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Clinical Guideline

Disclaimer

Clinical guidelines are best practice recommendations that are intended to assist clinical teams in the delivery of patient care at GOSH. Clinical guidelines attempt to reflect the best available research at the time of writing, but the interpretation and application of clinical guidelines remains the responsibility of the individual clinician. Caution is advised if using a GOSH clinical guideline outside of the organisation and/or beyond its review date.

Paediatric Hypertension Guideline

Document Details	
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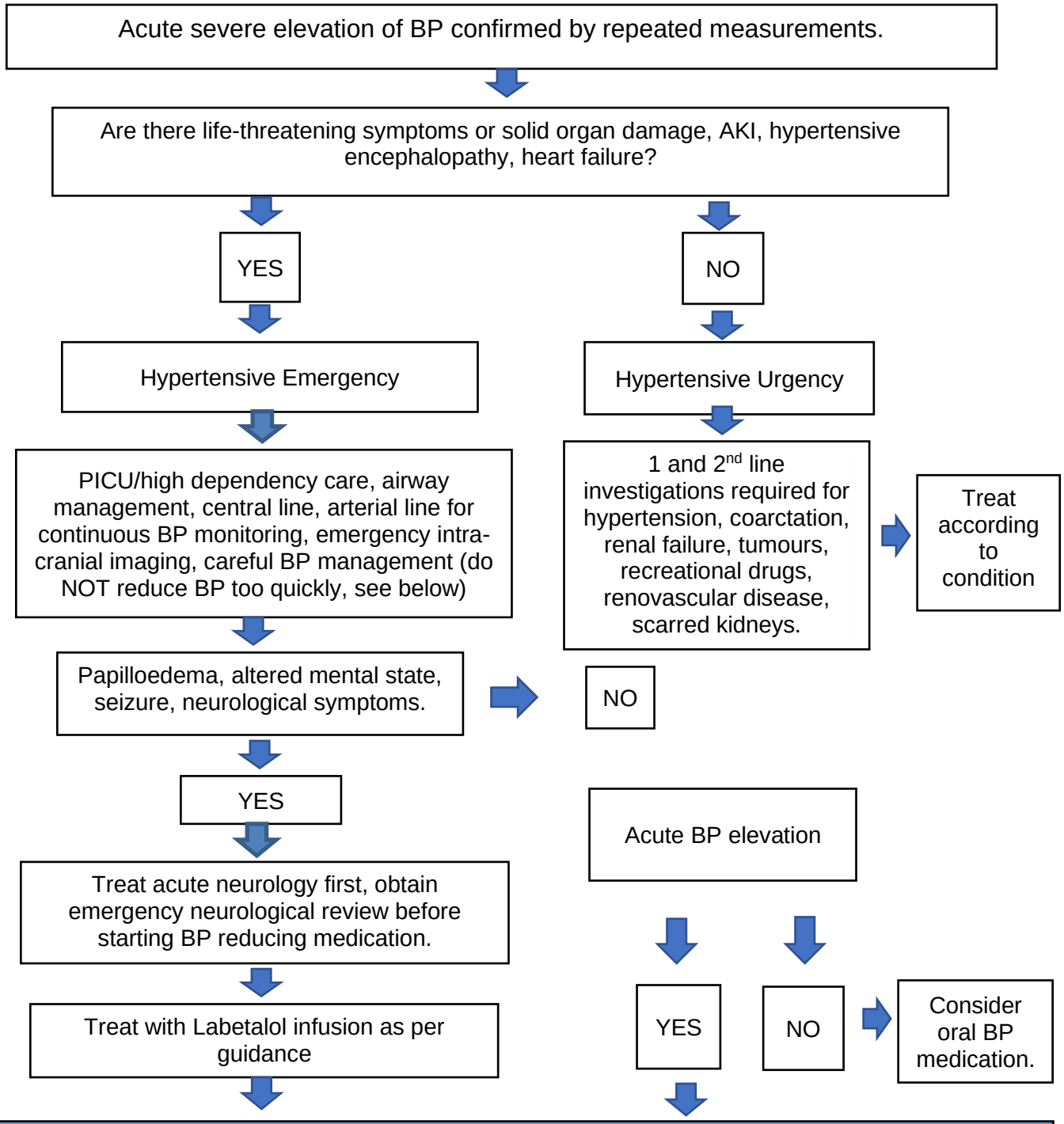
Guideline summary:	This guideline is directed at clinicians caring for children and young people with suspected or confirmed hypertension in the inpatient and outpatient settings. Recommendations for measurement, investigations and management are based on the best available evidence and on the consensus opinion of experts treating hypertension in children.
Key words:	'Best bet' word: **Hypertension** All other key words: **Blood pressure** *Anti-hypertensive medication* *Acute/ urgent/ emergency* *ACE inhibitors, Betablockers, Alpha blockers*
Exclusions:	N/A

Prompt card (Appendix 3)



Target reduction of blood pressure for CYP for Acute/urgent hypertension	
1st Presentation 0-12hrs	**Calculate desired reduction of BP, reduce slowly by 1/3 of total target reduction BP over the first 12hrs**
2nd period 13-24hrs after presentation	**If the CYP remains stable reduce by 1/3 of the total target BP agreed by the consultant**
3rd period after 24 hrs	**If the CYP remains stable aim to reduce again by 1/3 of total target BP, reduction agreed with the consultant**

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1 Introduction

This guideline is directed at clinicians caring for children and young people (CYP) in the inpatient and outpatient settings. Recommendations are based on the best available evidence and on the consensus opinion of experts treating hypertension in children.

Hypertension is defined in CYP at a blood pressure (BP) above the 95th centile using a defined set of data from guidelines by ESC/ESH European or ACC/AHA American societies for hypertension. In adults the levels of acceptable blood pressure are based on extensive data related to a major risk factor for stroke, myocardial infarction, heart failure, chronic kidney disease, cognitive decline, and premature death.

An estimated 0.5-3.5% of children are diagnosed with hypertension. Majority of school age CYP who have a family history of hypertension are overweight or obese and are likely to have primary hypertension. Young children who are not overweight and are found to have high blood pressure are more likely to have a secondary cause for hypertension (1) (2).

In children and adolescents, BP increases with age and body size, making it impossible to use a single BP cutoff value to define hypertension. Hypertension in the age range of 1– 15 years is diagnosed when office (measured in healthcare setting)BP values are found to be ≥ 95th percentile of the normative BP distribution for age, sex and height percentile, persistently on at least three separate occasions. Because of its superior reproducibility and association with hypertensive modified organ damage (HMOD) compared to office BP, Ambulatory blood pressure monitoring (ABPM) can be a valuable source of additional information, its elevation being also based on 24 h mean values over or equal to 95% percentile. ABPM is also indicated for the evaluation of BP control during treatment, the confirmation of resistant hypertension and the identification of white coat hypertension and masked hypertension, which are also not uncommon in children.

In hypertensive adolescents aged 16 years or older, the consensus is to shift to the diagnostic and treatment criteria largely similar to those used in adult hypertensive patients. That is, to (i) identify hypertension by office BP values ≥ 140mmHg for SBP and/or ≥ 90mmHg for DBP, (ii) pursue an office BP target of <130/80mmHg aiming at <125/75mmHg in the presence of HMOD or Chronic Kidney Disease CKD and (iii) lower BP by the same nonpharmacological and pharmacological treatment strategies used in adults.

2 Clinical Features

2.1 *Measurement of blood pressure*

Measurement of blood pressure in young children can be technically difficult and quite uncomfortable for those with significant hypertension. For this reason, we would recommend manual measurement. Manual blood pressure measurement using a validated sphygmomanometer and stethoscope or doppler is the gold standard in CYP for non-direct BP measurement. Recommended validation of equipment can be found on the British and Irish Society for Hypertension.

Isolated diastolic hypertension has been described in children but is rare. There is known association with high diastolic readings and cardiovascular disease in adults. In most circumstances the systolic measurement is the most accurate and consistent reading for which to guide treatment by but we would recommend baseline diastolic readings taken in all children on first assessment and continued diastolic readings for patients who remain with uncontrolled hypertension or ongoing acute illness as inpatients.

