

Hypertension in Childhood: A Growing Concern

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Abstract

Hypertension in pediatric age group is a growing health problem and is often overlooked by pediatrician. Measuring blood pressure is not a routine practice in a busy pediatric outpatient department. With the available literature, it has become clear that hypertension begins in childhood and adolescence, and contributes to the early development of cardiovascular disease in later age. This review article discusses about prevalence, causes, prevention and treatment of hypertension in pediatric age group.

Keywords: Hypertension; Childhood; Blood Pressure

With availability of literature, hypertension is being recognized a major health problem in children and adolescents. In three to 18 years of age, the prevalence of prehypertension is 3.4 percent and the prevalence of hypertension is 3.6 percent [1]. The combined prevalence of prehypertension and hypertension in adolescents who are obese is greater than 30 percent in boys and is 23 to 30 percent in girls [2]. High blood pressure in childhood commonly leads to hypertension in adulthood [3], and adult hypertension is the leading cause of premature death around the world [4]. Children with hypertension may have evidence of target organ damage, including left ventricular hypertrophy and pathologic vascular changes [5,6]. Primary hypertension in children is also commonly associated with other risk factors for cardiovascular disease (CVD), such as hyperlipidemia and diabetes mellitus [7,8].

Despite the high prevalence and potential risk of hypertension in children, often it is not diagnosed on time and so not evaluated for causative factor. In one study by Hansen, *et al.* [1], hypertension was diagnosed in only 26 percent of children with documented high blood pressure on reviewing electronic medical record. Increased awareness is needed among pediatrician to diagnose and treat hypertension in children.

Normal BP level and hypertension are defined as:

Definition of Hypertension [9]

- **Normal BP** is defined as SBP and DBP that is less than the 90th percentile for sex, age, and height.
- **Hypertension** is defined as average SBP and/or DBP that is greater than or equal to the 95th percentile for sex, age, and height on three or more occasions 1 - 3 weeks apart. Since the severity of hypertension influences its management, it should be staged as below.
 - **Stage 1 hypertension:** Systolic or diastolic blood pressure values exceeding the 95th percentile and up to 5 mmHg above the 99th percentile. Before labeling hypertension, blood pressures in this range should be rechecked at least twice in the

next 1 - 3 weeks or early if child is symptomatic.

- **Stage 2 hypertension:** Systolic or diastolic blood pressure values 5 mmHg or more above the 99th percentile and should be confirmed on same visit by repeat measurement. These patients require further evaluation within a week or immediately if symptomatic.
- **Pre-hypertension** in children is defined as average SBP or DBP levels that are greater than or equal to the 90th percentile, but less than the 95th percentile while in adolescents, BP greater than or equal to 120/80 mmHg should be considered pre-hypertensive.
- **White-coat hypertension** defines a clinical condition in which the patient has BP levels above the 95th percentile when checked clinic, whereas the patient’s average BP is below the 90th percentile outside a clinical setting. Ambulatory BP monitoring (ABPM) is usually required to make this diagnosis. In these children BP monitoring is required over a year since a proportion is at risk of sustained hypertension.

	Boys		Girls	
	Systolic	Diastolic	Systolic	Diastolic
3	100	59	100	61
4	102	62	101	64
5	104	65	103	66
6	105	68	104	68
7	106	70	106	69
8	107	71	108	71
9	109	72	110	72
10	111	73	112	73
11	113	74	114	74
12	115	74	116	75
13	117	75	117	76
14	120	75	119	77
15	120	76	120	78
16	120	78	120	78
17	120	80	120	78
18	120	80	120	80

Table 1: Simple to Identify Children and Adolescents Needing Further Evaluation of Blood Pressure.

Any reading equal to or above the readings in the simplified table indicates potentially abnormal blood pressures in one of three ranges: prehypertension; stage 1 hypertension; or stage 2 hypertension and requires additional evaluation. Pediatrics Volume 123 No. 6 June 2009, pp. e972-e974.

Tables of normal and abnormal blood pressure values based on age, sex, and height are available from the National Institutes of Health at <http://www.cc.nih.gov/cc/pedweb/pedsstaff/bptable1.PDF> for boys, and at <http://www.cc.nih.gov/cc/pedweb/pedsstaff/bptable2.PDF> for girls.

