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Management of hypertensive emergencies in children

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Hypertensive emergencies are uncommon in children. A good working knowledge of principles of management is essential to ensure successful management without any sequelae. Hypertensive emergencies can develop acutely in a previously normal patient or as an exacerbation of uncontrolled chronic hypertension[1].

Certain terms are commonly used in the context of acute elevation of blood pressure (BP).

Hypertensive crisis

These include hypertensive urgencies and hypertensive emergencies. Presence or absence of end organ damage is used to differentiate these conditions. The organs susceptible to damage include brain, eyes, heart and kidneys.

Hypertensive emergency is elevation of blood pressure resulting in hypertension related end organ damage such as encephalopathy, left ventricular failure and visual disturbance. Hypertensive emergency is not defined in terms of the blood pressure level, as this in itself cannot predict the severity of the problem**2**. The level of blood pressure (systolic or diastolic) at which hypertensive complications will occur cannot be defined. Immediate intervention is required to reduce blood pressure, but not necessarily to normal range, to prevent progression of end organ damage.

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Hypertensive urgency refers to marked elevation of blood pressure without evidence of end organ damage but with a possibility of such damage occurring in the next day or so. This is treated using an approach to control blood pressure over several hours. Blood pressure above the 99th percentile for the age and sex should be considered hypertensive urgency.

Hypertensive encephalopathy

Hypertension with symptoms and signs of neurological dysfunction such as headache, vomiting, altered mental status, visual disturbance, seizure and stroke.

Measurement of blood pressure

Appropriate cuff size and proper technique are essential pre-requisites for accurate documentation of blood pressure. The width of inflatable bladder should be at least 40% of arm circumference at a point between olecranon and acromian process. Cuff bladder length should cover 80 to 100% of arm circumference. Blood pressure should be measured in all 4 limbs to rule out coarctation and other causes of aortic obstruction. Blood pressure is measured in the following ways**3**:

1. Auscultatory method

(sphygmomanometry): This may be the only available method in many places. Availability of correct cuff size and difficulty in repeated manual measurements are the main limitations of this method during management of hypertensive emergency.

2. Doppler devices

Again appropriate cuff size is essential. Reliability may be compromised if the limb

position is not maintained during measurement

3. Oscillometry

Mean BP is determined directly by the device. Both systolic and diastolic BP are computed and displayed. This method may be unreliable in sick children and extremes of BP.

Doppler and oscillometry are more accurate for systolic BP.

4. Invasive method

Continuous invasive arterial pressure monitoring by pressure transducer is the gold standard and recommended during treatment of hypertensive emergencies.

PATHOPHYSIOLOGY

Though hypervolemia is a common feature of hypertensive emergencies, some may be relatively hypovolemic due to pressure diuresis. Further reduction in volume may worsen hypertension by increasing systemic vascular resistance (SVR). Therefore diuretics and fluid restriction are not standard therapy for hypertensive emergency; they are reserved for those with clinically apparent fluid overload.

Autoregulation of cerebral blood (CBF) flow is the process by which CBF is maintained at a stable level over a wide range of BP. In chronic hypertension the curve shifts to right to maintain CBF and to prevent cerebral edema even at a higher mean arterial BP. As a corollary, auto regulation may fail below a higher mean arterial pressure with sudden ischemic changes. In practice mean arterial BP should be reduced actually by no more than 25%, otherwise a sudden fall in cerebral blood flow will result in ischemia.[3]

EVALUATION

Identification of cause of hypertension is important in eventual management of hypertension. But initial management of hypertensive emergency is symptomatic treatment of elevated BP. Initial evaluation will include a focused history and thorough physical examination to identify effects on cardiovascular, neurologic, renal and ocular systems and for clues as to the cause of hypertension.