Oscillometer devices (automated) are most used, however in infants and young children with severe hypertension the accuracy is questionable and very high BP readings may not register at all. This is caused by different and inconsistent pulse wave amplitude and accuracy is age dependent. Systolic BP values which occur in infants and young children are associated with poorer monitoring quality due to the cardiac cycle being shorter, resulting in a shorter time to measure oscillation (1) (2).

For non-acute hypertension without symptoms the CYP should have 3 measurements, preferably monitored in a relaxed child friendly environment. The three measurements should be taken one minute apart, recorded on three different occasions before a diagnosis of hypertension is made.

Further information on blood pressure measurement technique can be found in Appendix 1.

Table for BP centiles for all ages can be found in the Appendix 2, included are centiles of neonate and infant hypertension, recognising that limited data is available for this age range. Dionne et al (3) have developed a standardized approach for preterm and term neonates.

2.2 *Definition of Hypertension in paediatrics*

Primary hypertension:
Increasing prevalence in paediatric population, intrinsically linked to global incidence of obesity. There is a strong association of primary hypertension associated with family history of hypertension. Treatment basis of primary hypertension is variable depending on screening assessment and other possible comorbidities.

Secondary hypertension:

Secondary hypertension should be suspected in younger patients where high blood pressure is present and/ or complications of hypertension are present.

The likelihood of identifying a secondary cause of hypertension is inversely related to the age of the child and directly related to the degree of blood pressure elevation.
Possible causes of hypertension dependent on aetiology (1,2):

Age	**Cause of hypertension**
Neonatal-1yr	Acute kidney injury (AKI) Renal artery stenosis (fibromuscular dysplasia, umbilical arterial catheter) Autosomol recessive polycystic kidney disease (ARPKD) End stage renal failure (ESRF) (WT1, dysplasia, renal atresia) Infantile Nephronophthisis Renal venous thrombosis Medication Neuroblastoma, Wilms, Adrenal tumours Raised intracranial pressure. Coarctation of the aorta
1-5-years	AKI CKD Atypical Haemolytic Uraemic Syndrome (HUS) Renal artery stenosis/Mid aortic syndrome Glomerulonephritis Renal venous thrombosis Neuroblastoma Kidney cystic disease/ nephronophthisis Corticosteroids Monogenic hypertension (Liddle disease)
5-10-years	AKI CKD Atypical HUS Renal scaring Glomerulonephritis Cystic renal disease Renal artery stenosis/Mid aortic syndrome Endocrine tumours (Cushing syndrome/Conn syndrome /neuroblastoma/ phaeochromocytoma /paraganglioma/neuroblastoma)
10-18	AKI CKD Obesity Autosomal dominant polycystic kidney diseaseADPKD Essential hypertension Reflux nephropathy. Glomerulonephritis Renal artery stenosis/Mid aortic syndrome Endocrine tumours (Cushing syndrome/Conn syndrome/neuroblastoma /phaeochromocytoma/paraganglioma)

	Monogenic hypertension Medication Pregnancy Recreational drugs (ecstasy, amphetamines)

Updated definitions of blood pressure for both systolic blood pressure (SBP) and diastolic blood pressure (DBP); Further categories and stages based on age, sex and height of children please ***see*** *appendix 1* (1).

Category	**0-15 years SBP and/or DBP percentile**	**16 years and older SBP and/or DBP values (mmHg)**
Normal	< 90th	120-129/80-84
High-Normal	≥ 90th to < 95th percentile	130-139/85-89
Hypertension	≥ 95th percentile	≥140/90
Stage 1 hypertension	95th percentile to the 99th percentile and 5 mmHg	140-159/90-99
Stage 2 hypertension	>99th percentile plus 5 mmHg	160-179/100-109
Isolated systolic hypertension	SBP ≥95th percentile and DBP <90th percentile	≥140/90

3 Investigations

In a new presentation of hypertension, the duration is unlikely to be known so the BP must be reduced slowly. The severity of symptoms when reducing the BP levels will be dependent on the length of time the CYP has had hypertension. The shorter the duration of hypertension the less symptoms the CYP will experience when lowering the BP.

3.1 *First line investigations*

Full blood count

Full serum electrolytes (inc. potassium, sodium, chloride, bicarbonate) with renal function

Thyroid function

Urine dipstick for protein and blood

Urine microscopy and culture if suspecting infection

Urine albumin: creatinine ratio and/or urine protein: creatinine ratio if there is proteinuria on urinary dipstick.

Abdominal ultrasound (assess, for any mass, lesion, kidneys urinary tract and supra renal spaces)

Chest x-ray, ECG and/or ECHO

24- hour Ambulatory blood pressure monitoring (ABPM) if available

Fasting lipids and glucose for children with elevated BMI

Consider urine pregnancy, toxicology.

3.2 *Second line investigations*

Should be performed in all cases of more severe hypertension and suspected target organ damage. The investigations listed below should be done in discussion with the consultant nephrologist and be used selectively in cases where they are felt to be needed.

Retinal examination

Plasma renin and aldosterone levels

Plasma and urinary metanephrines (please note plasma catecholamines are no longer processed)

Plasma random cortisol

Urine steroid profile if abdominal mass is suspected.

Urinary VMA/HVA (Vanillylmandelic acid and homovanillic acid)

Renal Doppler ultrasound if available

Nuclear medicine imaging:

DMSA (Dimercaptosuccinic acid san)

MAG 3 (Mercatuacetyltriglycine scan)- depending on history of UTI

ABPMAmbulatory blood pressure monitoring (ABPM):

ABPM is regarded as the gold standard for the diagnosis and management of hypertension. ABPM can be more accurate for the diagnosis of hypertension than clinic-measured BP. ABPM is not always appropriate in all clinical settings and not always appropriate for certain patient cohorts or age groups. For technical reasons, ABPM may need to be limited to children ≥5 years of age who can tolerate the procedure and those for whom reference data are available. Please consult hypertension team for consideration of ABPM for patients.

Uses:

- Identification of white coat hypertension
- Detection of masked hypertension in secondary disease like chronic kidney disease
- As surveillance of treatment for hypertension
- To help monitor target organ damage.
- To help determine hypertension secondary to fluid status in haemodialysis and peritoneal dialysis patients.

Interpretation of ABPM:

Normal BP: Systolic and diastolic BP < 90th percentile

Elevated BP: 90th - 95th

Hypertensive: BP ≥ 95th percentile within overall, day or night readings

Normal office-high ABPM: masked hypertension, increased cardiovascular risk, common in chronic renal failure and proteinuria.

High office-normal ABPM: White coat or poor BP measurement

Both the above high: confirms hypertension.

High day, normal night on ABPM: More common in primary hypertension

High day and high night on ABPM: More likely to be secondary cause for hypertension, increased cardiovascular risk.

Obesity: High day time BP when moving, large night dip ≥ 20%

Obesity with sleep apnoea: High day time BP and elevated night, non-dippers

***Further investigations on discussion with paediatric nephrology team if a secondary cause is suspected:**

Renal angiography and renal vein renin studies:

Should be considered in those cases with a reasonable suspicion of renal artery disease. This includes very severe hypertension and difficult to treat hypertension.

MIBG scan (meta- iodobenzylguanidine)

Should be performed when there is a suspicion of a catecholamine secreting tumour. This includes finding of an adrenal tumour on ultrasound, increased levels of urinary catecholamine's or VMA/HVA, or in children with episodic hypertension. On discussion with oncology multi-disciplinary team MDT.

Lifestyle changes:

It has been demonstrated that lifestyle interventions incorporating a dietary component alongside exercise can lead to improvements in weight and cardiometabolic factors including blood pressure. Below is recommended guidance from European guidelines (1).

Goals	
BMI	BMI <85th percentile: maintain BMI to prevent overweight. BMI 85-95th percentile: weight maintenance (younger children) or gradual weight loss in adolescents to reduce BMI to <85th percentile. BMI >95th percentile: gradual weight loss to achieve value <85th percentile.
Physical Activity	Children and youth aged 5-17 years should accumulate at least 60 min of moderate to vigorous intensity physical activity daily.

	Competitive sports participation should be limited only tin the presence of uncontrolled stage 2 hypertension.
Diet	Avoid intake of excess sugar, excess soft drinks, saturated fats, recommend fruits and vegetables. Limit salt intake.

