

CHAPTER 4

CARDIOVASCULAR SYSTEM

4.1 CARDIAC ARRHYTHMIAS

l49.9

DESCRIPTION

A heart rate that is either abnormally slow or fast for age or irregular.
Normal heart rate/minute for age:

Newborn	100–160
< 1 year	110–160
1–2 years	100–150
2–5 years	95–140
5–12 years	80–120
> 12 years	60–100

DIAGNOSTIC CRITERIA

Clinical

- » Presenting features may vary with the age of the patient:
 - > infants:

colour changes (pale, mottled), irritability, feeding difficulties, sweating, tachypnoeic/apnoeic spells.	irregular pulse, tachycardia, bradycardia, signs of cardiac failure,
---	---
 - > children:

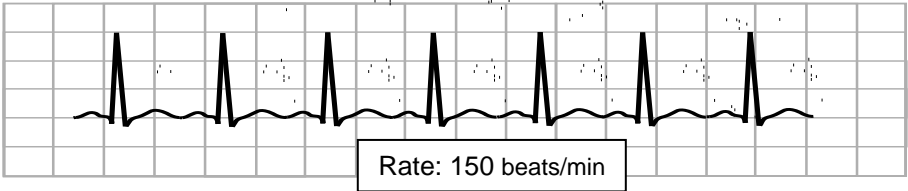
dizziness, palpitations, fatigue, chest pain,	tachycardia, bradycardia, syncope, signs of cardiac failure.
--	---

Investigations

- » ECG is essential for diagnosis, preferably a 12-lead ECG.
- » Monitors are inadequate to diagnose most arrhythmias.
- » A standard ECG is recorded at 25 mm/second. Each small block on the ECG paper is 1 mm x 1 mm and represents 40 milliseconds and each large block 5 mm x 5 mm and represents 200 milliseconds. A length of 300 large blocks represents 1 minute and the heart rate can be estimated from the ECG strip by dividing 300 by the number of large blocks between sequential R waves provided that there is not substantial variability in the RR interval lengths. The ECG tracings below show only the large (5 mm) blocks.

TACHYARRHYTHMIA

Sinus tachycardia

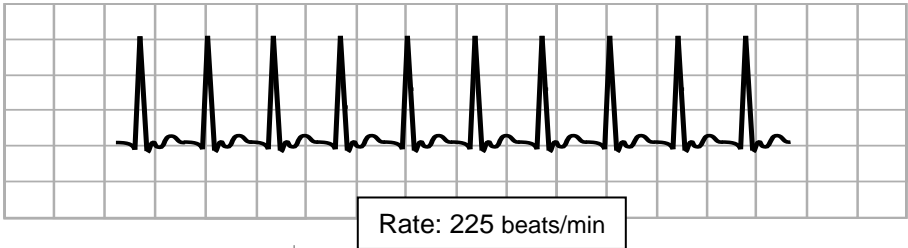


ECG Criteria

Rate: > upper limit for age
Rhythm: regular

P wave: present and normal
QRS: normal

Supraventricular tachycardia

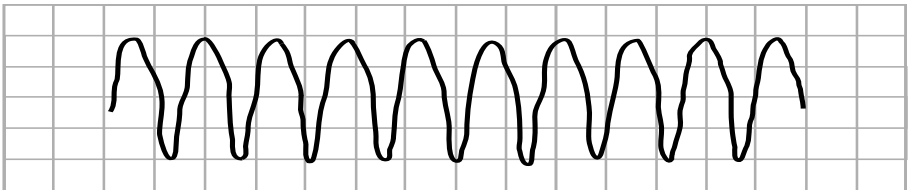


ECG Criteria

Rate: usually > 200 beats per minute
Rhythm: regular

P wave: abnormal
QRS: normal

Ventricular tachycardia



ECG Criteria

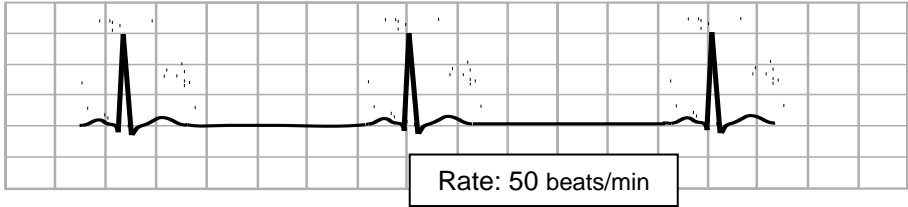
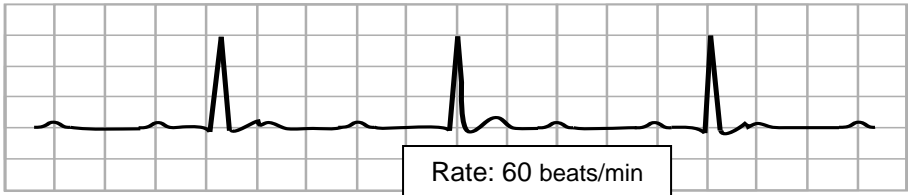
Rate: generally 100–220 beats per minute
Rhythm: generally regular

P wave: mostly not seen
QRS: abnormal, width of QRS > 120 milliseconds

BRADYARRHYTHMIA

» Important causes of bradycardia:

- > Hypoxia
- > Congenital heart block.
- > Hypothyroidism
- > Drug ingestion.
- > Excessive vagal stimulation.
- > Head injury.

Sinus bradycardia**ECG Criteria****Rate:** < lower limit for age**Rhythm:** regular**P wave:** present, all look the same**QRS:** normal, 80–120 milliseconds**Heart block (Complete)****ECG Criteria****Rate:** low, usually < 60 beats per minute**Rhythm:** regular**P wave:** independent P waves and QRS complexes with no relationship between the two (AV dissociation)**QRS complex:** can be normal or wide, depending on escape rhythm**GENERAL AND SUPPORTIVE MEASURES**

- » Sinus tachycardia usually requires management of the underlying condition.
- » Apply ABC of resuscitation if needed.
- » Admit to high care or intensive care unit if indicated.
- » Monitor:
 - > ECG,
 - > blood pressure,
 - > heart rate,
 - > respiratory rate,
 - > oxygen saturation,
 - > haemoglobin,
 - > acid-base status,
 - > blood gases.
- » Maintain adequate nutrition and hydration.
- » Treat pyrexia.

MEDICINE TREATMENT**Tachyarrhythmia**

Emergency treatment.

Narrow complex tachycardia

Commonly due to supraventricular tachycardia.

Stable patient:

Attempt vagal stimulation:

- » Place an ice bag on the face, or
 - » Infants: immerse the face in ice-cold water for a few seconds.
 - » Older children: try a Valsalva manoeuvre.
 - » Eye-ball pressure and carotid massage is contraindicated in children.
- In consultation with a paediatric specialist: Adenosine, IV, 0.1 mg/kg rapid IV push via a large bore cannula (within seconds). For infants, start with 0.2 mg/kg¹.
 - Follow immediately with a rapid flush of at least 5 mL sodium chloride 0.9%.
 - Increase dose in 0.1 mg/kg increments every 2 minutes until return of sinus rhythm. Follow each dose with a rapid flush of sodium chloride 0.9%.
 - Maximum dose: 0.5 mg/kg. Do not exceed 12 mg in total.
 - Because adenosine is rapidly metabolised, inject adenosine into an intravenous cannula capable of supporting rapid infusion and preferably located as centrally as possible (i.e. cubital rather than hand or foot). Follow immediately, with a rapid flush of a fluid bolus. It is helpful to have both the syringe with adenosine and the fluid bolus connected to the giving set. The line between the syringes and the patient should be as short as possible.

Unstable patient – heart failure/shocked:

- » DC synchronised cardioversion at 1 J/kg, and then 2 J/kg.
- » If possible, empty the stomach before cardioversion is attempted. Resuscitation facilities must be available.
- Ketamine for sedation, if necessary. Refer to Chapter 20 Pain: Section 20.1.2 Procedure Sedation and Analgesia, for ketamine dosing.

Broad complex tachycardia

Commonly due to ventricular tachycardia.

Causes include electrolyte disturbances and drug ingestion.

Stable patient (rare):

- » Send ECG immediately to paediatric cardiologist.
- » AVOID giving adenosine to patients with broad complex tachycardia unless the rhythm is regular with a monomorphic QRS complex.

Medicines that may be recommended by a paediatric cardiologist include:

- Magnesium sulphate, IV, 25–50 mg/kg over a few minutes for torsade de pointes.
- Amiodarone, IV, 5 mg/kg over 20 minutes.

LoE III[Ⓢ]

Unstable patient – heart failure/shock:

- » Pulseless – treat as ventricular fibrillation. See Chapter 1: Emergencies and Trauma, section 1.1.4: Cardiorespiratory arrest.
- » DC synchronised cardioversion at 1 J/kg, and then 2 J/kg.
- » If synchronised cardioversion fails, use asynchronised shocks.
- » Resuscitation facilities must be available.
- » Ketamine for sedation, if necessary. Refer to Chapter 20 Pain: Section 20.1.2 Procedure Sedation and Analgesia, for ketamine dosing.

Monitor and correct electrolytes and acid-base status on blood gases. Consider underlying causes.

If DC cardioversion fails:

- Amiodarone, IV, 5 mg/kg slowly over 20 minutes.

AND

Continue with DC cardioversion.

BRADYARRHYTHMIA

Try and correct underlying causes.

Stable patient:

Observe

Bradycardia due to vagal stimulation:

- Atropine, IV/IO, 0.02 mg/kg. Maximum single dose 0.5 mg.
 - If no response, repeat in 5 minutes.

LoE III ³

Unstable patient:

Treat as impending arrest:

- Adrenaline (epinephrine), IV/IO, 0.01 mg/kg.
 - Repeat if necessary, conferring with referral institution.

If no sustained response, consider:

- Adrenaline (epinephrine), IV infusion, 0.05–2 µg/kg/minute.