CAUSES OF HYPERTENSION4

In children severe hypertension should always be considered to be "secondary" to an underlying disorder. Among the causes of secondary hypertension renal causes such as reflux nephropathy, obstructive uropathy, renovascular disease, glomerular disease, polycystic kidney disease, hemolytic- uremic syndrome, and renal dysplasis predominate. Other rare causes of hypertension in children include coarctation of aorta, pheochromocytoma, Wilm's tumour, renal dysplasia and drug.s

Some other causes of high BP in acutely ill children where the heart rate can give a clue are:-

ASSOCIATED WITH TACHYCARDIA

1. Inadequately treated pain and agitation
2. Occult seizures; difficult to diagnose without EEG.
3. Vaso-active drugs, atropine.
4. Fluid overload.
5. Associated autonomic dysfunction as in Guillain Barre syndrome

ASSOCIATED WITH BRADYCARDIA

1. Increased intracranial pressure
2. Drug effect

ASSOCIATED WITH NORMAL HEART RATE

3. Drugs (steroids, NSAIDS)

Signs and symptoms in hypertensive emergency reflect the rapidity of onset, underlying cause and concurrent organ dysfunction. Neurologic symptoms are often the presenting features such as headache, dizziness, confusion, nausea, and vomiting, visual symptoms like blurred vision or transient blindness, facial palsy, convulsions, hemiplegia and frank encephalopathy. Cardiac symptoms like acute LVF with pulmonary edema are uncommon. They may be seen more commonly in very young children and also in conditions associated with hypervolemia such as acute nephritic syndrome.

FOCUSED HISTORY

Growth failure, weight loss, pallor or dysuria may indicate renal problems of long duration. On the other hand acute renal diseases like acute nephritic syndrome may be characterized by oliguria / anuria, facial puffiness or hematuria. Flushing, palpitation, sweating and weight loss may indicate pheochromocytoma. History may indicate end organ dysfunction such as acute onset breathlessness in left ventricular failure (LVF), visual symptoms and neurologic symptoms such as headache, vomiting, lethargy, seizures, etc.

PHYSICAL EXAMINATION

BP is to be recorded in all 4 limbs to identify coarctation of aorta. Presence of cutaneous lesions, evidence of endocrine dysfunction, abdominal masses and bruit are other useful pointers to diagnosis of underlying cause.

LAB STUDIES

Initial investigations will be complete blood count (CBC), peripheral smear, urinalysis, blood urea, creatinine, CXR, ECG, USG abdomen and Doppler studies. CT or MRI may be required if there are features of encephalopathy. ECHO cardiogram will be required to assess left ventricular function and to identify coarctation of aorta. Urine catecholamines and plasma renin / aldosterone levels and urinary porphyrin may be done wherever appropriate.

MANAGEMENT OF HYPERTENSIVE EMERGENCIES

Emergency treatment will depend on duration of symptoms, BP on presentation, rapidity of onset and severity of hypertension, concomitant problems and underlying cause. Attention to airway, breathing and circulation are a priority.

PRINCIPLES OF THERAPY

Primary aim is to control symptoms of hypertensive emergency and further end organ damage to brain, heart, kidneys and eyes while reducing BP and identification of cause after initial stabilization. Rate of BP reduction should be in a controlled manner. Abrupt lowering or normalization of chronically elevated BP may precipitate cerebral ischemia. Principle of slow reduction of severe chronic hypertension is paramount. Agents that can be titrated readily to desired end point are preferred. IV infusion therapy with short acting titratable agents should be started immediately. Bolus treatment and rapid BP reduction have been shown to be associated with higher incidence of permanent neurologic sequelae and should therefore be avoided in any child presenting with severe hypertension, especially if there are features of long standing hypertension**5.** The aim should be to reduce the mean arterial BP by 30% in first 3-4 hours, 30% over next 12 to 36 hours and 30% over 2 – 3 days**1.** Continuous invasive intra-arterial pressure monitoring is required for proper titration of IV agents. This labor intensive treatment is justified to prevent further hypertensive and hypotensive complications.

For hypertensive urgency in asymptomatic patients, oral drugs may be used to bring

down the BP slowly over hours. After treatment of emergency underlying cause is identified and treated.

Drug therapy

In renal diseases like acute nephritic syndrome if increased intravascular volume suspected, diuretic is the drug of choice. Some patients with chronic hypertension presenting with hypertensive emergency are volume depleted; in them, the initial treatment is antihypertensive and not diuretic. Renin dependant causes, particularly renovascular disorders, will influence the use of angiotensin converting enzyme (ACE) inhibitors. Catecholamine driven hypertension will require á and â- adrenergic blockage (Table 1).