4 Management

4.1 *Acute urgent hypertension*

The child may present with a variety of symptoms or as an incidental finding, the urgency or level of investigations will depend on the presenting history:
Clinicians may become concerned about acute target-organ damage when the CYP BP exceeds 30 mmHg above the 95th percentile for sex, age, and height. The presence or absence of severe symptoms or target organ damage is more important than the absolute BP level.

Hypertensive emergency: - An acute severe symptomatic elevation in BP with evidence of potentially life-threatening symptoms or target-organ damage (hypertensive with encephalopathy/heart failure/renal disease). Hypertensive emergencies in CYP most commonly manifest as hypertensive encephalopathy, severe BP elevation with cerebral oedema and neurological symptoms of lethargy, coma, and/or seizures. They should be admitted into a HDU for careful monitoring to start treatment, as above the BP should be reduced slowly.
Hypertensive urgency - Symptomatic (moderate to severe headache, fainting, chest pain, palpitations/tachycardia, sweating, anxiety) and persistent elevated BP over 95th+12 mmHg centile but patient may be asymptomatic without significant symptoms.

Further management of hypertensive emergencies can be seen in Appendix 3.

4.2 *Medication Guidance*

The clinical situation and investigations on screening, including the presence of any proteinuria will determine which medication is started. Please see appendix 4 for full dosing information.

αlpha-blockade: - Doxazosin (over 5yrs) Prazosin (3rd line treatment for renovascular disease). Phenoxybenzamine first line treatment for Phaeochromocytoma/paraganglioma (up to 100mg/day in 2 divided doses).

βeta-blockade: - Short acting (Propranolol) long acting (Atenolol) not suitable for certain types of cardiomyopathies. Care should be taken when prescribing for black or afro American groups, contraindicated in asthma, portal hypertension and heart failure.

Calcium channel blocker: - Use short acting Nifedipine with caution due to the high risk of unpredictable hypotension and reflex tachycardia in acute hypertension. (Always check the serum calcium first). Amlodipine long acting is a good first line treatment for hypertension of unknown origin and as a first line treatment for black and afro American CYP.

Angiotensin converting enzyme inhibitor: - Captopril, Enalapril, Lisinopril (Do not start before excluded all secondary causes of hypertension). Prescribe with caution for children with renal impairment, close monitoring of renal function bloods is required in at risk groups. Contraindication in suspected renal artery stenosis. When the GFR is < 20ml/min/1.73m^2, this should only be prescribed on the advice of the consultant nephrologist. ACE inhibitors all cause a drop in GFR, which may be detrimental to any residual function in those with CKD.

Angiotensin receptor blockers: - Losartan, Irbesartan (Do not start before you have excluded all secondary causes of hypertension). Prescribe with caution for children with renal impairment, close blood monitoring may be required in at risk groups. Contraindication in suspected renal artery stenosis.

Agents blocking renin angiotensin aldosterone system (ACE-I and ARB) are contraindicated until renal artery stenosis or bilateral renal artery disease is excluded. Consult medical team when uncertain.

Minoxidil: - Direct vasodilator can cause fluid retention and significant hirsutism.

Hydralazine: - Direct vasodilator of arterial smooth muscle, its onset of action is slower than Labetalol and the duration of action is longer. Useful in neonates but use with caution as carries a significant risk of hypotension.

Clonidine: - Sedation, vasodilator hypertension, may be used as a third or 4th line antihypertension medication.

Diuretics: - Furosemide, Spironolactone, Amiloride, Metolazone.

Short term emergency/urgency of treatments for hypertension should be administered on advice from a nephrologist and under HDU/ITU environments:

Sodium nitroprusside: - May cause thiocyanate toxicity, inactivated by light

Labetalol: - Contraindication in asthma, heart failure, may cause bradycardia

Nifedipine: - May cause unpredictable hypotension, reflex tachycardia (Check serum calcium before administration)

Furosemide: - Risk of Hypokalaemia

For dosing of antihypertensives please refer to *appendix 4* and the British National Formulary for children.

4.3 *Long term blood pressure management*

Our goal is to provide treatment to aim for a BP ≤ 90th centile for primary hypertension and around the 50th centile for secondary hypertension and chronic kidney disease with

proteinuria. Once daily medication is preferable as it aids adherence. Starting dose should be given as per BNFc or local formulary, and maximising treatment dosage before adding a further medication should be considered. The agent(s) used, and order of medication, will depend on a diagnosis already made.
ACEi or ARBS should only be started once a CYP has been fully investigated for secondary causes of hypertension and should not be started in children with significant renal impairment or if renal vascular disease is suspected, except on advice from the nephrologists.
The clinical situation, including the presence of any proteinuria will determine which medication is started. When the glomerular filtration rate is < 20ml/min/1.73m^2, this should only be prescribed on the advice of the consultant.

Blood pressure treatment goal in hypertensive children and young people (1):

General hypertensive population Blood pressure goal	<95th percentile is recommended. <90th should be considered.
Diabetes type 1 and 2	<90th percentile is recommended. <75th percentile is recommended in children with non-proteinuric CKD <50th percentile is recommended in children with proteinuric CKD
Children with CKD	<75th percentile is recommended in children with non-proteinuric CKD <50th percentile is recommended in children with proteinuric CKD

5 Phaeochromocytoma and paraganglioma

Phaeochromocytoma is a relatively rare cause of hypertension in children and accounts for around 1% of all childhood hypertensive cases with an annual estimated incidence of 0.11 per million children (total of 1 per 50,000 population with 10 - 20% presenting in children and adolescents). The incidence of malignant phaeochromocytoma is 0.02 per million children, ranging from 12 - 56% of reported cases, although 6% of paediatric cases are malignant. The endocrine society for clinical guidelines 2014 recommends genetic testing in all patients, with testing. CYP with paraganglioma should be tested for SDHx mutations, and those with metastatic disease for SDHB mutations. All CYP with genetic mutations should have lifelong follow-up with evaluation and treatment by multidisciplinary teams with appropriate expertise to ensure favorable outcomes (7).

5.1 *Common presenting symptoms*

Frequently symptomatic (64-93%) with headache, sweating, flushing, palpitations, blurred vision, syncope, tremor, gastrointestinal disturbance, weight loss, chest and abdominal pain, Pallor, and Polyuria (from glycosuria) and hypertension. Hypertension can be intermittent early in the disease and can present as a hypertensive emergency (8).

There is up to 12% recurrence rate, although in some cases this is due to inadequate primary clearance. In adult practice 10% are extra-adrenal, 10% are bilateral and 10% are malignant with diastolic and postural hypertension (7).

There is a strong predisposition for genetic mutations in this group of patients and DNA should be sent in all patients, as even 60% of apparently sporadic phaeochromocytoma in children aged 18 years or younger and 70% before 10 years of age, have an identified mutation (eg. germline mutation in Von Hippel-Lindau (VHL) gene, the genes encoding the subunits B and D of succinate dehydrogenase (SDHB and SDHD), neurofibromatosis type 1 (NF-1) gene and the RET proto-oncogene predisposing to multiple endocrine neoplasia type 2 (MEN 2 which is not excluded by normal calcitonin). Although children with genetically determined predisposition are at risk of developing multiple and bilateral lesions, generally the prognosis in childhood is excellent (7).

5.2 *Initial investigations*

Targeted investigation should be undertaken in suspected patients with phaeochromocytoma of the adrenal medulla (chromaffin cells) or extra-adrenal paraganglioma of the sympathetic paraganglia, which normally secrete catecholamine's (metanephrine). Note head and neck paraganglioma parasympathetic paraganglioma, carotid body chemodectomas and glomus jugular tumours do not usually secrete catecholamines.

Urine tests

- A spot urinary metanephrine is sufficient as most children with symptoms have significantly elevated levels of metanephrines. Children who have a slight elevation in the urine metanephrine should be asked to do a 24-hour urinary collection.

Blood tests

- Plasma metanephrines (97% sensitivity and 85% specificity) have become the test of choice.

Radiological investigations

- Abdominal ultrasound in symptomatic patients looking for adrenal and paravertebral masses.
- Cross-sectional imaging with MRI abdomen or CT abdomen
- 123I-labelled MIBG (metaiodobenzylguanidine) scan for confirmation, accurate staging, and pre-operative planning.