LoE III ⁴

REFERRAL

- » All children with tachyarrhythmias after acute treatment, excluding sinus tachycardia due to other causes.
- » Bradycardia unresponsive to medical treatment, or heart block.

4.2 CONGENITAL HEART DISEASE (CHD)

Q24.9

DESCRIPTION

Structural abnormalities of the heart or great vessels present at birth. They fall into 4 pathophysiological groups:

1. Acyanotic left to right shunts – ventricular septal defect (VSD), patent duct arteriosus (PDA), atrial septal defect (ASD), atrioventricular septal defect (AVSD).
2. Acyanotic obstructive lesions – pulmonary stenosis, aortic stenosis, coarctation of the aorta.
3. Cyanotic CHD – mostly right to left shunts – tetralogy of Fallot (TOF), pulmonary atresia (PA), truncus arteriosus, total anomalous pulmonary venous drainage (TAPVD), tricuspid atresia (TA), but including parallel circulation – transposition of great arteries (TGA) (see Chapter 19: Prematurity and Neonatal Conditions, section 19.4.2: Cyanotic heart disease in the newborn) and Eisenmenger syndrome.
4. Regurgitant lesions – aortic incompetence (AI), mitral incompetence (MI) which are not common in CHD.

Some patients with CHD present with life threatening symptoms in the newborn period, see Chapter 19: Prematurity and Neonatal Conditions, section 19.4.1: Heart failure in neonates. Left to right shunts, if large, may be symptomatic due to pulmonary over circulation and pulmonary hypertension or if small may present with an incidental murmur. Many will require surgery but this may follow a period of medical therapy.

Obstructive lesions are often asymptomatic until they precipitate ventricular failure or symptoms related to decreased cardiac output. The management is usually surgical or interventional. Angiotensin-converting enzyme inhibitors (ACE-inhibitors) should be avoided in the treatment of heart failure in patients with obstructive lesions.

Right to left shunts present with cyanosis and variable degrees of effort intolerance. Patients with tetralogy of Fallot may present with hypercyanotic spells.

4.2.1 CYANOTIC CONGENITAL HEART DISEASE WITH HYPOXAEMIA ATTACKS/SPELLS (HYPERCYANOTIC SPELLS)

Q24.9

DESCRIPTION

Acute worsening of central cyanosis in patients with a tetralogy of Fallot and certain other cyanotic heart diseases with pulmonary stenosis and a ventricular septal defect.

DIAGNOSTIC CRITERIA

Clinical

- » Rapid worsening of central cyanosis, tachypnoea/dyspnoea, anxiety and alteration in consciousness in the presence of congenital cyanotic heart disease.
- » Restlessness and crying in the presence of congenital cyanotic heart disease.
- » Decrease in intensity or disappearance of the systolic murmur in tetralogy of Fallot during crying.

GENERAL AND SUPPORTIVE MEASURES

- » Exclude and treat precipitants such as fever or dehydration.
- » Calm the patient and keep on mother's lap, if possible.
- » Place the patient in the knee-chest position to raise systemic blood pressure and increase systemic venous return.

- » Monitor SaO₂, heart rate, respiratory rate and acid-base status.
- » Ensure adequate hydration.

MEDICINE TREATMENT

- Oxygen, 100%, by facemask or by nasal cannula.
- Volume expander, e.g. sodium chloride 0.9%, IV bolus, 20 mL/kg administered over 5 minutes.
- Morphine, IV, 0.1–0.2 mg/kg as a single dose.
 - May cause impairment of airway reflexes and respiratory depression.

If clinically acidotic or pH < 7.2:

- Sodium bicarbonate 4.2%, IV, 2 mL/kg.

If failure to improve the cyanotic spell, consider:

- Ketamine, IV, 0.5–1 mg/kg.

OR

- Phenylephrine (in consultation with a specialist).

After resolution of spell:

If Hb < 10 g/dL, the child is anaemic:

- Packed red cells, 10 mL/kg administered over 3 hours.
- Propranolol, oral, 0.5–1 mg/kg/dose 6 hourly.
 - Do not exceed 5 mg/kg/day.

REFERRAL

- » If above measures do not work, refer urgently.
- » Refer all cases for assessment.

4.2.2 TETRALOGY OF FALLOT

Q21.3

DESCRIPTION

Ventricular septal defect with aortic override, right ventricular outflow tract obstruction and right ventricular hypertrophy.

Suspect tetralogy of Fallot in a child with cyanosis after the neonatal period.

DIAGNOSTIC CRITERIA

Clinical

- » Child with central cyanosis.
- » May be plethoric due to polycythemia – normal haemoglobin represents relative anaemia.
- » May have clubbing.
- » Possible history of cyanotic spells.

- » Heart not clinically enlarged.
- » Right ventricular hypertrophy usually not palpable.
- » Single second heart sound.
- » Coarse, ejection systolic murmur over the right ventricular outflow tract.
- » Chest X-ray:
 - > normal/small heart,
 - > boot shaped/pulmonary bay – concavity where pulmonary artery should be,
 - > oligoemic lung fields.
- » ECG:
 - > right axis deviation and right ventricular hypertrophy.

GENERAL AND SUPPORTIVE MEASURES

- » Good dental hygiene.

MEDICINE TREATMENT

- Iron (elemental), oral, 1 mg/kg/dose 8 hourly.
- Folic acid, oral, 2.5–5 mg/day.
- Propranolol, oral, 0.5–1 mg/kg/dose 6 hourly.
 - Do not exceed 5 mg/kg/day.

Endocarditis prophylaxis:

See section 4.3: Endocarditis, infective.

REFERRAL

- » Refer all children with cyanotic heart defects.

4.2.3 CONGENITAL HEART DISEASE WITH LEFT TO RIGHT SHUNT

DESCRIPTION

Structural abnormalities of the heart and great vessels that are usually associated with left to right shunting – most commonly: ventricular septal defect, atrial septal defect, patent ductus arteriosus and atrioventricular septal defect.

DIAGNOSTIC CRITERIA

Each condition has specific clinical, radiological and ECG findings.

Large left to right shunts present clinically with:

- » Tachypnoea and indrawing.
- » Sweating during feeds.
- » Failure to thrive.
- » Chest deformity: respiratory sulcus, praecordial bulge.
- » Chest X-ray: usually cardiomegaly with plethoric lung fields.
- » Cardiac impulse felt below the xiphisternum.

GENERAL AND SUPPORTIVE MEASURES

- » Pay special attention to nutrition.

MEDICINE TREATMENT

- Furosemide, oral, 1 mg/kg/dose 8–12 hourly.
 - Supplement with potassium chloride, oral, 25–50 mg/kg/dose 8–12 hourly.
- If needed:
- Spironolactone oral, 1 mg/kg/dose 12 hourly, in which case, potassium supplementation should be stopped.

And if needed, in consultation with a paediatric cardiologist:

- ACE-inhibitor, e.g.
 - Captopril, oral:
 - Infants: 0.15–0.3 mg/kg/dose, 8–12 hourly (maximum 2 mg/kg/day).
 - Children: 0.3–0.5 mg/kg/dose 8–12 hourly (maximum 6 mg/kg/day).

LoE II^{5,6}

REFERRAL

- » All children with suspected left to right shunts due to CHD should be referred to a paediatric cardiology centre for diagnostic evaluation and planning of further management.

4.3 ENDOCARDITIS, INFECTIVE

I33.0

DESCRIPTION

Infection of the endothelial surface of the heart.

Suspect infective endocarditis in all children with fever and underlying heart disease.

Antibiotic therapy in these children is highly dependent on the results of microbiology.

DIAGNOSTIC CRITERIA**Clinical**

- » An underlying heart defect and a persistent low grade fever without an obvious underlying cause.
- » Associated other findings include: fatigue, joint pain, new murmurs, clubbing, splenomegaly and haematuria.
- » Must be differentiated from acute carditis due to rheumatic fever.
- » The modified Duke criteria have been suggested as a guide to diagnosis, but have definite limitations as they were developed for use in adult patients.

Table 1: Major and minor clinical criteria used in the modified Duke criteria for diagnosis of infective endocarditis (IE)

MAJOR CRITERIA	MINOR CRITERIA
<ul style="list-style-type: none"> » Positive blood culture: <ul style="list-style-type: none"> > typical micro-organisms from two separate blood cultures: <i>S. viridans</i>, including nutritional variant strains, <i>S. bovis</i>, *HACEK group, <i>S. aureus</i>, or > Enterococci, in the absence of a primary focus, or > persistently positive blood culture with a micro-organism consistent with IE from blood cultures drawn > 12 hours apart, or > all 3 or a majority of 4 or more separate blood cultures, with the first and last drawn at least one hour apart, or > positive serology for Q fever, > single positive blood culture for <i>Coxiella burnetii</i> or anti-phase-1 IgG antibody titre > 1:800. » Evidence of endocardial involvement: <ul style="list-style-type: none"> > positive echocardiogram for IE (transoesophageal echocardiography is recommended for patients with prosthetic valves): oscillating intracardiac mass, on valve or supporting structures, or in the path of regurgitant jets, or on implanted materials, in the absence of an alternative anatomic explanation, or > abscess, or > new partial dehiscence of prosthetic valve, or > new valvular regurgitation. 	<ul style="list-style-type: none"> » Predisposing heart condition or IV drug use. » Fever ≥ 38°C. » Vascular phenomena: <ul style="list-style-type: none"> > major arterial emboli, > septic pulmonary infarcts, > mycotic aneurysm, > intracranial haemorrhage, > conjunctival haemorrhages, > Janeway lesions. » Immunologic phenomena: <ul style="list-style-type: none"> > Osler's nodes, > Roth spots, > glomerulonephritis, > rheumatoid factor. » Microbiologic evidence: <ul style="list-style-type: none"> > positive blood culture but not meeting major criterion, or > serologic evidence of active infection with organism consistent with IE.