Table 1: Drug selection based on etiology of hypertensive emergency[3]

Condition	I line drugs	II line drugs	Relatively contraindicted
Hypertensive encephalopathy	Nicardipine, SNP	Labetalol	
Intracranial hemorrhage	Labetalol	SNP	Vasodilators with reflex sympathetic stimulation (diazoxide, nifedipine)
LVF/Pulmonary oedema	SNP + diuretics ± ACE inhibitors(ACEI)	Nitroglycerine	Labetalol
Adrenergic crisis	SNP + β- blockers, phentolamine	Labetalol	Monotherapy with β-blockers
Acute renal failure	Labetalol	ACEI, diuretics	SNP

Antihypertensive drugs in hypertensive emergency

Most widely recommended for initial emergency management are sodium nitroprusside and labetalol. (Table 2)

Table 2: Drugs used for the treatment of hypertensive emergency

	Drug		Dose	Onset/peak/duration
1.	Sodium nitroprusside	IV	0.5 – 8 mcg/kg/min	Seconds/1-2 min/during infusion only
2.	Labetalol	IV	0.25 – 1 mg/kg bolus followed by 0.25 – 3.0 mg/kg/hr	2-5 min/5-15 min/ 2-4 hours
3.	Nifedipine	oral	0.25 – 0.5 mg/kg/dose	5-15min/30-60 min/ 3-6 hours
4.	Enalaprilat	IV	5 – 10 mcg/kg/dose	Upto 6 min/3-4hrs/ 4-6 hours

SODIUM NITROPRUSSIDE(SNP)

SNP has been the first line drug in hypertensive emergency as it has a rapid onset and short duration of action. It is a direct venous and arterial dilator due to stimulation of nitric oxide. Reflex tachycardia is an undesirable side effect of the drug. IV infusion is started at 0.5mcg/kg/min and increased every 15 to 30 mins upto 8mcg/kg/min till desired effect on BP is achieved. SNP deteriorates on light exposure to cyanide and therefore must be wrapped in aluminium foil. Close monitoring of BP through intra-arterial line is a must. Though SNP can be used in hypertensive encephalopathy, there is some fear of cerebral vasodilation and increased intracranial pressure with its use. Hence labetalol or nicardipine may be preferred in this situation.

Cyanide and thiocyanate toxicity may be seen with long term use of SNP infusion (more than 48 hours) but may be seen earlier in those with renal and hepatic impairment and in malnourished. In case of toxicity infusion has

be stopped; dialysis and IV hydroxy cobalamine may be needed. Co-administration of thiosulphate with SNP infusion removes cyanide from circulation.

LABETALOL

This drug blocks both â – adrenergic and á – adrenergic receptors with â – adrenergic effect

7 times more potent. This reduces systemic vascular resistance with inhibition of relative tachycardia and contractility. Labetalol is especially useful in hypertensive encephalopathy and hypertension with intracranial bleed as cerebral blood flow does not increase with this drug. It is also useful for hypertensive emergency in pheochromocyctoma. It can be given by bolus or infusion. A bolus dose of 1-3mg/kg/IV over 1 hour or infusion of 0.25 to 1 mg/kg/hour to start with and increasing by every 30 minutes upto 3mg/kg/hour can be used. Peak effect is at 5 – 15 minutes and duration of action is 2 – 4 hours. It is useful in many types of hypertensive emergencies including coarctation of aorta and end stage renal disease. Side effects are hypotension and hyperkalemia. The drug is contra-indicated in asthma and congestive cardiac failure**1.**

NIFEDIPINE

It is a calcium channel blocker. This drug has been used extensively in hypertensive crisis in the past. It use in acute phase is controversial. It is given in a dose of 0.25 mg – 0.5 mg/kg through oral or nasogastric route and can be repeated in 6 – 8 hours. There is no benefit of sublingual route over oral route and hence oral route (bite and swallow) is preferred. It lowers systolic and diastolic BP in 30 minutes of oral administration. Because of uncontrolled, rapid and unpredictable fall in BP with nifedipine, it is not suitable for those with long term hypertension where cerebral auto regulation is impaired**1**. It has a role in hypertensive urgency of recent onset with normal neurologic status as in acute nephritic syndrome where the risk for complications is low. In many places, nifedipine is still used as a first line drug because of lack of facilities for intra-arterial monitoring with SNP infusion. Difficulty in accurately measuring small doses of liquid from available capsule may lead to dosing errors. Care needs to be taken in administering appropriate dose. It is contraindicated in children with intracranial bleed.

