possible endocarditis.

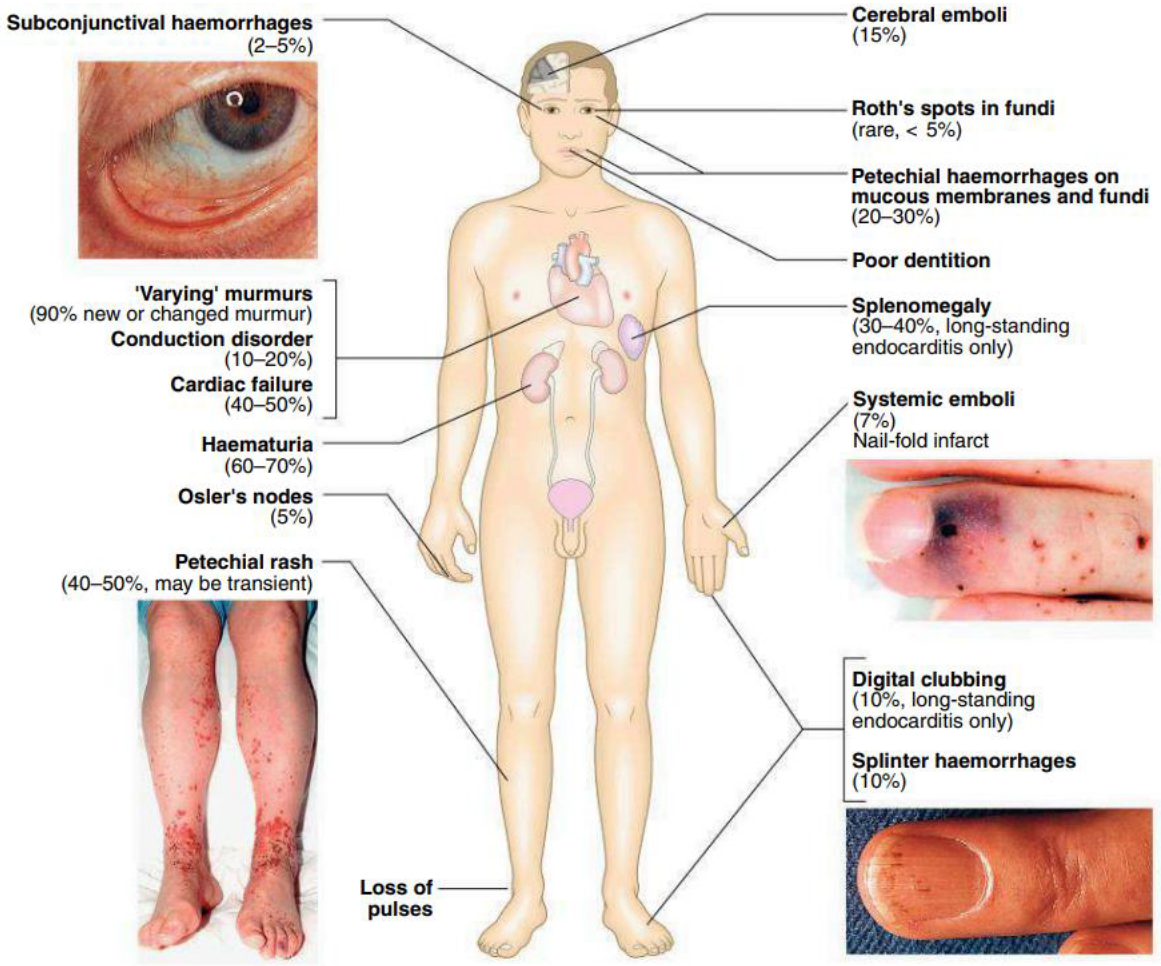


Fig. 16.87 Clinical features that may be present in endocarditis. *Insets (Petechial rash, nail-fold infarct) From Newby D, Grubb N. Cardiology: an illustrated colour text. Edinburgh: Churchill Livingstone, Elsevier Ltd; 2005.*