*A group of fastidious Gram-negative organisms originating in the mouth.

Table 2: Modified Duke criteria for diagnosis of infective endocarditis (IE)

DEFINITE IE	POSSIBLE IE	REJECTED
Pathological criteria: » Micro-organisms: > by culture or histology in a vegetation, or > in a vegetation that has embolised, or > in an intracardiac abscess, or » Lesions: > Vegetation or intracardiac abscess present – confirmed by histology showing active IE. Clinical criteria – see Table 1: » 2 major criteria, » 1 major and 3 minor, or » 5 minor.	» At least 1 major and 1 minor criterion, or » 3 minor.	» Alternative diagnosis for manifestation of endocarditis, or » resolution of manifestations, with antibiotic therapy ≤ 4 days, or » no pathologic evidence of IE at surgery or autopsy, after antibiotic therapy for ≤ 4 days.

Limitations of the modified Duke criteria in children

The clinical criteria rely heavily on relatively rare clinical features.

In contrast, common clinical features like splenomegaly, clubbing and haematuria have not been included.

Investigations like CRP or ESR, which may be of value, have also not been included.

Investigations

- » Blood cultures:
 - > Sterile blood culture technique is essential.
 - > Take 3 blood cultures (venous) from different sites within 2 hours if very ill, otherwise within 24 hours. There is little benefit from doing more than 5 blood cultures.
 - > Child need not necessarily have a fever as patients are mostly constantly bacteraemic.
- » Urine test strips – haematuria.
- » CRP/ESR may be helpful.

GENERAL AND SUPPORTIVE MEASURES

- » Bed rest/limit physical activity.
- » Ensure adequate nutrition.
- » Maintain haemoglobin > 10 g/dL.
- » Measures to reduce fever.

MEDICINE TREATMENT

For heart failure, see section 4.9: Heart failure.

For fever:

- Paracetamol, oral, 15 mg/kg/dose, 6 hourly as required.

Antibiotic therapy

Antibiotics are seldom indicated as part of emergency treatment.

It is important to obtain adequate blood culture specimens prior to initiation of antibiotics.

Antibiotics are **always** given IV.

Empiric treatment

If culture is not yet available or remains negative:

- Benzylpenicillin (Penicillin G), IV, 50 000 units/kg/dose, 6 hourly for 4–6* weeks.

PLUS

- Cloxacillin, IV, 50 mg/kg/dose 6 hourly for 4–6* weeks.

LoE III⁷

PLUS

- Gentamicin, IV, 3 mg/kg/day for 2 weeks.

LoE II⁶

**The longer duration of therapy is used for patients with complications or prosthetic valves.*

If positive culture available: Consult a paediatric cardiologist, infectious disease specialist or clinical microbiologist.

Prophylaxis

The use of prophylaxis is controversial but still recommended.

For children with the following cardiac conditions:

- » rheumatic heart disease,
- » prosthetic cardiac valve or prosthetic material used in valve repair,
- » previous infective endocarditis,
- » unrepaired cyanotic heart disease, including palliative shunts,
- » during the first 6 months after complete repair of a congenital heart defect with prosthetic material or device (complete endothelialisation of prosthesis after 6 months),
- » repaired cyanotic heart disease with residual defect at or adjacent to prosthetic patch or device, or
- » cardiac transplant recipients who develop cardiac valvulopathy.

Children with the above cardiac conditions should receive prophylaxis when undergoing the following procedures:

- » All dental procedures that involve manipulation of gingival tissues or periapical region of teeth or trauma to oral mucosa.
- » Prophylaxis is not recommended for procedures involving the GIT, GUT, respiratory tract, skin or soft tissue in the absence of existing infections. (If infections of GIT/GUT are present, include cover for enterococcus, e.g. amoxicillin

or ampicillin, and for infections of respiratory tract, soft tissue and skin, include cover for staphylococcus aureus, e.g. cloxacillin or cephalexin).

Regimens for dental procedures

- Amoxicillin, oral, 50 mg/kg (maximum 2 g) 1 hour before the procedure.

Patients unable to take oral medication:

- Ampicillin, IV, 50 mg/kg (maximum 2 g) ½ hour before the procedure.

Patients with penicillin allergy:

- Azithromycin, oral, 10 mg/kg, ½ to 1 hour before procedure.

LoE III ⁹

REFERRAL

- » All patients with suspected (for echocardiography) and confirmed (for antibiotic and possible surgical management) infective endocarditis as soon as possible.

4.4 RHEUMATIC FEVER, ACUTE

I01.9

*Notifiable condition.

DESCRIPTION

Rheumatic fever is an inflammatory condition that may follow a throat infection with group A streptococci. It is an important cause of acquired heart disease with significant morbidity and mortality rates, both in the acute phase of the disease and as a result of chronic valvular sequelae.

DIAGNOSTIC CRITERIA

Revised Jones criteria:

- » Evidence of recent streptococcal infection:
 - > Elevated ASO-titre or other streptococcal antibody titres.
 - > Positive throat culture for group A beta-haemolytic streptococcus.

PLUS

- » Two major manifestations, **or** one major and two minor manifestations, justifies the presumptive diagnosis of acute rheumatic fever (Jones Criteria 2015 – South African children are defined as members of a high risk population).

Major manifestations	Minor manifestations
<ul style="list-style-type: none"> » Mono or polyarthritis/polyarthralgia » Carditis » Erythema marginatum » Subcutaneous nodules » Sydenham's chorea 	<ul style="list-style-type: none"> » Monoarthralgia » Fever $\geq 38^{\circ}\text{C}$ » Acute phase reactants: increased erythrocyte sedimentation rate (ESR) ≥ 30 mm/hr or C-reactive protein (CRP) ≥ 30 mg/l » ECG: prolonged PR-interval, ≥ 0.16 seconds in the absence of carditis

- > Carditis is either defined clinically or after an echocardiographic study.
- > Chorea, for which other causes have been excluded, provides adequate evidence of rheumatic fever without the other criteria for diagnosis being required.
- > In children with rheumatic heart disease with fever, it is critical to differentiate recurrence of acute rheumatic fever from infective endocarditis.

For children with rheumatic heart disease, recurrence of some of the above criteria would suggest a recurrence of rheumatic fever but other causes such as IE should be excluded.

GENERAL AND SUPPORTIVE MEASURES

- » Hospitalise with bed rest until sleeping pulse is normal and signs of rheumatic activity have resolved.
- » Restrict physical activity for at least 2 weeks after acute phase reactants have normalised.
- » Keep a record of patients on rheumatic fever prophylaxis so that attendance can be monitored.

MEDICINE TREATMENT

Antibiotic therapy

To eradicate any streptococci:

- Benzathine benzylpenicillin (depot formulation), IM, as a single dose.
 - If < 30 kg: 600 000 IU.
 - If ≥ 30 kg: 1.2 MU.

OR

- Phenoxymethylpenicillin, oral, 15 mg/kg (up to a maximum of 500 mg) 12 hourly for 10 days.

LoE III^{0,11}

Patients with penicillin allergy:

- Azithromycin, oral, 10 mg/kg/day for 5 days.

Anti-inflammatory therapy

Do not start until a definite diagnosis is made. Paracetamol can be administered for joint pain. Anti-inflammatory therapy is no longer recommended for carditis alone.

Severe arthritis:

- Ibuprofen, oral, 10 mg/kg/dose, 8 hourly, oral, (non-steroidal anti-inflammatory agents are preferred to aspirin as a result of the side effect profile) until the arthritis resolves.

OR

- If necessary, with specialist consultation, aspirin, soluble, oral, 20 mg/kg/dose 6 hourly.

Cardiac failure: See section 4.9: Heart failure.

Chorea: See Chapter 13: The Nervous System, section 13.10: Sydenham's chorea.

Prevention of repeated attacks

Any patient with documented rheumatic fever must receive prophylaxis.

Intramuscular penicillin is superior to other forms of prophylaxis.

- Benzathine benzylpenicillin (depot formulation), IM, every 3–4 weeks.
 - If < 30 kg: 600 000 IU.
 - If > 30 kg: 1.2 MU.

OR

- Phenoxymethylpenicillin, oral, 250 mg 12 hourly.

Patients with penicillin allergy:

- Evidence is not robust in this area, thus consultation with a specialist on a case by case basis will be required.

Continue therapy until patients reach 21 years of age if no rheumatic valvular disease, and until 35 years of age in patients with rheumatic valvular disease.

LoE III^B**REFERRAL**

Rheumatic fever: all patients need to be referred for echocardiography and further evaluation.

4.5 MYOCARDITIS

I40

DESCRIPTION

Myocarditis is an inflammatory disease of the cardiac muscle. The majority of paediatric myocarditis cases are caused by viral infection. Viral myocarditis should be suspected whenever a child presents with arrhythmia, heart failure or cardiogenic shock following a viral illness. Myocarditis should be considered in children with unexplained shortness of breath.

DIAGNOSTIC CRITERIA**Clinical**

- » Tachycardia
- » Clinical signs of biventricular heart failure.
- » May present with cardiogenic shock.

Investigations

- » ECG changes are non-specific but ST elevation, T wave inversion, prolonged QTc, small complexes, arrhythmias or extra-systole may be seen.
- » Chest X-ray:
 - > pulmonary congestion,
 - > cardiomegaly,
 - > possible pleural effusion.
- » Elevated cardiac troponin-T levels are markers of myocarditis but normal levels do not exclude the diagnosis.

GENERAL AND SUPPORTIVE MEASURES

- » Restrict fluid (75% of daily requirements) – not at expense of adequate caloric intake.
- » Ensure adequate nutrition; tube-feeding may be necessary.

MEDICINE TREATMENT OF VIRAL MYOCARDITIS

To prevent hypoxia:

- Oxygen via face mask, nasal cannula, CPAP or high flow.