ESMOLOL

It is a selective â – 1 adrenergic blocker with a rapid onset (60 seconds) and duration of action (10 minutes) and hence easily titratable. It can be used as a bolus and continuous infusion. It is used alone or with vasodilator in post operative hypertension and after coarctation repair in children. It is administered as a loading dose of 100 – 500 mcg/kg IV over 1 – 2 min, followed by 50 – 300 mcg/kg/min as infusion.

ENALAPRILAT

It is an ACE inhibitor and is the intravenous form of enalapril. It is useful after co-arctation repair. Dose is 5-10 mcg/kg/dose IV and can be repeated to 6-8 hours. ACE inhibitor is not to be used in hypovolemic patients as it can cause rapid fall in BP and ischemic renal injury. Hyperkalemia is to be monitored for. It is contra-indicated in renal artery stenosis.

DIAZOXIDE

It is a direct vasodilator. It is given as a bolus of 1-3mg/kg and may be repeated in 5 to 15 minutes. It is very effective in rapidly lowering BP, but has unpredictable potency and can cause precipitous hypotension. Reflex tachycardia and hyperglycemia can occur. Because of difficulty in titrating its dose, it is no longer recommended for hypertensive emergency**3.**

HYDRALAZINE

It is a direct vasodilator used in a dose of 0.2 to 0.6mg/kg/dose IV or IM. IV bolus can be given 4 hourly. Reflex tachycardia and fluid retention are the side effects. This drug is not to be preferred in hypertensive emergency due to its prolonged and unpredictable antihypertensive effects.

PHENTOLAMINE

It is a direct á – 2 adrenergic receptor antagonist. It has rapid onset (1-2 mins) and short duration (3-10 mins) of action. The dose is 0.1 mg/kg IV. It is useful in hypertension associated with excess catecholamine activity such as pheochromocytoma.

NEWER ANTIHYPERTENSIVES IN HYPERTENSIVE EMERGENCY

FENOLDOPAM

It is a selective dopamine antagonist with the advantage of increasing renal perfusion and sodium excretion. It is administered as an infusion of 0.1 to 0.2 mcg/kg/min because of its short half life (5-10 min). It is more useful in hypertension with renal dysfunction. Side effects include reflex tachycardia and increased intracranial pressure. Data in children is limited regarding its use.

NICARDIPINE

It has a rapid onset of action in a few minutes and relatively short duration of action. It is a calcium channel blocker used IV. Nicardipine is given as IV infusion of 0.5mcg/kg/min every 10-15 minutes upto 5mcg/kg/min.it is equally effective as SNP and is also effective in hypertension secondary to renal failure. It is useful in hypertensive emergency in all ages. Reflex tachycardia can occur. It has to be administered only through a central line because of risk of thrombosis.

SUMMARY

Hypertensive emergency can be life threatening and can lead onto sequelae. Principles of management are as important as specifics of drugs used. Agents that can be titrated readily to desired end point by IV route are preferred. Invasive BP monitoring is required to titrate IV agents. Principle of gradual reduction of severe hypertension is paramount.

REFERENCES

1. Ranjit S. Hypertensive emergency.In: Manual of pediatric emergency and critical care. Paras Publication, Hyderabad, 2nd edition, 2010; 311-315.
2. Adelman RD, Coppo R, Dillon MJ. The emergency management of severe hypertension Pedratr Nephrol, 2000; 14: 422-427.
3. Zaritsky A, Whitby D. Hypertension in the Pediatric critical care unit. In: Fuhrman BP, Zimmerman J(Eds). Pediatric critical care. Mosby, Elsevier, Philadelphia, USA, 3rd edn, 2006; 1040-1053.
4. Houtman P. Management of hypertensive emergency in children. Paed and Perinatal Drug Ther, 2003; 5: 107-110.
5. Deal JE, Barrat TM, Dillon MJ. Management of hypertensive emergency. Arch Dis Child, 1992; 7: 1089-1092.