5.3 *Admission and peri operative management*

Blood tests

- Full blood count, including haematocrit.
- Coagulation screen
- Crossmatch 1 unit (discuss with anaesthetist and surgeon)
- U&Es, LFTs, glucose, ionised calcium, PTH, thyroid function

Urine tests

- Urine dipstick and urine albumin: creatinine ratio if proteinuria
- Repeat spot urinary metanephrine.

Cardiac investigations

- ECG (for evidence of tachycardia and/or arrhythmias)
- Echocardiography for left ventricular hypertrophy and overall function.

Peri-operative management (6):

Management of hypertension to be started at least 3-4 weeks prior to surgery with below medication regime:

α-blockade - Phenoxybenzamine should be started first
0.5 - 1.0mg/kg twice daily adjusted according to response (Starting dose of 1 capsule 10mg/dose can be increased by 10mg/day) adequate α-blockade is indicated by normotension, development of side effects (~10% orthostatic hypotension, tachycardia, nasal congestion). Max dose is dependent on response. *Please round doses to the closest capsule size as the drug is very insoluble making part dosing challenging*

β-blockade - Oral Propranolol
Starting dose 0.5 - 1.0mg/kg three times daily
If persistent tachycardia or dysrhythmia (and no cardiomyopathy)
(Administration of β-blocker prior to adequate α-blockade, may compound hypertension secondary to unopposed vasoconstriction and is contra-indicated)

Drug	**Route**	**Normal Starting dose**	**Normal dose range (to maximum)**	**Divided doses/ day**	**Comments**
Phenoxy-benzamine	oral	0.5 - 1.0mg/kg twice daily adjusted according to response (Starting dose of 1 capsule 10mg/dose can be increased by 10mg/day). Round dose to nearest capsule strength.	1-4mg/kg/day Increase daily Maximum dose 100mg/day	2	Capsules 10mg
Propranolol	oral	0.5-1mg/kg/dose	1-8mg/kg/day Increase daily	2-3	Tablets 10mg, 40mg, 80mg
Amlodipine	oral	100-200microgram/kg/dose	0.2 -0.4mg/kg *(Maximum 10mg/day)*	1	Syrup 1mg/ml, 5mg, 10mg tablets

Salt supplements may be required if the child has severe symptoms of hypotension.

Fluid management:
Fluid management is very important during this period. High metanephrine causes vasoconstriction and increases the blood pressure and pulse. The young person should be encouraged to drink 3litres/day. They may need several repeat ABPM's before they are proven to be adequately blocked, to see minimal spikes in blood pressure or pulse rate and ideally blood pressures at the 50th centile.
Intravenous fluids 0.9% sodium chloride and 0.5% dextrose should be started 24 hours before surgery (If the child is reluctant to take oral fluids) or when the patient is NBM. Full maintenance is required to ensure adequate intravascular volume.

5.4 *Anaesthetic management*

On anaesthetist orders only omit dose of Phenoxybenzamine on morning of surgery. Guidance from our anaesthetic team as below.

1. Premedication (midazolam or temazepam)
2. Intravenous induction (propofol or thiopentone)
3. Vecuronium
4. invasive monitoring of BP prior to or immediately after induction
5. lidocaine 1% to cords prior to intubation
6. Fentanyl or remifentanil (0.15 - 0.25 micrograms/kg/min)
7. Isoflurane or sevoflurane: O2: air
8. Central venous line (IJV)
9. Monitoring: ECG, SaO2, EtCO2, ABP, CVP, UO, Temp, ABG
10. Epidural for open procedure

Hypertensive during tumour manipulation

a. Sodium nitroprusside (1mg/ml) by infusion (0.1 - 2.0 micrograms/kg/min)
b. Phentolamine initially 10 micrograms/kg or 0.5mg bolus, titrated as per response up to 5mg doses and repeated as needed – intra operative use only. Intraoperative monitoring of blood pressure is required.
c. Esmolol (5mg loading over 2 minutes then 50 microgram/kg/min)

Hypotension - following adrenal vein ligation and tumour isolation.

d. Stop hypertensive agents.
e. Gelofusin 15mls/kg
f. Noradrenaline infusion if necessary
g. Phenylephrine
h. Vasopressin

5.5 *Post surgical management / long term follow u*p

1. Aim to extubate at end of procedure.
2. Admission to PICU for hemodynamic monitoring overnight under guidance from anaesthetic team
3. Analgesia: epidural or morphine PCA

Potential problems: hypotension, fluid overload, hypertension, hypoglycaemia.

Discharge:

1. 5-7 days post operatively.
2. Follow up outpatient appointment with nephrology/hypertension clinic in 8 weeks.
    a. ABPM
    b. Check plasma metanephrines.
    c. Yearly follow up with nephrology/oncology for life

6 References

1. Flynn JT, Kaelber DC, Baker-Smith CM, Blowey D, Carroll AE, Daniels SR, et al. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. Pediatrics [Internet]. 2017 Aug 21;140(3): e20171904. Available from: https://pediatrics.aappublications.org/content/140/3/e20171904 [Last accessed 7/9/23].
2. Lurbe E, Cifkova R, Cruickshank JK, Dillon MJ, Ferreira I, Invitti C, et al. Management of high blood pressure in children and adolescents: recommendations of the European Society of Hypertension. Journal of Hypertension. 2009 Sep;27(9):1719–42.
3. Dionne JM, Abitbol CL, Flynn JT. Hypertension in infancy: diagnosis, management and outcome. Paediatric Nephrology. 2011 Jan 22;27(1):17–32.
4. Flynn JT, Daniels SR, Hayman LL, Maahs DM, McCrindle BW, Mitsnefes M, et al. Update: Ambulatory Blood Pressure Monitoring in Children and Adolescents. Hypertension [Internet]. 2014 May;63(5):1116–35. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4146525/ [Last accessed 7/9/23].
5. Report of the Second Task Force on Blood Pressure Control in Children—1987. Paediatrics. 1987 Jan 1;79(1):1–25.
6. Connor D, Boumphrey S. Perioperative care of phaeochromocytoma. BJA Education. 2016 May;16(5):153–8.
7. Fishbein L, Merrill S, Fraker DL, Cohen DL, Nathanson KL. Inherited Mutations in Pheochromocytoma and Paraganglioma: Why All Patients Should Be Offered Genetic Testing. Annuals of Surgical Oncology. 2013 Mar 20;20(5):1444–50.
8. Nazari MA, Pacak K, Mickey, Patel M, Prodanov T, Rosenblum JS. Paediatric phaeochromocytoma and paraganglioma: A clinical update. Clinical Endocrinology. 2023 Jul 28; Available at: https://onlinelibrary.wiley.com/doi/10.1111/cen.14955 [Last accessed 7/9/2023].

7 Appendix 1 – Blood pressure measurement

Technique:

Doppler technique uses a probe held over the brachial or radial pulse and magnifies the sound of the K1 sound (suitable for systolic BP only). It may also overestimate the BP when used for casual BP readings in the clinic environment. A pulsatile blood flow through the vessel produces arterial wall oscillation, this is transferred to the cuff encircling the extremity. Systolic BP is recorded at the point where a rapid increase in the oscillation amplitude occurs (K1).

Many automated monitors now calculate the systolic and diastolic BP using the mean arterial pressure. Of note if an infant or small child's BP is > 200 mmHg, as seen in children with malignant hypertension, the monitor may not be able to calculate the reading so will just show an error. In this situation it is vital that manual BP equipment is used to check a BP reading.

Overestimation of BP may be due to the environment or equipment used, for this reason repeated measurements are recommended. For children and adolescents, it is important to obtain multiple measurements, over a period, before making a diagnosis of hypertension. If they are not symptomatic three measurements one minute apart, on three different occasions, a week apart is recommended.

Guidance:

The current guidance in the UK, Europe and the US state that if a child's BP is measured by oscillometer devices and found to be over the 90th centile on repeated visits, that the BP measurement should be confirmed by auscultation before making the diagnosis of hypertension.

Of equal importance to accuracy of BP measurement is the choice of cuff size. We recommend that the inflatable bladder length should encircle 80% - 100% of the child's arm circumference and that the width of the cuff should cover most of the upper arm from axilla to just above the elbow.