For pulmonary oedema:

- Furosemide, IV, 1 mg/kg, 8 hourly. Monitor urinary output.
- If response is inadequate, change to an IV infusion 0.1–1 mg/kg/hour.
- Switch to oral furosemide as soon as patient condition allows.
 - Monitor clinically and biochemically for, and avoid, over diuresis.
 - Monitor for hypokalaemia and other electrolyte disturbances.

LoE III^B

If response is still inadequate, consider:

- Spironolactone, oral, 1–3 mg/kg/dose once daily in consultation with a paediatric cardiologist. May be divided 12 hourly.
- Inotropic support may be needed, see section 4.9.1: Heart failure, acute with pulmonary oedema.
- IV immunoglobulins are not recommended¹².

REFERRAL

- » All children with suspected myocarditis should be managed in consultation with a paediatrician. Long-term (at least 6 months) exercise avoidance, medicine treatment and follow-up is needed.

4.6 DILATED CARDIOMYOPATHY

I42.0

DESCRIPTION

Dilated cardiomyopathy is a clinical diagnosis characterised by dilation and impaired contraction of the left or both ventricles that is not explained by abnormal loading conditions. It is difficult and sometimes impossible to distinguish myocarditis from dilated cardiomyopathy. Dilated cardiomyopathy is often a sequel to viral myocarditis.

DIAGNOSTIC CRITERIA**Clinical**

- » Cardiomegaly with clinical signs of heart failure and poorly localised apical impulse.
- » May present with cardiogenic shock.

Investigations

- » Chest X-ray:

- > pulmonary congestion,
- > cardiomegaly,
- > there may be pleural effusion.
- » ECG:
 - > Mostly non-specific.
 - > Arrhythmias or extra-systoles may occur.

GENERAL AND SUPPORTIVE MEASURES

- » Fluid restriction (75% of daily requirements) – not at expense of adequate caloric intake.
- » Ensure adequate nutrition; tube-feeding may be necessary.
- » Advise bed rest.

MEDICINE TREATMENT

To prevent hypoxia:

- Oxygen via face mask, nasal cannula, CPAP or high flow.

See section 4.9: Heart failure.

REFERRAL

- » Urgent: To ICU for inotropic support if indicated.
- » All patients for assessment and consideration of underlying disorders.

4.7 PERICARDIAL EFFUSION

130

DESCRIPTION

Accumulation of fluid in the pericardial space, usually secondary to pericarditis.

DIAGNOSTIC CRITERIA

Clinical

- » Most patients present with a prolonged history of:
 - > low cardiac output,
 - > distended neck veins,
 - > muffled or diminished heart sounds.
- » Patients with HIV may be asymptomatic and incidentally diagnosed on chest X-ray.
- » Often associated with TB.
- » Acute septic pericarditis may occur in patients with septicaemia.

Investigations

- » Exclude TB in all cases: Tuberculin skin test.
- » ECG:
 - > small complexes tachycardia,
 - > diffuse T wave changes.
- » Chest X-ray:

- > in pericardial effusion – ‘water bottle’ large globular heart or cardiac shadow with smoothed-out borders.
- » Ultrasound of heart and pericardium.
- » Diagnostic pericardiocentesis:
 - > in all patients with suspected bacterial or neoplastic pericarditis, and in all others in whom the diagnosis is not readily obtained;
 - > include cell count and differential, culture and Gram stain;
 - > an elevated adenosine deaminase (ADA) may be helpful in diagnosing TB.

CARDIAC TAMPONADE

Cardiac tamponade is the accumulation of pericardial fluid that restricts ventricular filling and stroke volume. The child usually presents with a tachycardia, pulsus paradoxus, elevated JVP, hypotension, shock or pulseless electric activity.

Features on ECG include electrical alternans and low voltage QRS.

Diagnosis is confirmed by ultrasound.

GENERAL AND SUPPORTIVE MEASURES

Urgent pericardiocentesis under ultrasound guidance by an experienced person.

Pericardiocentesis

- » Do a coagulation screen if coagulation problems are suspected.
- » Preferably under ultrasound guidance by an experienced person.
- » In an emergency, drainage by using a large bore intravenous cannula.
- » Technique:
 - > Ensure that full resuscitation equipment is available as well as an IV line and cardiac monitor.
 - > Administer oxygen via face mask, nasal cannula or head box.
 - > If the patient is restless, it may be necessary to sedate the patient. In an emergency situation, this is unnecessary.
 - > Position the patient in a 30° sitting-up position.
 - > Prepare the preferred site just to the left of the xiphoid process, 1 cm inferior to the costal margin.
 - > Infiltrate this area with 1% lidocaine (lignocaine).
 - > Maintaining negative pressure on the syringe, insert the needle at a 45° angle to the skin, advancing in the direction of the patient's left shoulder.
 - > While advancing the needle, observe closely on ECG for ventricular ectopic beats, a sign of myocardial contact. If this is noted, gradually withdraw the needle a few millimeters.
 - > Once air (pneumopericardium) or fluid begins to fill the syringe, advance the intravenous cannula, withdraw the needle, attach the syringe to the hub of the cannula and slowly aspirate the pericardial fluid.
 - > Potential complications include: haemopericardium (from laceration of the heart wall or coronary artery), cardiac dysrhythmias, pneumothorax, and pneumopericardium.

MEDICINE TREATMENT

If suspected or proven TB pericarditis, give antituberculosis drugs for 6 months plus corticosteroids.

- Prednisone, oral, for 6 weeks:
 - Week 1: 2 mg/kg/day,
 - Week 2: 1.5 mg/kg/day,
 - Week 3: 1 mg/kg/day,
 - Week 4: 1 mg/kg/day,
 - Week 5: 0.5 mg/kg/day,
 - Week 6: 0.25 mg/kg/day.

LoE III ^{13,14}

Pain management

See Chapter 20: Pain Control, section 20.1.1: Management of pain.

Antibiotic therapy

If suspected bacterial pericarditis, give empiric antibiotic treatment until culture and sensitivity results are available.

Antibiotic therapy should be continued for 4 weeks.

In case of purulent pericarditis:

- Cloxacillin, IV, 50 mg/kg/dose 6 hourly.

PLUS

- Ceftriaxone, IV, 100 mg/kg as a single daily dose.

REFERRAL

- » Refer all patients after stabilisation.

4.8 PERICARDITIS

I30.9

DESCRIPTION

An inflammation of the pericardium. Causes include viral or bacterial and autoimmune disease. The commonest cause is viral but the clinician should entertain a high index of suspicion for tuberculous and bacterial pericarditis as these require specific antimicrobial treatment.

DIAGNOSTIC CRITERIA

Inflammation of the pericardium:

- » Classical presentation of viral pericarditis, with a loud pericardial rub and chest pain that is relieved by sitting up. Children often do not complain of chest pain.
- » Acute septic pericarditis may occur in patients with septicaemia.

TB pericarditis

TB pericarditis may present as a pericardial effusion (most cases), effusive constrictive pericarditis or constrictive pericarditis.

Clinical features include:

- » chronic cough,
- » chest pain,
- » night sweats,
- » and weight loss.
- » dyspnoea,
- » fever,
- » orthopnoea,

Severe pericardial pain is uncommon.

Investigations

- » Exclude TB.
- » Echocardiogram

MEDICINE TREATMENT

Treat the cause.

For tuberculous and bacterial pericarditis treatment, see section 4.7: Pericardial effusion.

Viral pericarditis

NSAIDs, e.g.:

- Ibuprofen, oral, 5 mg/kg/dose 6 hourly.

REFERRAL

- » All patients in whom the cause is unidentifiable.

4.9 HEART FAILURE

150.9

DESCRIPTION

A clinical syndrome reflecting the inability of the myocardium to meet the oxygen and nutritional/metabolic requirements of the body.

Causes include:

- » volume overload:
 - > L-R shunt lesions,
 - > mitral/aortic regurgitation.
- » pump failure:
 - > myocarditis/cardiomyopathy.
- » high output failure:
 - > septicaemia,
 - > severe anaemia.

DIAGNOSTIC CRITERIA

Clinical

- » Acute cardiac failure may present with shock. See Chapter 1: Emergencies and Trauma, section 1.1.8: Shock.

- » History of recent onset of:
 - > poor feeding,
 - > tachypnoea,
 - > sweating,
 - > poor or excessive weight gain,
 - > breathlessness,
 - > cough.
- » Physical findings:
 - > tachycardia,
 - > hypotension,
 - > weak pulses,
 - > gallop rhythm with/without a cardiac murmur.
 - > pulmonary venous congestion and fluid retention:
 - tachypnoea,
 - dyspnoea,
 - orthopnoea,
 - recession,
 - wheezing,
 - coarse crepitations,
 - cyanosis.
 - > systemic venous congestion:
 - hepatomegaly,
 - periorbital oedema – not seen in infants,
 - abnormal weight gain.
 - > signs and symptoms of the underlying condition/disease.

Investigations as appropriate for the possible underlying cause

- » Chest X-ray: cardiomegaly is almost always present.
- » Electrocardiogram may show evidence of hypertrophy/enlargement of one or more heart chambers and/or arrhythmias.

4.9.1 HEART FAILURE, ACUTE WITH PULMONARY OEDEMA

150.9

GENERAL AND SUPPORTIVE MEASURES

- » Treat the underlying disorder/condition. Where the primary cause of acute pulmonary oedema is renal failure, treat as per renal failure. See Chapter 6: Nephrological/Urological Disorders, section 6.4: Acute kidney injury.
- » Restrict fluids, beware of IV fluids.
- » Place patient in an upright or semi-upright sitting position.
- » Intubation and ventilation may be required in an ICU setting.

MEDICINE TREATMENT

- Oxygen 100%, administered via face mask, nasal cannula, CPAP or high flow.

Treat the underlying condition:

- Furosemide, IV, 1 mg/kg, 8 hourly.
- If response is inadequate, change to an IV infusion 0.1–1 mg/kg/hour.
- Switch to oral furosemide as soon as the patient's condition allows.
 - Monitor clinically and biochemically for, and avoid, overdiuresis.