16.96 Antimicrobial treatment of common causative organisms in infective endocarditis

Antimicrobial susceptibility	Antimicrobial	Dose	Duration	
			Native valve	Prosthetic valve
Streptococci				
Penicillin MIC ≤ 0.125 mg/L	Benzylpenicillin IV	1.2 g 6 times daily	4 weeks[a]	6 weeks
Penicillin MIC > 0.125, ≤ 0.5 mg/L	Benzylpenicillin IV and gentamicin IV	2.4 g 6 times daily	4 weeks	6 weeks
		1 mg/kg twice daily[c]	2 weeks	2 weeks
Penicillin MIC > 0.5 mg/L	Vancomycin IV and gentamicin IV	1 g twice daily[b]	4 weeks	6 weeks
		1 mg/kg twice daily[c]	4 weeks	6 weeks
Enterococci				
Amoxicillin MIC ≤ 4 mg/L and gentamicin MIC ≤ 128 mg/L	Amoxicillin IV and gentamicin IV[d]	2 g 6 times daily	4 weeks	6 weeks
		1 mg/kg twice daily[c]	4 weeks	6 weeks
Amoxicillin MIC > 4 mg/L and gentamicin MIC ≤ 128 mg/L	Vancomycin IV and gentamicin IV[d]	1 g twice daily[b]	4 weeks	6 weeks
		1 mg/kg twice daily[c]	4 weeks	6 weeks
Staphylococci – native valve				
Meticillin-sensitive	Flucloxacillin IV	2 g 4–6 times daily[f]	4 weeks	–
Meticillin-resistant, vancomycin MIC ≤ 2 mg/L, rifampicin-sensitive	Vancomycin IV	1 g twice daily[b]	4 weeks	–
	Rifampicin orally	300–600 mg twice daily	4 weeks	–
Staphylococci – prosthetic valve				
Meticillin-sensitive	Flucloxacillin IV	2 g 4–6 times daily	–	6 weeks
	and gentamicin IV	1 mg/kg twice daily[c]	–	6 weeks
	and rifampicin orally	300–600 mg twice daily	–	6 weeks
Meticillin-resistant, vancomycin MIC ≤ 2 mg/L, rifampicin-sensitive	Vancomycin IV	1 g twice daily[b]	–	6 weeks
	and rifampicin orally	300–600 mg twice daily	–	6 weeks

[a]When conditions in Box 16.97 are met, 2 weeks of benzylpenicillin and gentamicin (1 mg/kg twice daily) may be sufficient. Ceftriaxone 2 g once daily IV/IM can be used instead of benzylpenicillin for those with non-severe penicillin allergy. [b]Pre-dose gentamicin level should be ≤ 1 mg/L, post-dose 3–5 mg/L. Adjust dose according to levels and renal function. [c]Pre-dose vancomycin level should be 15–20 mg/L. Adjust dose according to levels and renal function. [d]Use 6 times daily if weight > 85 kg.
(IM = intramuscular; IV = intravenous; MIC = minimum inhibitory concentration)
Adapted from Gould FK, Denning DW, Elliott TS, et al. Guidelines for the diagnosis and antibiotic treatment of endocarditis in adults: a report of the working party of the British Society for Antimicrobial Chemotherapy. J Antimicrob Chemother 2012; 67:269–289.

16.97 Conditions for the short-course treatment of endocarditis caused by fully sensitive streptococci

- Native valve infection
- Minimum inhibitory concentration (MIC) ≤ 0.125 mg/L
- No adverse prognostic factors (heart failure, aortic regurgitation, conduction defect)
- No evidence of thromboembolic disease
- No vegetations > 5 mm diameter

Clinical response within 7 days

16.98 Indications for cardiac surgery in infective endocarditis*

- Heart failure due to valve damage
- Failure of antibiotic therapy (persistent/uncontrolled infection)
- Large vegetations on left-sided heart valves with echo appearance suggesting high risk of emboli
- Previous evidence of systemic emboli
- Abscess formation

*Patients with prosthetic valve endocarditis or fungal endocarditis often require cardiac surgery.