Epidemiology

Prevalence of Hypertension is 2 - 5% in school children in India in various studies [10-12]. In a study by N Buch., *et al.* prevalence of hypertension was 6.48% with significant association with obesity, family history of diabetes mellitus and ischemic heart disease [13]. Jafar TH., *et al.* observed in their study that despite lower BMIs of south Asian children, the prevalence of hypertension was substantially greater than the 5% predicted prevalence of high blood pressure in children in the United States based on same criteria [14]. Recommendation of the task force on hypertension in children and adolescents in US gave stimulus to many epidemiological and screening studies in various ethnic groups in that nation. They gave enough evidences to indicate noticeable trend of increasing incidence of hypertension in these age groups. In USA recently four studies revealed that the levels of both systolic and diastolic BP are slowly rising in few ethnic American boys and girls over the years [15-18]. A study from Shimla (India) by Sharma A., *et al.* found that, in school children, 5.9% had hypertension and an additional 12.3% had pre-hypertension [19]. This reflects an alarming situation, where overall almost 1 out of every 5 children needs some intervention as guided by the Fourth Task Force recommendations [19,20]. On the basis of these evidence, it is now apparent that primary hypertension is detectable in the young and occurs commonly. It is important that measures should be taken to reduce long-term health risks of hypertension to optimize health outcomes.

Screening for hypertension

Now more emphasis is given on screening for hypertension and the recommendation is annual measurement of blood pressure in all children more than 3-year-old, who are seen by physician. Blood pressure should also be measured in at-risk younger children.

Conditions under which Children < 3 Years old should have blood pressure measured

- History of prematurity, very low birth weight, or other neonatal complication requiring intensive care,
- Congenital heart disease,
- Recurrent urinary tract infections, hematuria, or proteinuria,
- Known renal disease or urologic malformations,
- Family history of congenital renal disease,
- Solid organ transplant,
- Malignancy or bone marrow transplant,
- Treatment with drugs known to raise BP,
- Other systemic illnesses associated with hypertension (neurofibromatosis, tuberous sclerosis, ambiguous genitalia etc.),
- Altered sensorium, headache or visual impairment or any evidence of elevated intracranial pressure.

Measurement Techniques

- **Mercury sphygmomanometer:** Preferred method for BP measurement is sphygmomanometer as normative values for BP are based on that only. As per American Heart Association (AHA) recommendation [21], an appropriate cuff size is must while taking BP. A cuff with an inflatable bladder width that is at least 40 percent of the arm circumference at a point midway between the olecranon and the acromion is appropriate. Cuff bladder length should cover 80 - 100 percent of the circumference of the arm. Such a requirement demands that the bladder width to- length ratio be at least 1:2. BP measurements are overestimated when a cuff is too small and underestimated by a cuff that is too large. In case appropriate cuff size for that child is not available, it is advisable to use the next larger size.

- **Oscillometric devices:** These devices are used in infants where auscultation is difficult and in children where continuous noninvasive BP monitoring is required. With Oscillometric devices, mean arterial BP is measured and then it calculate systolic and diastolic values. By oscillometric devices, readings of systolic and diastolic pressures are fallacious in case of wide pulse pressure as anemia and aortic runoff lesions. When BP values exceed the 90th percentile, it is advisable to confirm it by sphygmomanometer.
- **Aneroid sphygmomanometer:** Instead of mercury, spring-based technology is used in aneroid devices. In these devices, frequent calibration and validation is required. A study by Shah AS [22], demonstrated that systolic and diastolic BPs measured by mercury and aneroid devices are highly correlated for the entire sample and by age group. In individuals' ≥ 10 to 18 years, a significantly lower mean diastolic BP was found when using the aneroid sphygmomanometer. On the basis of their analyses, a mean correction of +1.8 mm Hg could be added to an aneroid BP measurement to equate the mercury and aneroid devices if both are used in a single study. As per their observation, this correction is not significant in clinical setting.
- **Ambulatory blood pressure monitoring:** In children where we need BP measurements over a specified period or when one BP reading is in upper limit of normal or borderline high but there are factors leading to high blood pressure as with renal disease, ambulatory BP monitoring (ABPM) is used. Ambulatory device is a portable device, worn by the patient over a specified period of time. ABPM takes multiple BP reading at defined intervals and after computation we get average BP during that specified period (day, night and over 24 hours), BP fluctuation/variation during that period and effect of activity. One would be able to know that what percentage of time BP exceeds upper limit of normal. ABPM is especially indicated paroxysmal hypertension, renal disease, diabetes, autonomic dysfunction and in white coat hypertension.