- Monitor for hypokalaemia and other electrolyte disturbances.

LoE III³

If response still inadequate, consider:

- Hydrochlorothiazide, oral, 1 mg/kg/dose, 12 hourly in consultation with a paediatric cardiologist.

LoE III^{15,16}

Manage severe hypotensive or refractory failure in an ICU setting.

Inotropic support may help to stabilise patients with severe myocardial dysfunction and hypotension.

May be lifesaving in severe myocarditis or cardiogenic shock.

- Dobutamine, IV infusion, 2–15 µg/kg/minute.
 - Continue until myocardial function and blood pressure improve.

If no response to dobutamine, consider adrenaline (epinephrine) infusion. Ensure adequate renal function.

Once patient stable and maintaining blood pressure, wean the inotrope and introduce:

- ACE-inhibitor. **Note:** ACEI should be avoided in patients with obstructive heart lesions.
- Captopril, oral:
 - Initial dose: 0.5–1 mg/kg/24 hours in 3 divided doses (8 hourly) for 24–48 hours.
 - Increase by 0.5 mg/kg/24 hours every 24–48 hours until maintenance dose of 3–5 mg/kg/24 hours is reached. Monitor blood pressure and renal function.
 - Continue for as long as needed to control the cardiac failure and allow myocardial recovery.

LoE III¹⁷

4.9.2 HEART FAILURE, MAINTENANCE THERAPY

150.9

GENERAL AND SUPPORTIVE MEASURES

- » Recognise and treat the underlying condition, e.g. infection, hypertension, cardiac tamponade, fluid overload.
- » Fluid restriction (75% of daily requirements) – but not at the expense of adequate caloric intake.
- » Ensure adequate nutrition; tube-feeding may be necessary.
- » Monitor blood potassium levels, urea and electrolytes.

MEDICINE TREATMENT

- Oxygen 100%, administered via face mask or nasal cannula.

Combination drug therapy is usually indicated, i.e. start with a diuretic, then add an ACE-inhibitor.

Diuretic

- Furosemide, oral, 1–2 mg/kg/dose 12 hourly. Titrate dose against clinical response. Potassium supplements are necessary if furosemide is used without an aldosterone antagonist, i.e. spironolactone.
- Monitor for response.

LoE III¹⁸

If response still inadequate, consider:

- Hydrochlorothiazide 1 mg/kg/dose oral, 12 hourly in consultation with a paediatric cardiologist.

LoE III^{15,12}

AND ACE-inhibitor

Note:

ACE-inhibitors are contraindicated in bilateral renal artery stenosis, coarctation of the aorta, aortic stenosis and mitral stenosis.

- Captopril, oral:
 - Initial dose: 0.5–1 mg/kg/24 hours in 3 divided doses (8 hourly) for 24–48 hours.
 - Increase by 0.5 mg/kg/24 hours every 24–48 hours until maintenance dose of 3–5 mg/kg/24 hours is reached. If < 1 year do not exceed 4 mg/kg/day.
 - Continue as long as needed to control the cardiac failure and allow myocardial recovery.

LoE III¹³

OR

- Enalapril, oral, 0.2–1 mg/kg/day as a single dose or 2 divided doses. Start at the low dose and increase by 0.2 mg/kg/day at 1–2 day intervals.

If still symptomatic, add:

- Spironolactone, oral, 1–3 mg/kg/dose once daily. May be divided 12 hourly.

In those patients that are refractory, refer to a paediatric cardiologist for consideration of beta-blockers and digoxin.

REFERRAL

- » For determination of the underlying cause where this is not known, and review of treatment after stabilisation.
- » Deterioration despite adequate treatment.

4.10 DYSLIPIDAEMIA

E78.9

See Chapter 7: Endocrine System, section 7.5.2.5: Dyslipidaemia.

4.11 HYPERTENSION IN CHILDREN

110

DESCRIPTION

Hypertension is defined as systolic and/or diastolic blood pressure \geq the 95th percentile for gender, age and height percentile on at least three consecutive occasions. A sustained blood pressure of $> 130/90$ mmHg in a child older than 13 years is defined as hypertension. Measure blood pressure with the child in a sitting or supine position with the entire arm in line with the level of the heart.

In the majority of children, hypertension is due to an identifiable cause. Severe hypertension suggests renal disease.

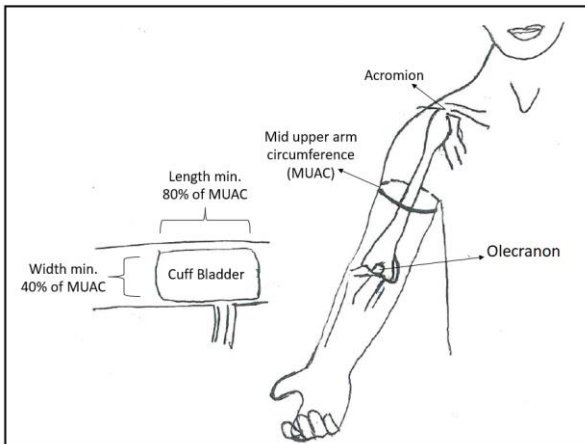
Hypertensive emergency/crisis exists when CNS signs of hypertension appear, such as encephalopathy, convulsions, retinal haemorrhages or blindness. Great care is required to reduce the blood pressure in a controlled manner to avoid potentially serious consequences of impaired auto-regulation of cerebral blood flow.

Hypertensive urgency is defined as a significant elevation of blood pressure without accompanying end-organ damage. Patients are generally symptomatic with complaints of headache, blurred vision and nausea, despite the lack of end-organ involvement.

A valid assessment of the blood pressure is of extreme importance. The blood pressure is measured by standard auscultation technique in children > 1 year of age.

Measure the BP in at least one limb, preferably the right upper arm. If hypertension is present, measure BP in all four limbs.

One should use the widest cuff that can be applied to the upper arm. The cuff bladder must encircle at least 80% of the upper arm and should cover at least 40% of the distance between the acromion and the olecranon.



1. Palpate the bony prominence of the acromion and olecranon posteriorly to determine the mid-upper arm point, where the mid-upper arm circumference (MUAC) is measured.
2. MUAC for BP measurement is done on the right arm whereas for malnutrition, use the non-dominant arm.

It is better to use a cuff that is slightly too large than one that is too small. Large cuffs, if covered with linen-like material, can be folded to the appropriate size in smaller infants as long as the bladder encompasses the arm.

DIAGNOSTIC CRITERIA

Clinical

- » Symptoms and signs of any of the following systems:
 - > central nervous,
 - > cardiovascular,
 - > respiratory,
 - > urogenital.
- » The most common associated features are:
 - > oedema, haematuria, proteinuria,
 - > skin sores (impetigo),
 - > convulsions, coma and visual symptoms,
 - > acute heart failure and pulmonary oedema,
 - > acute respiratory distress, cyanosis and apnoea.
- » Some children may be asymptomatic.
- » Blood pressure in children correlates with body size and increases with age.

Categories of hypertension

- » Normal: below 90th percentile.
- » Elevated blood pressure: 90th–95th percentile or BP > 120/80 mmHg.
- » Stage 1 hypertension: > 95th–99th percentile plus 12 mmHg.
- » Stage 2 hypertension: > 99th percentile plus 5 mmHg.

Age of child	95 th Percentile of systolic and diastolic blood pressure	
	First 12 hours	First week
Newborn – preterm	65/45 mmHg	80/50 mmHg
Newborn – full term	80/50 mmHg	100/70 mmHg

Screening blood pressure values requiring further evaluation¹⁹

Age (years)	Blood Pressure (mmHg)			
	Boys		Girls	
	Systolic	Diastolic	Systolic	Diastolic
1	98	52	98	54
2	100	55	101	58
3	101	58	102	60
4	102	60	103	62
5	103	63	104	64
6	105	66	105	67
7	106	68	106	68
8	107	69	107	69
9	107	70	108	71
10	108	72	109	72
11	110	74	111	74
12	113	75	114	75
≥ 13	120	20	120	80

Note: Blood pressure levels by age and height percentiles. Various growth charts can be obtained from:

https://www.cdc.gov/growthcharts/clinical_charts.htm#Set1

Blood pressure levels for Boys by age and height percentile¹⁶

Age (year)	BP Percentile	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		Percentile of Height							Percentile of Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1	Height (cm)	77.2	78.3	80.2	82.4	84.6	86.7	87.9	77.2	78.3	80.2	82.4	84.6	86.7	87.9
	50 th	85	85	86	86	87	88	88	40	40	40	41	41	42	42
	90 th	98	99	99	100	100	101	101	52	52	53	53	54	54	54
	95 th	102	102	103	103	104	105	105	54	54	55	55	56	57	57
	95 th + 12 mmHg	114	114	115	115	116	117	117	66	66	67	67	68	69	69
2	Height (cm)	86.1	87.4	89.6	92.1	94.7	97.1	98.5	86.1	87.4	89.6	92.1	94.7	97.1	98.5
	50 th	87	87	88	89	89	90	91	43	43	44	44	45	46	46
	90 th	100	100	101	102	103	103	104	55	55	56	56	57	58	58
	95 th	104	105	105	106	107	107	108	57	58	58	59	60	61	61
	95 th + 12 mmHg	116	117	117	118	119	119	120	69	70	70	71	72	73	73
3	Height (cm)	92.5	93.9	96.3	99	101.8	104.3	105.8	92.5	93.9	96.3	99	101.8	104.3	105.8
	50 th	88	89	89	90	91	92	92	45	46	46	47	48	49	49
	90 th	101	102	102	103	104	105	105	58	58	59	59	60	61	61
	95 th	106	106	107	107	108	109	109	60	61	61	62	63	64	64
	95 th + 12 mmHg	118	118	119	119	120	121	121	72	73	73	74	75	76	76
4	Height (cm)	98.5	100.2	102.9	105.9	108.9	111.5	113.2	98.5	100.2	102.9	105.9	108.9	111.5	113.2
	50 th	90	90	91	92	93	94	94	48	49	49	50	51	52	52
	90 th	102	103	104	105	105	106	107	60	61	62	62	63	64	64
	95 th	107	107	108	108	109	110	110	63	64	65	66	67	67	68
	95 th + 12 mmHg	119	119	120	120	121	122	122	75	76	77	78	79	79	80
5	Height (cm)	98.5	100.2	102.9	105.9	108.9	111.5	113.2	98.5	100.2	102.9	105.9	108.9	111.5	113.2
	50 th	90	90	91	92	93	94	94	48	49	49	50	51	52	52
	90 th	102	103	104	105	105	106	107	60	61	62	62	63	64	64
	95 th	107	107	108	108	109	110	110	63	64	65	66	67	67	68
	95 th + 12 mmHg	119	119	120	120	121	122	122	75	76	77	78	79	79	80
Age	BP	Systolic BP (mmHg)							Diastolic BP (mmHg)						