If the child or young adult has a very large upper arm, it's acceptable for the cuff bladder length to overlap and for the width of the cuff to cover the brachial pulse. In this situation use the radial pulse to measure the BP. A cuff that is too small is likely to make the BP artificially high. Use of larger thigh cuffs should be considered for elevated BMI groups.

- BP should always be measured in the right arm initially for all children including small infants and toddlers to exclude coarctations.
- 4 limb BP should be measured if hypertension is suspected.
- Cuff inflation should be 20-30 mmHg above point the pulse disappears. Deflation should be at 2-3 mmHg per second.
- Note that the systolic BP in the leg is usually 10%-20% higher than the arm.

Manual measurement

- Position the child so they are sitting with the legs uncrossed
- Resting with their feet on the floor and the back supported resting for 5 minutes
- The arm should be bare to the shoulder
- The cuff should be placed at heart level directly on skin
- The arm should be supported to prevent isometric contraction of the muscle
- The child should be relaxed and requested not to talk during the procedure
- The cuff should be placed on the upper arm 1-2 cm above the crease of the elbow to avoid interference during measurement using a stethoscope or doppler
- Make sure the cuff fits snuggly on the arm with the mid portion of the cuff in line with the brachial artery, an indicator line is usually seen on the outside of the cuff
- Place the stethoscope or doppler over the brachial or radial artery
- Inflate the cuff to 20mmHg above the last pulse sound. This can be palpated before starting the measurement if a doppler is not used
- The pressure of the cuff should be released slowly at 2mm/second
- The point at which the tapping sounds first appear for at least 2 consecutive beats is K1 the systolic BP
- When using a stethoscope, the point when the sounds completely disappear is K5 is the diastolic BP
- If the sounds do not disappear which is common in infants the muffling sounds at K4 can be taken as the diastolic BP level

Automated measurement: - A validated monitor for paediatrics should be used for measurement.

- Position the child so they are sitting with the legs uncrossed
- Resting with their feet on the floor and the back supported resting for 5 minutes
- The arm should be bare to the shoulder
- The cuff should be placed at heart level on the upper arm
- The arm should be supported to prevent isometric contraction of the muscle
- The child should be relaxed and requested not to talk during the procedure
- The cuff should be placed on the upper arm just above the crease of the elbow, this is not always possible in obese children and adolescents and in this instance, it is important to position the arterial line over the brachial artery.

Ambulatory blood pressure monitoring:

This is a very useful form of oscillometer monitoring for children over 5 years of age to aid in the diagnosis of hypertension. Young children and adolescents need to be able to keep their arm completely still during measurement and tolerate wearing the monitor for 24hrs. It is not suitable for all children. Results should be reviewed by clinicians experienced in interpreting ABPM.

Measurements in neonates:

Acutely unwell neonates may have direct arterial BP monitoring, alternatively the automated monitors are reasonable to use in this group as they are less mobile so less effect on

readings. If clinicians are concerned with automated readings the Doppler technique can be used using the same techniques regarding cuff size documented above.

Documentation:

- Cuff size used.
- Systolic BP
- Diastolic BP (when appropriate)
- Limb used.
- Child's state (e.g. asleep, awake settled or irritable)
- Method of measurement
- Number of measurements

If the BP continues to be elevated above the 95th centile on three separate occasions, they can be referred to a specialised unit for further assessment if required. If the BP is elevated above the 95th and less than the 99th centiles and the child is obese they should be encouraged to make healthy lifestyle changes with advice on diet and exercise for 6 months before referral to specialised units.

8 Appendix 2 – Blood pressure centiles by gender, age, and height

Neonatal centiles post conceptual age: This table was reproduced from: Dionne et al (2012) Hypertension in infancy: diagnosis, management, and outcome. Paediatric Nephrology (6)

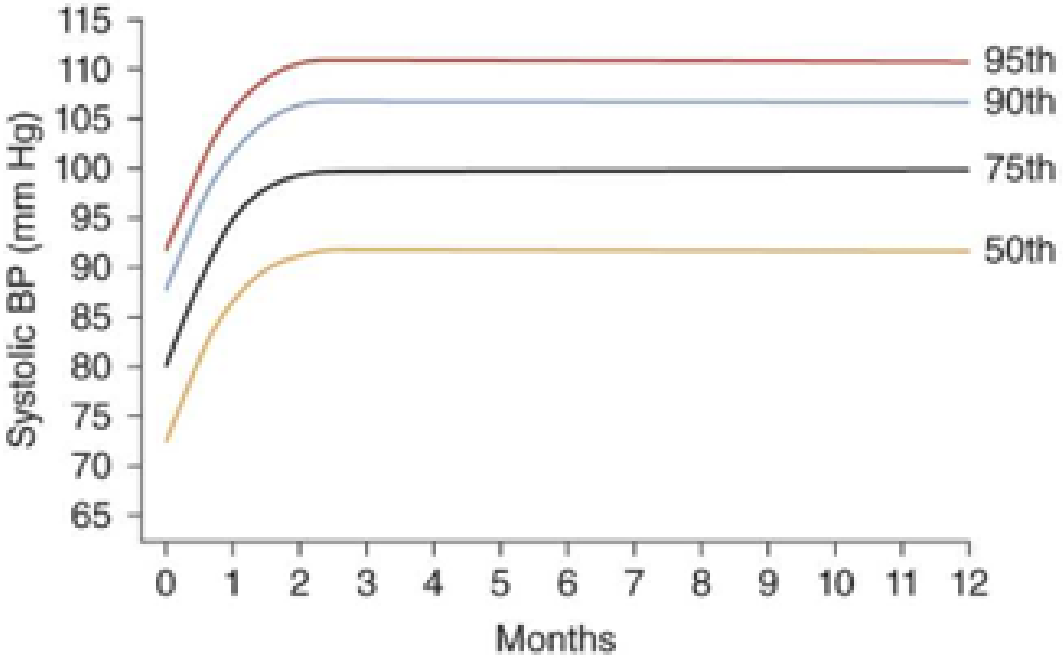
Birth to 12 months blood pressure centiles: Table was reproduced from Task Force on Blood Pressure Control in Children (1987).

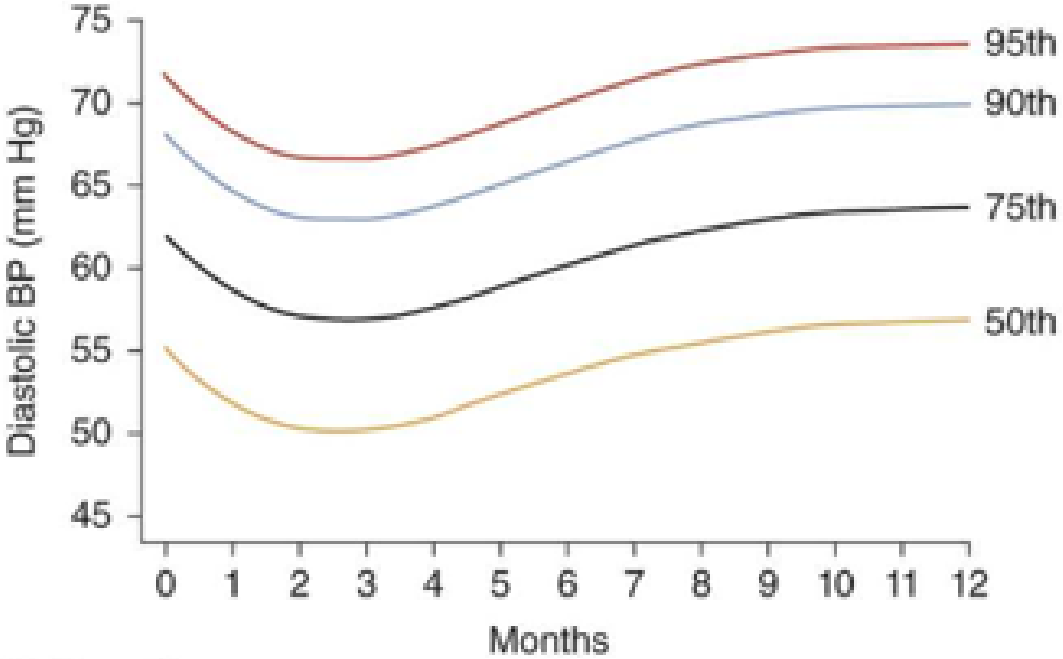
Age 1- 17 years of age: Tables reproduced from: Flynn et al (2017) Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. Paediatrics. 2017; 140 (3)