Important points in BP Evaluation in children and adolescents

- The mercury sphygmomanometer is generally accepted as the most accurate and is the instrument of choice.
- Hypertension should not be diagnosed on the basis of single measurement. At least three measurements on separate occasions are essential to diagnose hypertension. Again, three pressures at or above the 95th percentile on three occasions are necessary for a diagnosis of hypertension.
- Proper cuff bladder size is essential.
- In recent years, there is increasing use of automated devices to measure BP in children, most commonly used are oscillometric methods to measure systolic and mean BP.

Classification

- **Primary/Essential Hypertension:** Hypertension for which no obvious cause is apparent and this is the most common type of mild hypertension in children.
- **Secondary Hypertension:** Raised blood pressure caused by primary disease or abnormality in other organs, usually the kidneys is the most common cause of severe hypertension in children.
- **Isolated Systolic Hypertension:** Isolated systolic hypertension, with a wide pulse pressure, may be feature of hyperthyroidism, aortic valvar incompetence, patency of the arterial duct, arteriovenous fistula, and high output states.

Causes of secondary hypertension

Causes of transient secondary hypertension

1. Renal
 - a) Acute glomerulonephritis

- b) Hemolytic-uremic syndrome
 - c) Renal failure
 - d) Nephritis with anaphylactoid purpura
2. Neurological
- a) Increased intracranial pressure
 - b) Guillain-barré syndrome
3. Drug related: Steroids, phencyclidine, amphetamines, mercury poisoning.
4. Vascular: Painful sickle cell crisis
5. Metabolic
- a) Hypercalcemia
 - b) Hyponatremia
 - c) Congenital adrenal hyperplasia
 - d) Acute intermittent porphyria
6. Miscellaneous
- a) Stevens-Johnson Syndrome
 - b) Postoperative status
 - c) Stress related

Causes of sustained Hypertension

1. Renal
- a) Bilateral obstructive uropathy
 - b) Chronic glomerulonephritis
 - c) Renal parenchymal disease (pyelonephritis, infarction, radiation, trauma)
 - d) Renal artery lesions (stenosis, thrombosis, aneurysm)
 - 1. Intrinsic: Fibromuscular hyperplasia, arteritis, thrombosis
 - 2. Extrinsic compression
 - e) Congenital defects (hypoplastic, polycystic kidney)
 - f) Tumours
 - g) Post renal transplantation
 - h) Familial nephritis
 - i) Renal vein thrombosis
2. Vascular
- a) Coarctation of the aorta(CoA)
 - b) Aortitis

- c) Conditions with large stroke volume (patent ductus arteriosus, aortic insufficiency, systemic arteriovenous fistula, complete heart block) (these conditions cause only systolic hypertension)
3. Endocrine
- a) Pheochromocytoma
 - b) Cushing’s syndrome
 - c) Primary aldosteronism
 - d) Hyperparathyroidism
 - e) Ovarian or adrenal tumours
 - f) Congenital adrenal hyperplasia
 - g) Neuroblastoma
4. Metabolic
- a) Diabetes mellitus with renal involvement
 - b) Gouty nephropathy

Common Causes of Sustained Hypertension by Age group

Age	Group Causes
Newborns	Renal artery thrombosis, renal artery stenosis, congenital renal malformation, CoA, bronchopulmonary dysplasia.
< 6 yr	Renal parenchymal disease, CoA, renal artery stenosis.
6 - 10 yr	Renal artery stenosis, renal parenchymal disease, primary hypertension.
> 10 yr	Primary hypertension, renal parenchymal disease

Risk factors for primary hypertension

- **Systolic BP:** Above 90th percentile doubles the risk.
- **Family history:** Two or more members in the family with hypertension increase the risk two to four times.
- **Weight more than 20% above the normal for height:** Two third found to be hypertensive.
- **Dietary cations:** Increased dietary sodium in salt sensitive individuals and decreased potassium intake.
- **Others:** Hyperlipidemia, stress, smoking, alcohol, drug intake, and diabetes mellitus.