CHAPTER 4

CARDIOVASCULAR SYSTEM

(year)	Percentile	Percentile of Height							Percentile of Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
6	Height (cm)	110.3	112.2	115.3	118.9	122.4	125.6	127.5	110.3	112.2	115.3	118.9	122.4	125.6	127.5
	50 th	93	93	94	95	96	97	98	54	54	55	56	57	57	58
	90 th	105	105	106	107	109	110	110	66	66	67	68	68	69	69
	95 th	108	109	110	111	112	113	114	69	70	70	71	72	72	73
	95 th + 12 mmHg	120	121	122	123	124	125	126	81	82	82	83	84	84	85
7	Height (cm)	116.1	118	121.4	125.1	128.9	132.4	134.5	116.1	118	121.4	125.1	128.9	132.4	134.5
	50 th	94	94	95	97	98	98	99	56	56	57	58	58	59	59
	90 th	106	107	108	109	110	111	111	68	68	69	70	70	71	71
	95 th	110	110	111	112	114	115	116	71	71	72	73	73	74	74
	95 th + 12 mmHg	122	122	123	124	126	127	128	83	83	84	85	85	86	86
8	Height (cm)	121.4	123.5	127	131	135.1	138.8	141	121.4	123.5	127	131	135.1	138.8	141
	50 th	95	96	97	98	99	99	100	57	57	58	59	59	60	60
	90 th	107	108	109	110	111	112	112	69	70	70	71	72	72	73
	95 th	111	112	112	114	115	116	117	72	73	73	74	75	75	75
	95 th + 12 mmHg	123	124	124	126	127	128	129	84	85	85	86	87	87	87
9	Height (cm)	126	128.3	132.1	136.3	140.7	144.7	147.1	126	128.3	132.1	136.3	140.7	144.7	147.1
	50 th	96	97	98	99	100	101	101	57	58	59	60	61	62	62
	90 th	107	108	109	110	112	113	114	70	71	72	73	74	74	74
	95 th	112	112	113	115	116	118	119	74	74	75	76	76	77	77
	95 th + 12 mmHg	124	124	125	127	128	130	131	86	86	87	88	88	89	89
10	Height (cm)	130.2	132.7	136.7	141.3	145.9	150.1	152.7	130.2	132.7	136.7	141.3	145.9	150.1	152.7
	50 th	97	98	99	100	101	102	103	59	60	61	62	63	63	64
	90 th	108	109	111	112	113	115	116	72	73	74	74	75	75	76
	95 th	112	113	114	116	118	120	121	76	76	77	77	78	78	78
	95 th + 12 mmHg	124	125	126	128	130	132	133	88	88	89	89	90	90	90

CHAPTER 4

CARDIOVASCULAR SYSTEM

Age (year)	BP Percentile	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		Percentile of Height							Percentile of Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
11	Height (cm)	134.7	137.3	141.5	146.4	151.3	155.8	158.6	134.7	137.3	141.5	146.4	151.3	155.8	158.6
	50 th	99	99	101	102	103	104	106	61	61	62	63	63	63	63
	90 th	110	111	112	114	116	117	118	74	74	75	75	75	76	76
	95 th	114	114	116	118	120	123	124	77	78	78	78	78	78	78
	95 th + 12 mmHg	126	126	128	130	132	135	136	89	90	90	90	90	90	90
12	Height (cm)	140.3	143	147.5	152.7	157.9	162.6	165.5	140.3	143	147.5	152.7	157.9	162.6	165.5
	50 th	101	101	102	104	106	108	109	61	62	62	62	62	63	63
	90 th	113	114	115	117	119	121	122	75	75	75	75	75	76	76
	95 th	116	117	118	121	124	126	128	78	78	78	78	78	79	79
	95 th + 12 mmHg	128	129	130	133	136	138	140	90	90	90	90	90	91	91
13	Height (cm)	147	150	154.9	160.3	165.7	170.5	173.4	147	150	154.9	160.3	165.7	170.5	173.4
	50 th	103	104	105	108	110	111	112	61	60	61	62	63	64	65
	90 th	115	116	118	121	124	126	126	74	74	74	75	76	77	77
	95 th	119	120	122	125	128	130	131	78	78	78	78	80	81	81
	95 th + 12 mmHg	131	132	134	137	140	142	143	90	90	90	90	92	93	93
14	Height (cm)	153.8	156.9	162	167.5	172.7	177.4	180.1	153.8	156.9	162	167.5	172.7	177.4	180.1
	50 th	105	106	109	111	112	113	113	60	60	62	64	65	66	67
	90 th	119	120	123	126	127	128	129	74	74	75	77	78	79	80
	95 th	123	125	127	130	132	133	134	77	78	79	82	82	83	84
	95 th + 12 mmHg	135	137	137	142	144	145	146	89	90	91	94	94	95	96

CHAPTER 4

CARDIOVASCULAR SYSTEM

Age (year)	BP Percentile	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		Percentile of Height							Percentile of Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
15	Height (cm)	159	162	166.9	172.2	177.2	181.6	184.2	159	162	166.9	172.2	177.2	181.6	184.2
	50 th	108	110	112	113	114	114	114	61	62	64	65	66	67	88
	90 th	123	124	126	128	129	130	130	75	76	78	79	80	81	81
	95 th	127	129	131	132	134	135	135	78	79	81	83	84	85	85
	95 th + 12 mmHg	139	141	143	144	146	147	147	90	91	93	93	96	97	97
16	Height (cm)	162.1	165	169.6	174.6	179.5	183.8	186.4	162.1	165	169.6	174.6	179.5	183.8	186.4
	50 th	111	112	114	115	115	116	116	63	64	66	67	68	69	69
	90 th	126	127	128	129	131	131	132	77	78	79	80	81	82	82
	95 th	130	131	133	134	135	136	137	80	81	83	84	85	86	86
	95 th + 12 mmHg	142	143	145	146	147	148	149	92	93	95	96	97	98	98
17	Height (cm)	163.8	166.5	170.9	175.8	180.7	184.9	187.5	163.8	166.5	170.9	175.8	180.7	184.9	187.5
	50 th	114	115	116	117	117	118	118	65	66	67	68	69	70	70
	90 th	128	129	130	131	132	133	134	78	79	80	81	82	82	83
	95 th	132	133	134	135	137	138	138	81	82	84	85	86	86	87
	95 th + 12 mmHg	144	145	146	147	149	150	150	93	94	96	97	98	98	99

Blood pressure levels for Girls by age and height percentile¹⁷

Age (year)	BP Percentile	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		Percentile of Height							Percentile of Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1	Height (cm)	75.4	76.6	78.6	80.8	83	84.9	86.1	75.4	76.6	78.6	80.8	83	84.9	86.1
	50 th	84	85	86	86	87	88	88	41	42	42	43	44	45	46
	90 th	98	99	99	100	101	102	102	54	55	56	56	57	58	58
	95 th	101	102	102	103	104	105	105	59	59	60	60	61	62	62
	95 th + 12 mmHg	113	114	114	115	116	117	117	71	71	72	72	73	74	74
2	Height (cm)	84.9	86.3	88.6	91.1	93.7	96	97.4	84.9	86.3	88.6	91.1	93.7	96	97.4
	50 th	87	87	88	89	90	91	91	45	46	47	48	49	50	51
	90 th	101	101	102	103	104	105	106	58	58	59	60	61	62	62
	95 th	104	105	106	106	107	108	109	62	63	63	64	65	66	66
	95 th + 12 mmHg	116	117	118	118	119	119	121	74	75	75	76	77	78	78
3	Height (cm)	91	92.4	94.9	97.6	100.5	103.1	104.6	91	92.4	94.9	97.6	100.5	103.1	104.6
	50 th	88	89	89	90	91	92	93	48	48	49	50	51	53	53
	90 th	102	103	104	104	105	106	107	60	61	61	62	63	64	65
	95 th	106	106	107	108	109	110	110	64	65	65	66	67	68	69
	95 th + 12 mmHg	118	118	119	120	121	122	122	76	77	77	78	79	80	81
4	Height (cm)	97.2	98.8	101.4	104.5	107.6	110.5	112.2	97.2	98.8	101.4	104.5	107.6	110.5	112.2
	50 th	89	90	91	92	93	94	94	50	51	51	53	54	55	55
	90 th	103	104	105	106	107	108	108	62	63	64	65	66	67	67
	95 th	107	108	109	109	110	111	112	66	67	68	69	70	70	71
	95 th + 12 mmHg	119	120	121	121	122	123	124	78	79	80	81	82	82	83
5	Height (cm)	103.6	105.3	108.2	111.5	114.9	118.1	120	103.6	105.3	108.2	111.5	114.9	118.1	120
	50 th	90	91	92	93	94	95	96	52	52	53	55	56	52	57
	90 th	104	105	106	107	108	109	110	64	65	66	67	68	64	70
	95 th	108	109	109	110	111	112	113	68	69	70	71	72	67	73
	95 th + 12 mmHg	120	121	121	122	123	124	125	80	81	82	83	84	79	85