16.99 Incidence and relative frequency of congenital cardiac malformations

Lesion	% of all congenital heart defects
Ventricular septal defect	30
Atrial septal defect	10
Persistent ductus arteriosus	10
Pulmonary stenosis	7
Coarctation of aorta	7
Aortic stenosis	6
Tetralogy of Fallot	6
Complete transposition of great arteries	4
Others	20

16.100 Presentation of congenital heart disease throughout life

Birth and neonatal period

- Cyanosis
- Heart failure

Infancy and childhood

- Cyanosis
- Heart failure
- Arrhythmia
- Murmur
- Failure to thrive

Adolescence and adulthood

- Heart failure
- Murmur
- Arrhythmia
- Eisenmenger syndrome
- Hypertension (coarctation)
- Complications of previous cardiac surgery:
  - Arrhythmia related to scarring
  - Heart failure secondary to scarring

16.101 Pregnancy in women with congenital heart disease

- **Obstructive lesions**: poorly tolerated and associated with significant maternal morbidity and mortality.
- **Cyanotic conditions**: especially poorly tolerated. Specialised pre-conception counselling should explain the increased risks.
- **Surgically corrected disease**: patients often tolerate pregnancy well.
- **Children of patients with congenital heart disease**: 2%–5% will be born with cardiac abnormalities, especially if the mother is affected. The risk may be up to 20% in babies born of women with left-sided lesions.

16.102 Other causes of cyanotic congenital heart disease

Defect	Features
Tricuspid atresia	Absent tricuspid orifice, hypoplastic RV, RA-to-LA shunt, ventricular septal defect shunt, other anomalies Surgical correction may be possible
Transposition of the great arteries	Aorta arises from the morphological RV, pulmonary artery from LV Shunt via atria, ductus and possibly ventricular septal defect Palliation by balloon atrial septostomy/ enlargement Surgical correction possible
Pulmonary atresia	Pulmonary valve atretic and pulmonary artery hypoplastic RA-to-LA shunt, pulmonary flow via ductus Palliation by balloon atrial septostomy Surgical correction may be possible
Ebstein's anomaly	Tricuspid valve is dysplastic and displaced into RV, RV 'atrialised' Tricuspid regurgitation and RA-to-LA shunt Wide spectrum of severity Arrhythmias Surgical repair possible but significant risk

(LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle)

16.103 Congenital heart disease in adolescence

- **Patients**: a heterogeneous population with residual disease and sequelae that vary according to the underlying lesion and in severity; each patient must be assessed individually.
- **Management plan**: should be agreed with the patient and include short- and long-term goals and timing of transition to adult care.
- **Risks of surgery**: non-cardiac surgery for associated congenital abnormalities carries increased risks and needs to be planned, with careful pre-operative assessment. Risks include thrombosis, embolism from synthetic shunts or patches, and volume overload from fluid shifts. Operative approaches should address cosmetic concerns, such as site of implantation of abdominal generator.
- **Exercise**: patients with mild or repaired defects can undertake moderately vigorous exercise but those with complex defects, cyanosis, ventricular dysfunction or arrhythmias require specialist evaluation and individualised advice regarding exercise.
- **Genetics**: Between 10% and 15% have a genetic basis and this should be assessed to understand the impact it may have for the patient's own future children. A family history, genetic evaluation of syndromic versus non-syndromic disorders and, sometimes, cytogenetics are required.
- **Education and employment**: may be adversely affected and occupational activity levels need to be assessed.
- **End of life**: some adolescents with complex disorders may misperceive and think they have been cured; transition to adult services may be the first time they receive information about mortality. Expectations on life expectancy need to be managed and adolescents are often willing to engage with this and play a role in decision-making.

16.104 Some causes of myocarditis

Infections

Viral

- Coxsackie
- Adenovirus
- Influenza A
- Human immunodeficiency virus (HIV)
- Influenza B
- SARS-CoV-2

Bacterial

- *Borrelia burgdorferi* (Lyme disease)
- *Mycoplasma pneumoniae*

Protozoal

- *Trypanosoma cruzi* (Chagas' disease)
- *Toxoplasma gondii*

Fungal

- *Aspergillus*

Parasitic

- *Shistosoma*

Drugs/Toxins

- Alcohol
- Anthracyclines
- Clozapine
- Cocaine
- Lithium

Autoimmune

- Systemic lupus erythematosus
- Systemic sclerosis
- Rheumatoid arthritis
- Sarcoidosis
- Hypersensitivity reaction to penicillins, sulphonamides, lead, carbon monoxide