Clinical features

The presenting symptoms of hypertension vary according to the severity of the causative disease, the severity of the hypertension and the age of the child. The raised blood pressure may be an unexpected cause of a common childhood symptom, such as recurrent abdominal pain or headache, or it may be an incidental and apparently unconnected finding on physical examination in a child with another complaint. The major clinical symptoms of infants are congestive cardiac failure, respiratory failure, failure to thrive, vomiting, irritability and convulsions. In children the major presenting symptoms are headache nausea, vomiting, encephalopathy, polyuria, polydipsia, visual problems, tiredness, irritability, cardiac failure, weight loss, heart murmur, abdominal pain etc.

Congestive cardiac failure with fluid overload is a common feature in severe hypertension caused by renal disease. Cardiac dilatation with mitral valve incompetence may be present and this will disappear after control of the hypertension. Pulmonary edema may be life

threatening and require immediate positive pressure ventilation along with blood pressure control. Malignant hypertension which is defined as the presence of hypertensive retinopathy may be associated with myocardial dysfunction and with improvement in ventricular function as the vasculitis subsides following antihypertensive therapy.

About one tenth of children with hypertension have neurological symptoms and complications. The neurological complications could be classified into three syndromes: hypertensive encephalopathy, lacunar infarction and cerebral haemorrhage. In hypertensive encephalopathy, there is focal damage to cerebral arterioles which increases capillary permeability and results in cerebral edema. Headache, visual complaints which range from blurring of vision to transient blindness, nausea/vomiting and convulsions, both focal and generalized, occur more frequently in children. Long-term follow up suggests that the prognosis is good with no permanent neurological deficit. A tendency to convulsion may continue. Infarction and cerebral hemorrhage may lead to permanent disability.

Visual disturbances may be caused by retinal involvement; cortical blindness associated with cerebral edema, which usually resolves leaving no residual impairment; vitreous hemorrhage; and infarction of the anterior visual pathways.

Approach to a child with hypertension

At diagnosis, it is necessary to establish the severity of the effect and the cause, which required detailed history, complete physical evaluation, and a battery of investigations.

A complete history:

1. Family history
 - Essential hypertension-often familial
 - Some types of renal diseases
 - Diabetes mellitus-Familial predisposition
 - Congenital adrenal hyperplasia-Autosomal recessive inheritance
 - Neurofibromatosis-autosomal dominant inheritance
 - Sickle cell disease-Autosomal recessive
 - Connective tissue disorders-familial
2. Past history
 - Neonatal: use of umbilical artery catheters or bronchopulmonary dysplasia, trauma to kidney
 - Urinary tract infection
 - Polyuria, polydipsia
 - Hematuria, proteinuria
 - Perinatal asphyxia-Renal infarction, renal vein thrombosis
 - Congenital rubella
 - Abdominal radiation
3. Paroxysmal hypertension (Intermittent episodes of headache, sweating, palpitation)-
 - Pheochromocytoma
4. History of drug ingestion
5. H/O limb claudication
6. Coarctation of aorta

Examination

Detailed physical evaluation include:

1. Proper blood pressure measurement in upper limb and lower limb
2. Record of weight and height
3. Palpation of all peripheral pulses
 - In 15 - 30% of children, secondary hypertension is caused by aortic coarctation
 - Non-specific aortoarteritis may also present as hypertension
4. Examination of bruits particularly over carotids and renal
5. Full cardiac and neurological examination
6. Per abdominal examination -abdominal mass (Wilm’s tumour, neuroblastoma, pheochromocytoma, polycystic kidneys, other tumour) or enlargement of the bladder
7. Evidence of neurofibromatosis, Cushing’s disease, the depigmented areas of tuberous sclerosis, systemic lupus erythematosus
8. Facies- Cushingoid facies, William’s syndrome, Turner syndrome.