Post-conceptual age	50th percentile	95th percentile	99th percentile
44 weeks			
SBP	88	105	110
DBP	50	68	73
MAP	63	80	85
42 weeks			
SBP	85	98	102
DBP	50	65	70
MAP	62	76	81
40 weeks			
SBP	80	95	100
DBP	50	65	70
MAP	60	75	80
38 weeks			
SBP	77	92	97
DBP	50	65	70
MAP	59	74	79
36 weeks			
SBP	72	87	92
DBP	50	65	70
MAP	57	72	77

34 weeks			
SBP	70	85	90
DBP	40	55	60
MAP	50	65	70
32 weeks			
SBP	68	83	88
DBP	40	55	60
MAP	49	64	69
30 weeks			
SBP	65	80	85
DBP	40	55	60
MAP	48	63	68
28 weeks			
SBP	60	75	80
DBP	38	50	54
MAP	45	58	63
26 weeks			
SBP	55	72	77
DBP	30	50	56
MAP	38	57	63

Age-specific percentiles of blood pressure measurements in boys birth to 12 months

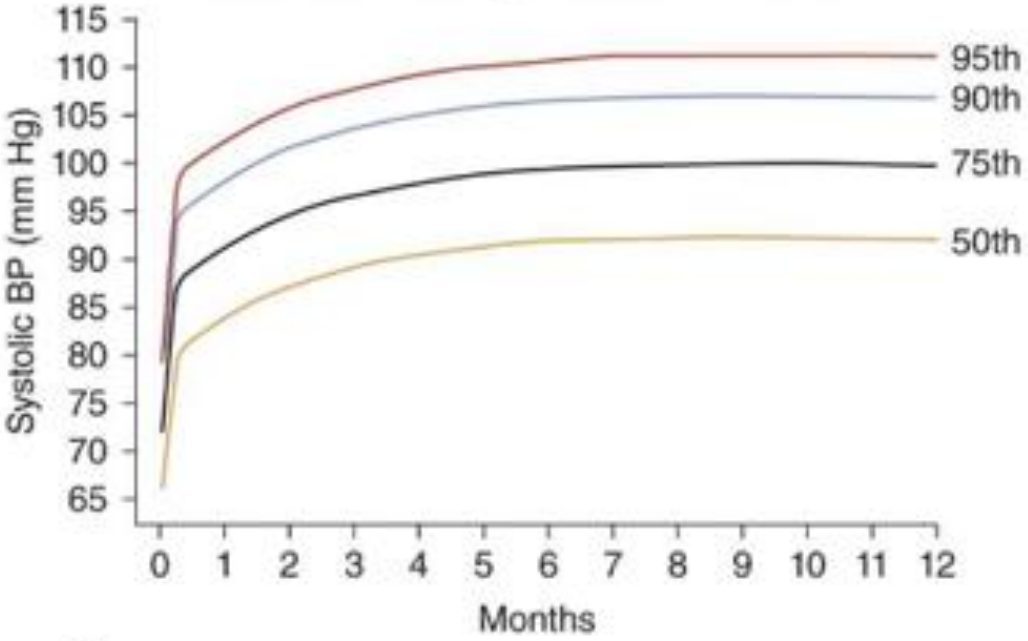


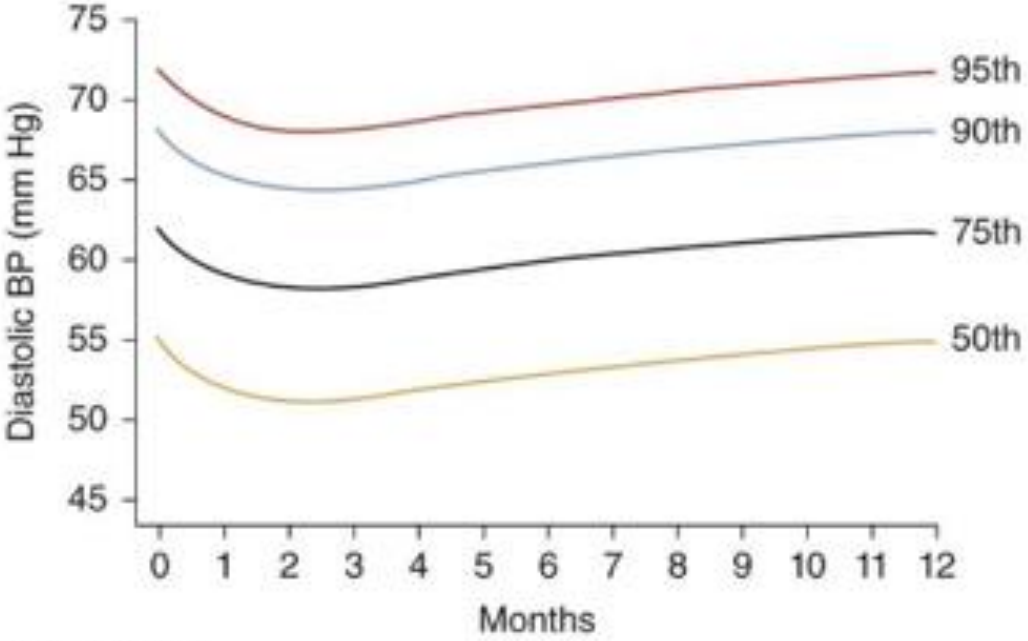


90th Percentile

Systolic BP	87	101	106	105	106	106	106	106	106	106	106	106	106
Diastolic BP	68	65	63	63	63	65	66	67	68	68	89	69	89
Height (cm)	51	59	63	66	68	70	72	73	74	76	77	78	80
Weight (kg)	4	4	5	5	6	7	8	9	9	10	10	11	11

Age-specific percentiles of blood pressure measurements in girls birth to 12 months





90th Percentile

Systolic BP	76	98	101	104	105	106	106	106	106	106	106	105	105
Diastolic BP	68	65	64	64	65	65	66	66	66	67	67	67	67
Height (cm)	54	56	56	58	61	63	66	66	70	72	74	75	77
Weight (kg)	4	4	4	5	5	6	7	8	9	9	10	10	11

Blood Pressure Levels for Boys by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50th	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50th	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50th	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50th	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50th	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50th	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50th	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90th	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95th	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99th	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	50th	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90th	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95th	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99th	120	121	123	125	127	128	129	84	85	86	87	88	88	89
10	50th	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90th	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95th	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99th	122	123	125	127	128	130	130	85	86	86	88	88	89	90

Blood Pressure Levels for Boys by Age and Height Percentile (Continued)

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
11	50th	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90th	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95th	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99th	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50th	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90th	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95th	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99th	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50th	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90th	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95th	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99th	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50th	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90th	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95th	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99th	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	50th	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50th	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	50th	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90th	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