16.105 Clinical features of hypertrophic cardiomyopathy

Symptoms

- Angina on effort
- Dyspnoea on effort
- Syncope on effort
- Sudden death

Signs

- Jerky pulse*
- Palpable left ventricular hypertrophy
- Double impulse at the apex (palpable fourth heart sound due to left atrial hypertrophy)
- Mid-systolic murmur at the base*
- Pansystolic murmur (due to mitral regurgitation) at the apex

*Signs of left ventricular outflow tract obstruction may be augmented by standing up (reduced venous return), inotropes and vasodilators

16.106 Risk factors for sudden death in hypertrophic cardiomyopathy

- A history of previous cardiac arrest or sustained ventricular tachycardia
- Recurrent syncope
- An adverse genotype and/or family history
- Exercise-induced hypotension
- Non-sustained ventricular tachycardia on ambulatory ECG monitoring
- Marked increase in left ventricular wall thickness

16.107 Specific diseases of heart muscle

Infections

Viral
- Coxsackie A and B
- Influenza
- HIV
- SARS-CoV-2

Bacterial
- Diphtheria
- *Borrelia burgdorferi*

Protozoal
- Trypanosomiasis
- *Toxoplasma gondii*

Endocrine and metabolic disorders
- Diabetes
- Hypo- and hyperthyroidism
- Acromegaly
- Carcinoid syndrome
- Phaeochromocytoma
- Inherited storage diseases

Connective tissue diseases
- Systemic sclerosis
- Systemic lupus erythematosus
- Polyarteritis nodosa

Infiltrative disorders
- Haemochromatosis
- Haemosiderosis
- Sarcoidosis
- Amyloidosis

Toxins
- Doxorubicin
- Alcohol
- Cocaine
- Irradiation

Neuromuscular disorders
- Dystrophia myotonica
- Friedreich's ataxia

16.108 Causes of acute pericarditis and pericardial effusion

Infection
- Viral
- Bacterial
- Tuberculosis

Inflammatory
- Rheumatoid arthritis
- Systemic lupus erythematosus
- Rheumatic fever

Other
- Post-myocardial infarction
- Uraemia
- Malignancy
- Trauma

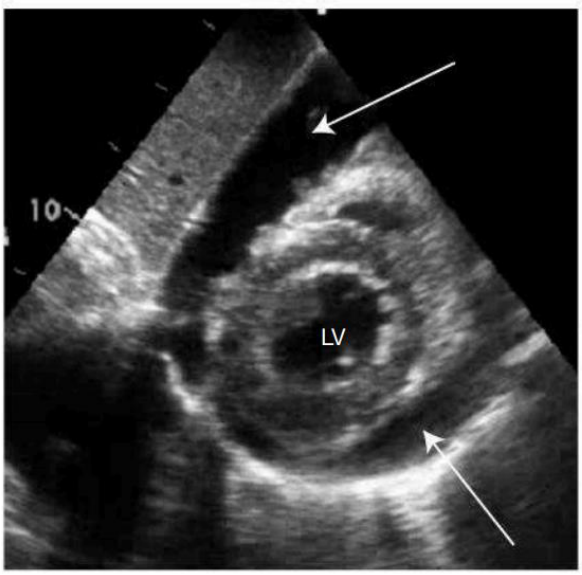


Fig. 16.100 Pericardial effusion: echocardiogram (apical view). Short-axis view of the heart showing a large circumferential pericardial effusion (arrows). (LV = left ventricle)

16.109 Clinical features of constrictive pericarditis

- Fatigue
- Rapid, low-volume pulse
- Elevated JVP with a rapid *y* descent
- Loud early third heart sound or 'pericardial knock'
- Kussmaul's sign
- Hepatomegaly
- Ascites
- Peripheral oedema
- Pulsus paradoxus

(JVP = jugular venous pressure)

16.110 Clinical features of cardiac tamponade

- Dyspnoea
- Collapse
- Tachycardia
- Hypotension
- Gross elevation of the JVP
- Soft heart sounds with an early third heart sound
- Pulsus paradoxus (a large fall in BP during inspiration, when the pulse may be impalpable)
- Kussmaul's sign (a paradoxical rise in JVP during inspiration)

(JVP = jugular venous pressure)

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