Laboratory investigations

Routine test in all hypertensive children:

- Complete blood count
- Urinalysis
- Renal function test including electrolytes and serum uric acid
- Fasting plasma glucose
- Serum lipid profile
- Chest X-Ray, 12 lead ECG, detailed Echocardiography
- Ultrasound KUB area

Next line of investigations

DMSA scan	Chronic pyelonephritis
Renal Doppler ultrasound and MRI Digital subtraction angiography	Renal artery stenosis
Echocardiography	LV hypertrophy (target organ damage) and to rule out coarctation of aorta/Takayasu’s arteritis
Plasma rennin level	Increased in Renal artery stenosis Decreased in primary hyperaldosteronism
Plasma aldosterone level	Increased in Renal artery stenosis and primary hyperaldosteronism
Plasma deoxycorticosterone	Increased in Congenital adrenal hyperplasia
Urinary steroids	Congenital adrenal hyperplasia, Mineralocorticoid excess

Specialized investigations following initial work up

Color Doppler USG	Estimation of carotid wall intima- media thickness
Urinary catecholamine, metanephrins, Normetanephrins VMA	Pheochromocytoma, Neuroblastoma
Captopril primed MAG 3 labeled isotope renal scan	Renal artery stenosis
Renal vein Renin estimation, CT scan, MRI	Renal Tumour
Radioisotopic 1311 metaiodobenzyl guanidine scan	Pheochromocytoma
Molecular genetic study	Apparent Mineralocorticoid excess, Liddles syndrome

Screening for target organ damage

- Retinal fundus examination
- Urine: microalbumin, spot protein to creatinine ratio
- Chest X-ray, ECG, echocardiography

Therapy

Goal: Ultimate goal of antihypertensive therapy is the reduction of cardiovascular, renal morbidity and mortality.

Non-pharmacological measures: Adolescents who may benefit from non-pharmacological antihypertensive measure include.

1. Those with consistently high normal BP (above the 90th percentile).
2. Those with a trend of upward tracking pressures or pressures occasionally above the 95th percentile.
3. Those who are obese, particularly parents are obese.
4. Those with hyperlipidemia or a family history of hyperlipidemia, particularly together with coronary artery disease or stroke.
5. Those with diabetes mellitus.

Non-pharmacological interventions include:

- Weight reduction-Maintain normal body weight (BMI-18.5-24.9 wt (kg)/ht (mt)²)
- Adopt DASH [dietary advice to stop hypertension] eating program -Consume a diet rich in fruits, vegetables, and low-fat dairy products with a reduced content of saturated and total fat
- Avoidance of excess salt: Institute of medicine 23 set upper level for different age groups:
 - 1-3 years: 1500 gm/day; 4-8 years: 1900 gm/day; 9-13 years: 2200 gm/day; 14-18 years: 2300 gm/day
- Regular physical exercise
- Discontinuation of alcohol and smoking
- Search and evaluation of other cardiovascular risk factors
- Use of methods such as behavior modification, biofeedback

Pharmacological treatment

Indications

- Symptoms

- Severely high BP
- Evidence of target organ damage
 - Heart-Left ventricular hypertrophy, heart failure
 - Brain-Encephalopathy, stroke/Transient ischemic attack
 - Retinopathy
- Chronic renal disease
- Peripheral arterial disease

Antihypertensive agents should be chosen to obtain to maximum benefit with the fewest and least side effects and goal is to reduce BP below the 95% percentile. The ideal hypertensive agent should:

- Lower BP in almost all hypertensive individuals
- Reverse specific pathogenic mechanism
- Improve hemodynamics
- Be associated with few biochemical changes and less side effects

Principles of treatment

- The goal for treatment is reduction of blood pressure to < 95th percentile
 - With comorbid conditions or target-organ damage, BP should be lowered to < 90th percentile.
- Preferred drugs in children are: angiotensin converting enzyme inhibitor (ACEI), calcium channel blockers (CCB), vasodilators, β blockers and thiazide diuretics.
- It is advisable to start therapy with one drug in appropriate dose and the dose should be increased until targeted blood pressure is achieved. Different class of drug is added or substituted when the highest dose of first drug is not effective or if there are side effects.
- Medications with a longer duration of action (once, twice daily dosing) are preferred for better compliance and less side effects.