CHAPTER 4

CARDIOVASCULAR SYSTEM

Age (year)	BP Percentile	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		Percentile of Height							Percentile of Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
6	Height (cm)	110	111.8	114.9	118.4	122.1	125.6	127.7	110	111.8	114.9	118.4	122.1	125.6	127.7
	50 th	92	92	93	94	96	97	97	54	54	55	56	57	58	59
	90 th	105	106	107	108	109	110	111	67	67	68	69	70	71	71
	95 th	109	109	110	111	112	113	114	70	71	72	72	73	74	74
	95 th + 12 mmHg	121	121	122	123	124	125	126	82	83	84	84	85	86	86
7	Height (cm)	115.9	117.8	121.1	124.9	128.8	132.5	134.7	115.9	117.8	121.1	124.9	128.8	132.5	134.7
	50 th	92	93	94	95	97	98	99	55	55	56	57	58	59	60
	90 th	106	106	107	109	110	111	112	68	68	69	70	71	72	72
	95 th	109	110	111	112	113	114	115	72	72	73	73	74	74	75
	95 th + 12 mmHg	121	122	123	124	125	126	127	84	84	85	85	86	86	87
8	Height (cm)	121	123	126.5	130.6	134.7	138.5	140.9	121	123	126.5	130.6	134.7	138.5	140.9
	50 th	93	94	95	97	98	99	100	56	56	57	59	60	61	61
	90 th	107	107	108	110	111	112	113	69	70	71	72	72	73	73
	95 th	110	111	112	113	115	116	117	72	73	74	74	75	75	75
	95 th + 12 mmHg	122	123	124	125	127	128	129	84	85	86	86	87	87	87
9	Height (cm)	125.3	127.6	131.3	135.6	140.1	144.1	146.6	125.3	127.6	131.3	135.6	140.1	144.1	146.6
	50 th	95	95	97	98	99	100	101	57	58	59	60	60	61	61
	90 th	108	108	109	111	112	113	114	71	71	72	73	73	73	73
	95 th	112	112	113	114	116	117	118	74	74	75	75	75	75	75
	95 th + 12 mmHg	124	124	125	126	126	129	130	86	86	87	87	87	87	87
10	Height (cm)	129.7	132.2	136.3	141	145.8	150.2	152.8	129.7	132.2	136.3	141	145.8	150.2	152.8
	50 th	96	97	98	99	101	102	103	58	59	59	60	61	61	62
	90 th	109	110	111	112	113	115	116	72	73	73	73	73	73	73
	95 th	113	114	114	116	117	119	120	75	75	76	76	76	76	76
	95 th + 12 mmHg	125	126	126	128	129	131	132	87	87	88	88	88	88	88

CHAPTER 4

CARDIOVASCULAR SYSTEM

Age (year)	BP Percentile	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		Percentile of Height							Percentile of Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
11	Height (cm)	135.6	138.3	142.8	147.8	152.8	157.3	160	135.6	138.2	142.8	147.8	152.8	157.3	160
	50 th	98	99	101	102	104	105	106	60	60	60	61	62	63	64
	90 th	111	112	113	114	116	118	120	74	74	74	74	74	75	75
	95 th	115	116	117	118	120	123	124	76	77	77	77	77	77	77
	95 th + 12 mmHg	127	128	129	130	132	135	135	88	89	89	89	89	89	89
12	Height (cm)	142.8	145.5	149.9	154.8	159.6	163.8	166.4	142.8	145.5	149.9	154.8	159.6	163.8	166.4
	50 th	102	102	104	105	107	108	108	61	61	61	62	64	65	65
	90 th	114	115	116	118	120	122	122	75	75	75	75	76	76	76
	95 th	118	119	120	122	124	125	126	78	78	78	78	79	79	79
	95 th + 12 mmHg	130	131	132	134	136	137	138	90	90	90	90	91	91	91
13	Height (cm)	148.1	150.6	154.7	159.2	163.7	167.8	170.2	148.1	150.6	154.7	159.2	163.7	167.8	170.2
	50 th	104	105	106	107	108	108	109	62	62	63	64	65	65	66
	90 th	116	117	119	121	122	123	123	75	75	75	76	76	76	76
	95 th	121	122	123	124	126	126	127	79	79	79	79	80	80	81
	95 th + 12 mmHg	133	134	135	136	138	138	138	91	91	91	91	91	92	93
14	Height (cm)	150.6	153	156.9	161.3	165.7	169.7	172.1	150.6	153	156.9	161.3	165.7	169.7	172.1
	50 th	105	106	107	108	109	109	109	63	63	64	65	66	66	66
	90 th	118	118	120	122	123	123	123	76	76	76	76	77	77	77
	95 th	123	123	124	125	126	127	127	80	80	80	80	81	81	82
	95 th + 12 mmHg	135	135	136	137	138	139	139	92	92	92	92	93	93	94

CHAPTER 4

CARDIOVASCULAR SYSTEM

Age (year)	BP Percentile	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		Percentile of Height							Percentile of Height						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
15	Height (cm)	151.7	154	157.9	162.3	166.7	170.6	173	151.7	154	157.9	162.3	166.7	170.6	173
	50 th	105	106	107	108	109	109	109	64	64	64	65	66	67	67
	90 th	118	119	121	122	123	123	124	76	76	76	77	77	78	78
	95 th	124	124	125	126	127	127	128	80	80	80	81	82	82	82
	95 th + 12 mmHg	136	136	137	138	139	139	140	92	92	92	93	94	94	94
16	Height (cm)	152.1	154.5	158.4	162.8	167.1	171.1	173.4	152.1	154.5	158.4	162.8	167.1	171.1	173.4
	50 th	106	107	108	109	109	110	110	64	64	65	66	66	67	67
	90 th	119	120	122	123	124	124	124	76	76	76	77	78	78	78
	95 th	124	125	125	127	127	128	128	80	80	80	81	82	82	82
	95 th + 12 mmHg	136	137	137	139	139	140	140	92	92	92	93	94	94	94
17	Height (cm)	152.4	154.7	158.7	163.0	167.4	171.3	173.7	152.4	154.7	158.7	163.0	167.4	171.3	173.7
	50 th	107	108	109	110	110	110	110	64	64	65	66	66	66	67
	90 th	120	121	123	124	124	125	125	76	76	77	77	78	78	78
	95 th	125	125	126	127	128	128	128	80	80	80	81	82	82	82
	95 th + 12 mmHg	137	137	138	139	140	140	140	92	92	92	93	94	94	94

GENERAL AND SUPPORTIVE MEASURES

- » There is a strong association between overweight patients and high blood pressure.
- » The majority of these patients have mild hypertension and usually only need lifestyle modification.
- » Acute hypertension:
 - > Bed rest – Fowler’s position.
 - > Control fluid intake and output (restriction).
 - > Restrict dietary sodium.
 - > Manage end-organ effects.
- » Chronic hypertension:
 - > Advise a change in lifestyle.
 - > Institute and monitor a weight reduction programme for obese individuals.
 - > Regular aerobic exercise is recommended in essential hypertension.
- » Dietary advice:
 - > Limit salt and saturated fat intake.
 - > Increase dietary fibre intake.

4.11.1 HYPERTENSION, ACUTE SEVERE

110

For acute or chronic hypertension, blood pressure needs to be lowered cautiously.

Initiate medicines for sustained control as soon as possible to maintain the effect when the emergency measures are discontinued.

Rate of BP reduction depends upon starting BP and age of the child.

In the absence of central nervous system signs, acute hypertension can be rapidly controlled over 24 hours. If in doubt about the duration of hypertension, reduce BP slower over 48 hours.

Aim to reduce the systolic BP with not more than $\frac{1}{3}$ of the interval between the patient’s systolic blood pressure and the 95th percentile for that age or height in the first 8 hours, then a further gradual decline over the next 24–48 hours.

Do not decrease BP to < 95th percentile in first 24 hours.

GENERAL AND SUPPORTIVE MEASURES

- » Admit the patient to a paediatric intensive care unit, if possible.
- » Monitor BP every 10 minutes until stable, thereafter, every 30 minutes for 24 hours.
- » Set up two peripheral intravenous drips.

MEDICINE TREATMENT

Do not combine medicines of the same class.

- Furosemide, IV, 1–2 mg/kg as a bolus slowly over 5 minutes.
 - If oliguric, maximum dose: 5 mg/kg/dose.
 - Repeat appropriately for fluid overload.

AND

- Labetalol, IV, 0.5–3 mg/kg/hour.
 - 100 mg labetalol in 80 mL sodium chloride 0.45% = 1 mg/mL.
 - Infuse with an infusion pump.
 - Give a bolus of 0.5 mg/kg and then titrate the dose slowly upwards until the desired blood pressure is achieved.
 - Repeat, based on BP response.

If there is an inadequate response:

ADD

- Amlodipine, oral, 0.2 mg/kg/dose.
 - May be repeated after 12 hours.
 - Thereafter, every 24 hours.

If pheochromocytoma suspected: Consult a specialist and refer.

Once blood pressure is controlled, taper to oral treatment.

See section 4.11.2: Hypertension, chronic.

URGENT REFERRAL

- » Severe hypertension for specific diagnosis and treatment.

4.11.2 HYPERTENSION, CHRONIC

110

DESCRIPTION**Primary/Essential hypertension**

Occurs most commonly in adolescents.

The patient is often asymptomatic and well.

It is diagnosed by excluding underlying causes of hypertension.

Hypertension is confirmed by sustained high blood pressure measured on 3 follow-up occasions.

Chronic secondary hypertension

All children with incurable forms of persistent secondary hypertension require medicine treatment over and above general and supportive measures.