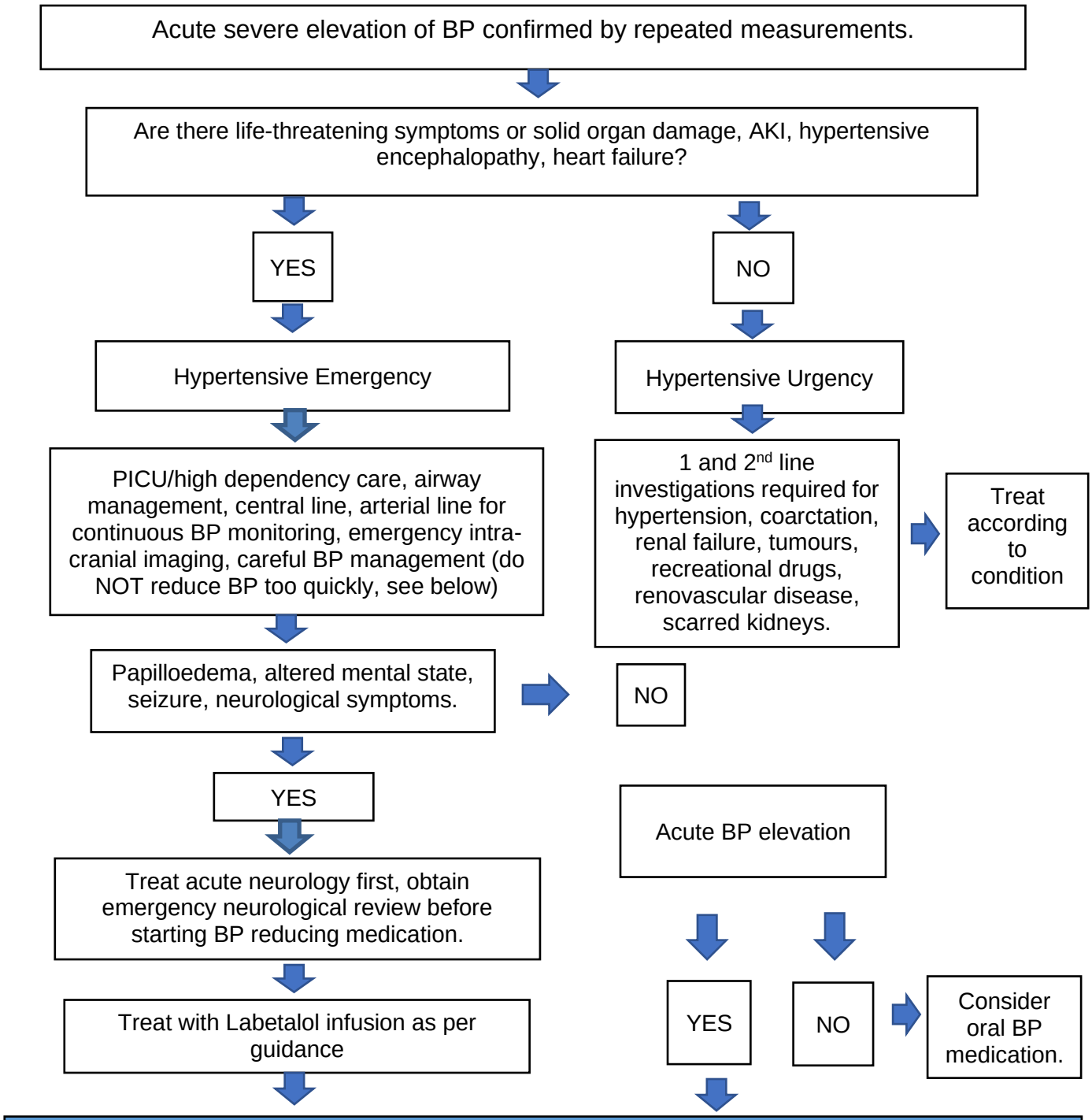
Blood Pressure Levels for Girls by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		← Percentile of Height →							← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	83	84	85	86	88	89	90	38	39	39	40	41	41	42
	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	50th	85	85	87	88	89	91	91	43	44	44	45	46	46	47
	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	50th	86	87	88	89	91	92	93	47	48	48	49	50	50	51
	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	50th	88	88	90	91	92	94	94	50	50	51	52	52	53	54
	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	50th	89	90	91	93	94	95	96	52	53	53	54	55	55	56
	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	50th	91	92	93	94	96	97	98	54	54	55	56	56	57	58
	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86
9	50th	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87
10	50th	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88

Blood Pressure Levels for Girls by Age and Height Percentile (Continued)

Age (Year)	BP Percentile ↓	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		← Percentile of Height →							← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
11	50th	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	50th	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	50th	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92
15	50th	107	108	109	110	111	113	113	64	64	64	65	66	67	67
	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93
16	50th	108	108	110	111	112	114	114	64	64	65	66	66	67	68
	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	50th	108	109	110	111	113	114	115	64	65	65	66	67	67	68
	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

9 Appendix 3 - Algorithm for acute severe elevation of blood pressure



Target reduction of blood pressure for CYP for Acute/urgent hypertension	
1st Presentation 0-12hrs	**Calculate desired reduction of BP, reduce slowly by 1/3 of total target reduction BP over the first 12hrs**
2nd period 13-24hrs after presentation	**If the CYP remains stable reduce by 1/3 of the total target BP agreed by the consultant**
3rd period after 24 hrs	**If the CYP remains stable aim to reduce again by 1/3 of total target BP, reduction agreed with the consultant**

10 Appendix 4 – Pharmacological Guideline for hypertension

Class	Agent	Dose	Renal Impairment	Side effects	Cautions	Monitoring requirement
Angiotensin Converting enzyme (ACE) Inhibitors	**Captopril** Tablets; 12.5 mg, 25 mg 25 mg per 5 ml (100 ml) – Shelf life 21-28 days once opened.	BNFc GSTT Paediatric formulary **THREE** times a day	Use with caution in renal impairment, starting with a low dose and adjusting according to response. Generally safe in chronic renal failure. **Avoid in renal artery stenosis.** In all cases, the use of ACE will drop baseline renal function slightly. Hyperkalaemia more likely to occur in renal failure patients. Avoid use of concomitant potassium retaining drugs.	Hyperkalaemia, cough, dizziness and headaches. Angioedema; ACE inhibitor should be stopped immediately. If possible, ARBs should also be avoided in these patients.	Avoid where possible in pre-term and term neonates owing to increased risk of renal failure and hypotension. Avoid in renal artery stenosis. Use with caution in people of black African or Caribbean origin, as known to respond less well to ACE inhibitors. Avoid potassium supplements, potassium sparing diuretics or ARB's in conjunction. Withhold in hyperkalaemia. Concomitant diuretic dosages may need to be reduced to avoid hypotension.	Assess baseline U&E's and renal function before initiation and regularly afterwards. Monitor for hypotension particularly after 1st dose. Close observation required every 15 minutes for the first hour and then every 4 hourly. **1mg Enalapril can be substituted for 7.5mg of Captopril** **1mg of Lisinopril can be substituted for 5mg of captopril**.
	Lisinopril (1st choice for long acting ACEi) Tablets; 2.5 mg, 5 mg, 10 mg Tablets can be crushed and dispersed in water.	BNFc GSTT Paediatric formulary **ONCE** daily dosing				
	Enalapril Tablets; 2.5 mg, 5 mg 10 mg Tablets can be crushed and dispersed in water.	BNFc GSTT Paediatric formulary **ONCE** daily dosing. (However total daily dose can be given as two split doses)				
	Ramipril Tablets; 1.25mg, 2.5mg Capsules; 1.25mg Tablets can be crushed and dispersed in water. Capsules can be opened.	BNF adults **ONCE** daily dosing. Consider starting in children over the age of 12 years at 1.25mg once daily and titrate.				
Angiotensin Receptor Blockers (ARBs). **Alternate for those who**	**Losartan** Tablets; 25mg Can be crushed and dispersed.	BNFc GSTT Paediatric formulary **ONCE** daily dosing (dose can	Use in caution with renal impairment, starting with a low dose and adjusting according to	Similar to ACE inhibitors, without the chronic cough.	As with ACE inhibitors.	Assess baseline U&E's and renal function before initiation and regularly afterwards.

cannot tolerate ACE inhibitors.		be split over 2 doses)	response. Generally safe in chronic renal failure. **Avoid in renal artery stenosis.** Hyperkalaemia more likely to occur in renal failure patients. Avoid use of concomitant potassium retaining drugs.			Monitor for hypotension particularly after 1st dose. Close observation required every 15 minutes for the first hour and then every 4 hourly Use of ARB with an ACE-I is not recommended.
	Irbesartan Tablets; 75mg, 150mg Can be crushed and dispersed in water	GSTT Paediatric formulary **ONCE** daily dosing				
Calcium Channel Blockers (CCB's)	**Nifedipine** M/R tablets: 10 mg, 20 mg (tablets can be crushed and dispersed in water however modified release characteristics maybe modified) Liquid: 20 mg in 1 ml (1 drop = 1mg) Note liquid is an imported product (Avoid using in acute hypertension).	BNFc GSTT Paediatric Formulary **Frequency depends on formulation**	Dose as in normal renal function. Start with a low dose and adjust according to response.	Constipation, malaise, oedema, vasodilation.	Not all formulations are bioequivalent therefore care in prescribing. Where possible prescribe drug name, formulation and trade name to ensure continuity of the same preparation. Grapefruit juice can enhance the effect of nifedipine.	May cause unpredictable and severe reduction of blood pressure—monitor closely following administration.
	Amlodipine Tablets; 5 mg, 10 mg Tablets can be crushed and dispersed in water. Liquid: 5 mg in 5 ml (fridge)	BNFc GSTT Paediatric formulary **ONCE** daily dosing **Maximum dose 10mg/day**	Dose as in normal renal function. Start low and titrate according to response.	Abdominal pain, dizziness, drowsiness, headache, facial flushing, peripheral odema/ankle swelling. (Diuretics will not help with ankle odema)	Concomitant use of clarithromycin and erythromycin will enhance the effect of Amlodipine. Grapefruit juice can enhance the effect of amlodipine.	Monitor BP Amlodipine is always expressed as base regardless of the salt prescribed.