Doses of drugs used to control hypertension are given in table 5 and 6.

Drug/class	Dose/route	Comments
Esmolol (beta blocker)	100 - 500 cg/kg/minute, IV infusion	Very short acting, constant infusion preferred. May cause bradycardia. Modest reduction in blood pressure
Hydralazine (vasodilator)	0.2 - 0.6 mg/kg per dose, IV/IM	Should be given every 8 h when given IV bolus
Labetalol (alpha and beta blocker)	Bolus 0.2 - 1.0 mg/kg per dose upto 40 mg per dose. Infusion: 0.25 - 3.0 mg/kg per h, IV infusion	may cause reflex tachycardia
Nicardipine (calcium channel blocker)	1 - 3 mcg/kg per minute, IV infusion	may cause reflex tachycardia
Sodium nitroprusside (vasodilator)	0.53 - 10 mcg/kg per minute, IV infusion	Monitor cyanide level with prolonged (>72 h) use or in renal failure
Clonidine (central alpha agonist)	0.05 - 0.1 mg/dose, may be repeated up to 0.8 mg total dose Oral	side effects: dry mouth and sedation

Table 5: Antihypertensive Drug Therapy for Hypertensive emergencies in Children.

Drug	Dose (Oral)		Side effects/ Precaution
Adrenoreceptor blockers			
α and β receptor blocker			Rash, dry eyes, dizziness
Labetalol	1 - 2 mg/kg 6 - 8 hourly		Cardiac failure, asthma
β adrenoreceptor blocker	0.2 - 2.0 mg/kg 8 hourly		Cardiac failure, asthma
Propranolol	1 - 2 mg/kg once a day		Cardiac failure, asthma
Atenolol			
α adrenoreceptor blocker	0.01 mg/kg 8 hourly, max 0.5 mg/kg 8 hourly		Hypotension after first dose, dizziness
Prazosin			
Direct vasodilators			
Hydralazine	0.2-1.0 mg/kg		Flushing, tachycardia, lupus syndrome
Minoxidil	0.1mg/kg twice daily, increase to max 0.5 mg/kg twice daily		Fluid retention, tachycardia, hirsutism
Calcium antagonist			
Nifedipine	0.25 mg/kg		Flushing, tachycardia, headache
Diuretics			
Chlorothiazide	10 mg/kg per day		Hypokalemia, hyperuricaemia/Renal insufficiency
Furosemide	1 - 4 mg/kg once or twice daily		Hypokalaemia
Spirolactone	1 - 3 mg/kg twice or thrice daily		Hyperkalaemia, gynaecomastia/Renal insufficiency
ACE inhibitors			
Captopril	0.3 - 0.5 mg/kg/dose Maximum: 6 mg/kg per d Neonates 0.01 - 0.05 mg/kg three times a day	Hypotension, cough, agranulocytosis	<p>Avoid in renal artery stenosis</p> <p>All ACE inhibitors are contraindicated in pregnancy;</p> <p>2. Check serum potassium and creatinine periodically to monitor for hyperkalemia and azotemia.</p> <p>3. Cough and angioedema are reportedly less common with newer members of this class than with captopril.</p> <p>4. Benazepril, enalapril, and lisinopril labels contain information on the preparation of a suspension; captopril may also be compounded into a suspension.</p> <p>5. FDA approval for ACE inhibitors with pediatric labeling is limited to children < 6 years of age and to children with creatinine clearance < 30 ml/min per 1.73m².</p>
Enalapril	0.08 mg/kg per d up to 5 mg/d Maximum: 0.6 mg/kg per d up to 40 mg/d	Hypotension, cough	
Benazepril	Initial: 0.2 mg/kg per d up to 10 mg/d Maximum: 0.6 mg/kg per d up to 40 mg/d		
Lisinopril	Initial: 0.07 mg/kg per d up to 5 mg/d Maximum: 0.6 mg/kg per d up to 40 mg/d		
Quinapril	0.2 mg/kg Maximum adult dose: 80 mg/d (safety not established in pediatric age)		
Angiotensin - receptor Blocker (ARB)			
Irbesartan	6 - 12 years: 75 - 150 mg/d > 13 years: 150 - 300 mg/d	Hyperkalemia	<p>All ARBs</p> <p>1. Contraindicated in pregnancy;</p> <p>2. Check serum potassium, creatinine periodically</p> <p>3. Losartan label contains information on the preparation of a suspension.</p> <p>4. FDA approval for ARBs is limited to children <6 years of age and to children with creatinine clearance <30 ml/min per 1.73m².</p>
Losartan	Initial: 0.7 mg/kg per d up to 50 mg/d Maximum: 1.4 mg/kg per d up to 100 mg/d	Hyperkalemia	