DIAGNOSTIC CRITERIA**Investigations**

- » Urine dipstick test.
- » Urine MCS.
- » Blood urea, calcium, creatinine and electrolytes.
- » Chest X-ray, ECG and abdominal ultrasound.

If all tests are negative, start lifestyle intervention.

GENERAL AND SUPPORTIVE MEASURES

- » Introduce physical activity, diet management and weight reduction, if obese.
- » Advise teenagers against smoking.
- » Follow up to monitor blood pressure and educate patient on hypertension:
 - > if blood pressure decreases, continue with non-drug management and follow-up;
 - > if BP is increasing progressively, reinvestigate to exclude secondary causes or refer;
 - > if BP is stable but persistently > 95th percentile and secondary causes have been excluded, start medicine treatment after failed non-drug management for 6 months.
- » Consider earlier initiation of medicine treatment if positive family history for cardiovascular disease, essential hypertension or diabetes mellitus.

MEDICINE TREATMENT

The goal of treatment in uncomplicated primary hypertension with no target-organ damage is to achieve BP < 95th percentile. For chronic renal disease, diabetes or hypertension with target-organ damage, the target is BP < 90th percentile.

Medicine treatment is initiated for Stage 2 hypertension. Consider therapy in Stage 1 hypertension if there is a family history of cardiovascular disease, hypertension or diabetes.

Aim to achieve control of BP over 48–72 hours in symptomatic patients.

For ambulatory patients start at the lowest dose of the preferred medicine and increase the dose until control is achieved.

Once the highest recommended dose is reached or if the patient experiences adverse effects from the medicine, add a second medicine from a different class.

For patients with persistent hypertension despite the use of first-line medicine, add a second/third medicine. There is no specific order in which medicine should be added.

There is no evidence of superiority of specific classes of drugs, however, daily dose improves compliance.

ACE-inhibitor

ACE-inhibitors are contraindicated in bilateral renal artery stenosis, coarctation of the aorta, aortic stenosis and mitral stenosis.

- Enalapril, oral, 0.04 mg/kg/dose 12 hourly.
 - Maximum dose: 0.3 mg/kg/dose up to 40 mg/day.

OR

For young children less than 10 kg body weight:

- Captopril, oral:
 - Initial dose: 0.1 mg/kg/dose 8 hourly.
 - Maximum dose: 2 mg/kg/dose.

β -blocker

Contraindicated in severe heart failure and asthma.

- Atenolol, oral, 0.5–1 mg/kg/dose once daily.
 - Maximum dose: 2 mg/kg/day.

OR

If child less than 10 kg body weight:

- Propranolol, oral, 0.25–1 mg/kg/dose 8–12 hourly.
 - Maximum dose: 1.5 mg/kg/dose.

Calcium channel blocker

- Amlodipine, oral, 0.1–0.2 mg/kg/dose once daily.
 - Maximum daily dose: 10 mg/day

Diuretic

- Hydrochlorothiazide, oral, 0.5–1 mg/kg/dose once daily.
 - May cause hypokalaemia.

OR

- Furosemide, oral, 0.5–1.5 mg/kg/dose 12–24 hourly.
 - Maximum dose: 6 mg/kg/day.
 - May cause hypokalaemia.

 α -blocker

May be indicated in patients with phaeochromocytoma-associated hypertension.

Consult a specialist and refer for management of phaeochromocytoma-associated hypertension.

REFERRAL

- » All children with chronic hypertension for specific diagnosis, planning of treatment and long-term follow-up.
- » Patients with phaeochromocytoma-associated hypertension.

4.12 CHILDREN WITH PROSTHETIC HEART VALVES

Z95.2

DESCRIPTION

Valve replacement may be required for severe valvular disease when valve repair is not feasible or advisable. The valves may be mechanical valves or bioprosthetic valves or preserved human tissue valves.

In children, bioprosthetic valves tend to degenerate, calcify and have structural deterioration more frequently and more rapidly compared with adults.

Mechanical valves are more commonly used in children.

Complications include:

- » Valve failure. May be abrupt (tearing of components) or gradual (with calcification and stiffening of leaflets).

- » Prosthetic valve thrombosis.
- » Prosthetic valve endocarditis.
- » Haemolytic anaemia.

MEDICINE TREATMENT

After mechanical valve replacement warfarin therapy is indicated to achieve an INR of 2.5 (range 2.0–3.0):

- Warfarin, oral, 0.1 mg/kg/day.
 - Adjust the dose depending on INR.
 - Beware of haemorrhage.

PLUS

- Aspirin, oral, 1 mg/kg/day in patients at a low risk of bleeding.

LoE III ²⁰

Warfarin dose adjustment based on INR

INR < 1.5	Verify adherence. If non-adherent, resume at previous dose. If dosage adjustments needed, increase dose by 20% and review in 3–7 days.
INR 1.5–1.9	Verify adherence first. Increase maintenance dose by 10%.
INR 2.0–3.0	No change needed. In mitral valve prosthesis, INR should be closer to 3.0.
INR 3.1–4.0	Consider withholding one dose, and decrease by 10%.
INR 4.1–4.5	Decrease dose by 20%.
INR > 4.5	Withhold dose, evaluate INR daily until < 4.5, then restart at 20% below previous dose.

The half-life of warfarin is 40 hours; dose adjustments may thus be calculated over a 48-hour period. The 10% and 20% dose adjustments may not be precisely achieved; approximate doses are acceptable.

If warfarin of 1 mg per tablet is not available and dosage adjustments are problematic, discuss with paediatric cardiologist.

Some medicines and foods interfere with the warfarin effect.

Medicines that enhance anticoagulant effect include:

- » allopurinol,
- » aspirin,
- » NSAIDS,
- » paracetamol (regular use),

- » valproate,
- » phenytoin,
- » imidazoles,
- » metronidazole,
- » macrolides, and
- » quinolones.

Medicines that diminish anticoagulant effect include:

- » carbamazepine,
- » phenobarbital,
- » phenytoin, (both diminished and enhanced effects have been reported)
- » nevirapine,
- » rifampicin.

Foods that contain high amounts of vitamin K can decrease the effectiveness of warfarin, e.g.:

- » spinach,
- » parsley, and
- » brussel sprouts.

Certain drinks can increase the effect of warfarin, e.g. cranberry juice.

References

- ¹ Adenosine Dose: South African Medicines Formulary (SAMF), 13th Edition. Division of Pharmacology, Faculty of Health Sciences, University of Cape Town. 2020.
- ² Kleinman ME, et.al. Pediatric Life Support: Part 14. Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2010; 122: S876-S908.
- ³ Barrington KJ. The Myth of a Minimum Dose for Atropine. *Pediatrics*. 2011;127 (4): 783-784. <http://pediatrics.aappublications.org/content/127/4/783.full>
- ⁴ Shann F. Drug Doses. 16th Edition. 2014.
- ⁵ Leversha AM. Efficacy and dosage of enalapril in congenital and acquired heart disease. *Archives of Disease in Childhood*. 1994; 70(1):35-39.
- ⁶ Shaw N, et. al. Captopril in heart failure secondary to left to right shunt. *Archives of Disease in Childhood*. 1988, 65:360-363.
- ⁷ The Task Force on the Prevention, Diagnosis, and Treatment of Infective Endocarditis of the European society of Cardiology. Guidelines on the prevention, diagnosis, and treatment of infective endocarditis. *European Heart Journal*. 2009;30:2369-2413.
- ⁸ Dahl A, et. al. *Enterococcus faecalis* Infective Endocarditis: A pilot study of the relationship between duration of gentamicin treatment and outcome. *Circulation*. 2013;127:1810-1817.
- ⁹ Wilson WR et.al. Prevention of Viridans Group Streptococcal Infective Endocarditis. A Scientific Statement from the American Heart Association. *Circulation*. 2021, 143: e963-e978.
- ¹⁰ RHD Australia. The 2020 Australian guideline for prevention, diagnosis and management of acute rheumatic fever and rheumatic heart disease, 3rd Edition. 2020. <https://www.rhdaustralia.org.au/arf-rhd-guideline>
- ¹¹ Gerber MA, et.al. Prevention of Rheumatic Fever and Diagnosis and Treatment of Acute Streptococcal Pharyngitis. American Heart Association Statement. *Circulation*. 2009;119:1541-1551.
- ¹² Robinson J, Hartling L, Vandermeer B, Sebastianski M, Klassen TP. Intravenous immunoglobulin for presumed viral myocarditis in children and adults. *Cochrane Database of Systematic Reviews* 2020, Issue 8. Art. No.: CD004370. DOI: 10.1002/14651858.CD004370.pub4.
- ¹³ Mayosi BM, et. al. Prednisolone and Mycobacterium indicus pranii in Tuberculous Pericarditis. *NEJM*. 2014; 371: 1121-1130.
- ¹⁴ Strang JIG, et.al. Controlled trial of prednisolone as adjuvant in treatment of tuberculous constrictive pericarditis in Transkei. *The Lancet*. 1987. 330; 8573:1418-1422.
- ¹⁵ Kantor PF. Clinical Practice - Heart failure in children. Part I: clinical evaluation, diagnostic testing, and initial management. *Eur J Pediatr*. 2010, 169: 269-279.
- ¹⁶ Kantor PF. Clinical Practice - Heart failure in children. Part II: current maintenance therapy and new therapeutic approaches. *Eur J Pediatr*. 2010, 169: 403-410.
- ¹⁷ Capoten® Package Insert. Bristol-Myers Squibb. 2014.
- ¹⁸ Lasix® Package Insert. Sanofi-Aventis. 2012.
- ¹⁹ Flynn JT, Kaelber DC, Baker-Smith CM, et al. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. *Pediatrics*. 2017;140(3):e20171904
- ²⁰ Whitelock RP, et. al. Antithrombotic and Thrombolytic Therapy for Valvular Disease. *Antithrombotic Therapy and Prevention of Thrombosis 9th Edition*. CHEST. 2012; 141 (2): e576S-e600S.