Beta - blockers	**Propranolol** Tablets; 10 mg, 40 mg Liquid; 5 mg in 5 ml	BNFc GSTT Paediatric Formulary **TWO - THREE** times a day.	Should be used with caution in renal impartment, starting with a low dose and adjusting according to response. Not dialysed.	Abdominal discomfort, bradycardia, depression, confusion and peripheral coldness.	Can induce bronchospasm in asthmatic patients and those with a history of obstructive airway disease therefore avoid. Where there is no alternative cardio selective beta blockers can be given with caution and supervision (**atenolol** and **metoprolol** are cardio selective). Caution in use for those with diabetes (mask symptoms of hypoglycaemia). Avoid abrupt withdrawal. Avoid in cardiogenic shock and marked bradycardia.	Monitor lung function in patients with a history of obstructive airway disease. Monitor heart rate and blood pressure. Add on therapy for hypertension, reduces sympathetic drive.
	Atenolol Tablets; 25 mg, 50 mg, 100 mg Liquid: 25 mg in 5 ml (contains sorbitol) Injection: 5mg in 10 ml	BNFc GSTT Paediatric Formulary **ONCE** daily dosing.	CrCl >35ml/min no dose adjustment. CrCl 10-35ml/min use 50% of the dose. <10ml/min 30-50% of normal dose and adjust as per response.			
Alpha-blockers **Both have vasodilator and alpha blocking properties.**	**Prazosin** Tablets; 500 microgram, 1 mg Tablets can be dispersed in water when shaken. Forms a dispersion.	BNFc GSTT Paediatric Formulary **TWO – FOUR times a** day dosing	Not dialysed, dose as in normal renal function. Patients in renal failure maybe more sensitive to effects of alpha blockers.	Blurred vision, depression, drowsiness and GI disturbances.	Avoid use in history of postural hypotension, and modified-release formulation in those with GI or oesophageal obstruction.	Monitor blood pressure after the first dose. BP can be reduced rapidly; therefore, weekly increments with monitoring are recommended. Doses maybe preferable before bedtime owing to the drop in blood pressure on initial doses. Add on therapy for resistant hypertension
	Doxazosin Tablets; 1 mg, 4mg. Tablets disperse in water.	BNFc GSTT Paediatric Formulary **ONCE** daily dosing		Anxiety, back pain, coughing, influenza-like symptoms.		
Peripheral vasodilators **Usually adjunct for resistant hypertension,**	**Hydralazine** Tablets: 25mg Injection: 20mg (injection can be diluted and given orally)	BNFc GSTT Paediatric Formulary	Start at low dose and adjust according to response. Avoid long-term use in	The incidence of side-effects is lower if the dose is kept low, but systemic lupus erythematosus should be	Hepatic impairment (risk of accumulation) Use with caution in patients with coronary artery disease or	Test for antinuclear factor, proteinuria (every 6 months) and check for

when used alone causes fluid retention and tachycardia.		**TWICE** or **THRICE** daily dosing	severe renal insufficiency and dialysis patients, due to accumulation of metabolites.	suspected if there is **unexplained weight loss**, **arthritis**, or any other unexplained ill health.	cerebrovascular disease. Consider betablocker and diuretic use in conjunction to offset side effects.	acetylator status.
Loop diuretics **Potent diuretics effective in the loop of henle.** **Effective for hypertension associated with fluid overload.**	**Furosemide** Tablets: 20mg, 40mg (can be crushed and dispersed) Oral solution: 50mg/5mL (multiple strengths available in primary care) Injection: 20mg/2mL, 50mg/5mL Injection can be given orally.	BNFc GSTT Paediatric Formulary Multiple dosing regimen 6 hour duration of action therefore advised morning and early afternoon for those with urine output.	Dose as in normal renal function If GFR is <10mL/min increased doses may be required. Loop diuretics are effective in renal failure, thiazides are ineffective <30ml/min.	Dizziness; electrolyte imbalance; fatigue; headache; metabolic alkalosis; muscle spasms; nausea	Marked fall in blood pressure when combined with ACE/ARB. Nephrocalcinosis observed in pre-term neonates. Caution in prescribing as multiple strengths of liquid is available. Parents often mention doses in mls rather than mg.	Monitor electrolytes – especially potassium as hypokalaemia commonly can occur. Monitor blood pressure and fluid balance/urine output.
Potassium Sparing Diuretic **Commonly used alongside furosemide to reduce hypokalaemia induced by loop diuretics.**	**Spironolactone** Tablets: 25mg, 50mg. Tablets can be crushed and dispersed. Liquid 50mg in 5ml specials	BNFc GSTT Paediatric Formulary ONCE to THRICE daily dosing, usually matched with loop frequency	10-50 mL/min – use 50% of dose; <10 mL/min – use with caution, metabolites with long half-lives. Monitor serum potassium levels and adjust accordingly. High risk of hyperkalaemia in severe insufficiency. Avoid combinations which can result in hyperkalaemia e.g. ACE/ARB and potassium supplements especially in renal impairment	Gynaecomastia may develop in association with the use of spironolactone. Development appears to be related to both dosage level and duration of therapy and is normally reversible when the drug is discontinued. Electrolyte imbalances.	Do not use in acute renal insufficiency, significant renal compromise, anuria, Addison's disease, hyperkalaemia	Monitor serum potassium — discontinue if hyperkalaemia occurs. Avoid combinations which can result in hyperkalaemia e.g. ACE-I/ARB and potassium supplements especially in renal impairment.
	Amiloride Tablets: 5mg Tablets can be crushed and dispersed	BNFc GSTT Paediatric Formulary	Caution in renal impairment: Avoid where possible use in	Except for hyperkalaemia, significant side effects are infrequent.	As spironolactone. Hyperkalaemia more prominent in diabetics	Monitor electrolytes – especially potassium (hyperkalaemia).

	however poorly soluble. Consider liquid for part tablet doses. Oral solution: 5mg/5mL	**TWICE** daily dosing	renal impairment or use alternative agents owing to risk of severe hyperkalaemia. 10-50 mL/min – use 50% of dose; <10 mL/min - avoid			Avoid combinations which can result in hyperkalaemia i.e. with spiro/ACE-I/ARB

Phentolamine and phenoxybenzamine dosing can be found in section 5.3

11 Document Control

Document Control	
Hosting Clinical Directorate:	Body Bones Mind
Clinical specialty/specialties to be published under:	Nephrology
Version Information	
New guideline ☐ Scheduled review ☒ Amended due to updates ☒	
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Consultation	
Individuals/groups/teams consulted on the guideline development/updates:	None other new
Local Ratification Process	
Committees that have ratified the guidelines prior to presentation at Clinical Guidelines Committee:	N/A
Legal Team sign off (if applicable):	
Does the guideline include information about consent?	No
If yes, has the Legal Team reviewed the guideline and signed it off?	N/A
Drugs and Therapeutics Committee sign off (if applicable):	
Does the guideline include information about drugs or therapeutic agents?	Yes, DTC reference of approval: IN00081
If yes, and the specialist pharmacist has confirmed that DTC approval is required, has this been done?	N/A
Nutrition Steering Committee sign off (if applicable):	

Does the guideline include information about nutrition or feeds or nutrition-related products?	No
If yes, has the NSC approved the described nutrition or feeds or nutrition-related product guidance?	N/A
Medical Equipment and Supplies Group sign off (if applicable):	
Does the guideline include information about use of a medical device or medical equipment that is to be used innovatively / is not what the manufacturer has intended as its use?	No
If yes, has the MESG approved the described innovative use of medical devices/equipment?	N/A
Clinical Guidelines Committee approval:	
Date Approved by Guideline Committee:	**17th February 2025**
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