Table 6: Antihypertensive drug therapy for chronic hypertension.

Specific recommendations depending on cause of hypertension

Acute glomerulonephritis: In this scenario, hypertension is of short duration and associated with salt and water retention. Loop diuretics along with salt and water restriction are useful in these patients. This helps in relieving circulatory congestion, hypertension and edema. Severe hypertension with or without encephalopathy is an emergency and should be treated in intensive care unit with loop diuretics and drugs listed in table 5. They usually responds to treatment with loop diuretics and CCB, occasionally there is need of adding a β -blocker or ACEI to treatment regimen.

Chronic kidney disease: In children with chronic renal disease, aim is to keep BP below 90th percentile. Chronic renal disease with GFR above 30 ml/minute/1.73 m², ACE inhibitors are preferred agents. These antihypertensive agents also reduce proteinuria and retard progression of renal damage. With ACEI, monitoring of serum potassium and creatinine is necessary, initially weekly and then every 1 - 3 months. If blood investigations show rising serum creatinine (exceeds 30 - 35% from the baseline) or hyperkalemia, dose of ACEI or ARBs needs to be reduced.

FDA does not recommend use of ACEI and RBs in patients with advanced chronic kidney disease (GFR < 30 mL/min/1.73 m²). Antihypertensive drug preferred in these patients is CCB or β -blocker.

Guidelines for managing hypertension in patients with chronic kidney disease also include:

- Daily Sodium intake: as recommended by Institute of medicine [23].
- Co-administration of diuretics helps in reducing sodium and volume overload.
- Thiazides (hydrochlorothiazide, chlorthalidone) are the diuretics of choice but not in children with GFR < 30 mL/min/1.73 m².
- Other drugs which can be used in patients with renal disease are α -blockers (prazosin, labetalol), centrally acting agents (clonidine) or direct vasodilators (hydralazine, minoxidil).

Renovascular disease: CCB and/or β -blocker should be used when there is suspicion or confirmed renovascular disease. Additional drugs which can be used in this scenario are prazosin, labetalol, clonidine, hydralazine and/or minoxidil.

ACEI or ARBs should be avoided in patients with bilateral renovascular disease, these agents might be used in unilateral renovascular disease with precaution.

Ventricular dysfunction: Loop diuretics and ACEI are the preferred initial agents in children with ventricular dysfunction. ACEI should be started under close hemodynamic monitoring in children with ventricular dysfunction. Additional therapy may be given with β blockers and aldosterone antagonists.

Follow up

Once antihypertensive therapy is started, patients should be followed at monthly interval until the BP goal is achieved, after that 3 - 6 months interval.

Conclusion

- In infancy, commonest cause of hypertension is renal.
- Treatable causes of hypertension are-coarctation of aorta, renal artery stenosis, pheochromocytoma, drug induced etc.
- With family history of hypertension, prevention should be started in infancy.
- In 15 - 30% of children, secondary hypertension is caused by coarctation of aorta and non-specific aortoarteritis.
- In a child with hypertension-laboratory investigations requires a stepwise approach.
- Indications of pharmacological treatment are-symptomatic patient, severely high blood pressure, evidence of end organ damage as LVH, heart failure, encephalopathy, and retinopathy.

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