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# Hypertension in childhood

## Approach to diagnosis and management

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# Origin and aetiology of adult hypertension

- Research has shown that chronic diseases in adults like CHD, type II diabetes mellitus and HT are determined by a range of characteristics which originate **antenatally and continue throughout infancy and childhood**
- In early life humans are “plastic”, molded by their environment
- Adverse intrauterine conditions can permanently alter the structure, homeostatic systems and functions of the body – a process termed **programming**

- Link between developmental plasticity and chronic diseases like CHD, HT, stroke, Type II Diabetes and LBW
- Adverse intra-uterine conditions result in Low Birth Weight (LBW) babies who have ↓ in nephron number
- **Adult hypertension – linked to ↓ in nephron number**

# Teenage hypertension = new disease

- Linked to childhood obesity – “MacDonald Syndrome”
- Ambulatory systolic BP showed a correlation between teenage HT and increasing BMI <sup>(1)</sup>
- Increased risk of CVS disease + Metabolic Syndrome (obesity, insulin resistance + dyslipidaemia)
- IUGR linked to risk of HPT in childhood, marker for adult cardiovascular disease <sup>(2)</sup>

1 Paediatrics 2008;121:115-22

2 Arch Pediatr Adolesc Med 2006; 160:977-81

# Origins & Aetiology of Adult Hypertension

The most important of these early life determinants are

- Poor socio-economic environment <sup>1</sup>
- Those whose mothers had pregnancy induced HT
- Those whose mothers smoke throughout pregnancy
- Those with low birth weight
- Who were not breast-fed
- Who have high sodium diets in infancy
- Who are obese in childhood or adolescence

1. Galobardes, B et al. Epidemiol Rev 2004; 26:7-21

# Monitoring childhood BW and BP

- It is rate of  $\uparrow$  in fatness after the age of 2 years rather than the level of fatness at any given age that needs monitoring
- Serial measurements of BMI becomes necessary
- Children whose BMI's cross percentiles upwards beyond the age of 2 years should have their BP routinely monitored

# Interpretation of BP

- BP in children correlates with body size and increases with age
- BP “tracks across the life course, such that those at the higher end of the BP distribution in early life tend to be at the higher end of the distribution
- Age and sex-specific height percentiles should be used to interpret the measured BP<sup>1,2</sup>
- 1. Easy-to- use childhood BP tables (International Pediatric Hypertension Association [Http://www.pediatrichypertension.org](http://www.pediatrichypertension.org))
- 2. [Http://nhlbi.nih.gov/health/prof/heart/hbp/hbp\\_measure\\_child.htm](http://nhlbi.nih.gov/health/prof/heart/hbp/hbp_measure_child.htm)>(2007)

## Definition of Hypertension

- Normal : SBP and DBP  $< 90^{\text{th}}$  percentile BP for sex, age and height percentile
- Hypertension : SBP and/or DBP  $\geq 95^{\text{th}}$  percentile for BP for age, sex and height percentile on 3 separate occasions



# Definition of Hypertension

- National High BP Education Program Working Group defined 3 categories of high BP in children :<sup>1</sup>
- → specific management implications
- Pre hypertension
- Stage 1 HT
- Stage 2 HT

1. National High BP Education Program Working Group on High BP in Children and Adolescents – 4th Report Paediatrics 2004;114(2):555-576

- **Prehypertension** = systolic or diastolic BP  $>90^{\text{th}}$  to  $<95^{\text{th}}$  percentile\* or if BP exceeds 120/80 mm Hg even if  $<90^{\text{th}}$  to  $<95^{\text{th}}$  percentile
- **Stage 1 HT** = systolic or diastolic BP between  $95^{\text{th}}$  -  $99^{\text{th}}$  percentile \* plus 5 mm Hg
- **Stage 2 HT** = systolic or diastolic BP  $>99^{\text{th}}$  percentile \* plus 5 mm Hg
- \*Value for age, gender and height percentile measured on at least 3 separate occasions

## Technical aspects of measuring BP

- Use correct cuff size:
  - Cuff must encircle the arm
  - Width should be 40-50% of the arm circumference
  - Rather use too wide cuff
- Situation
  - Environment
  - Anxious, crying infant
  - White coat hypertension
  - Activity



# Purpose of BP Measurement

To identify pathology and differentiate between

- Underlying disease secondary HT
- Essential HT

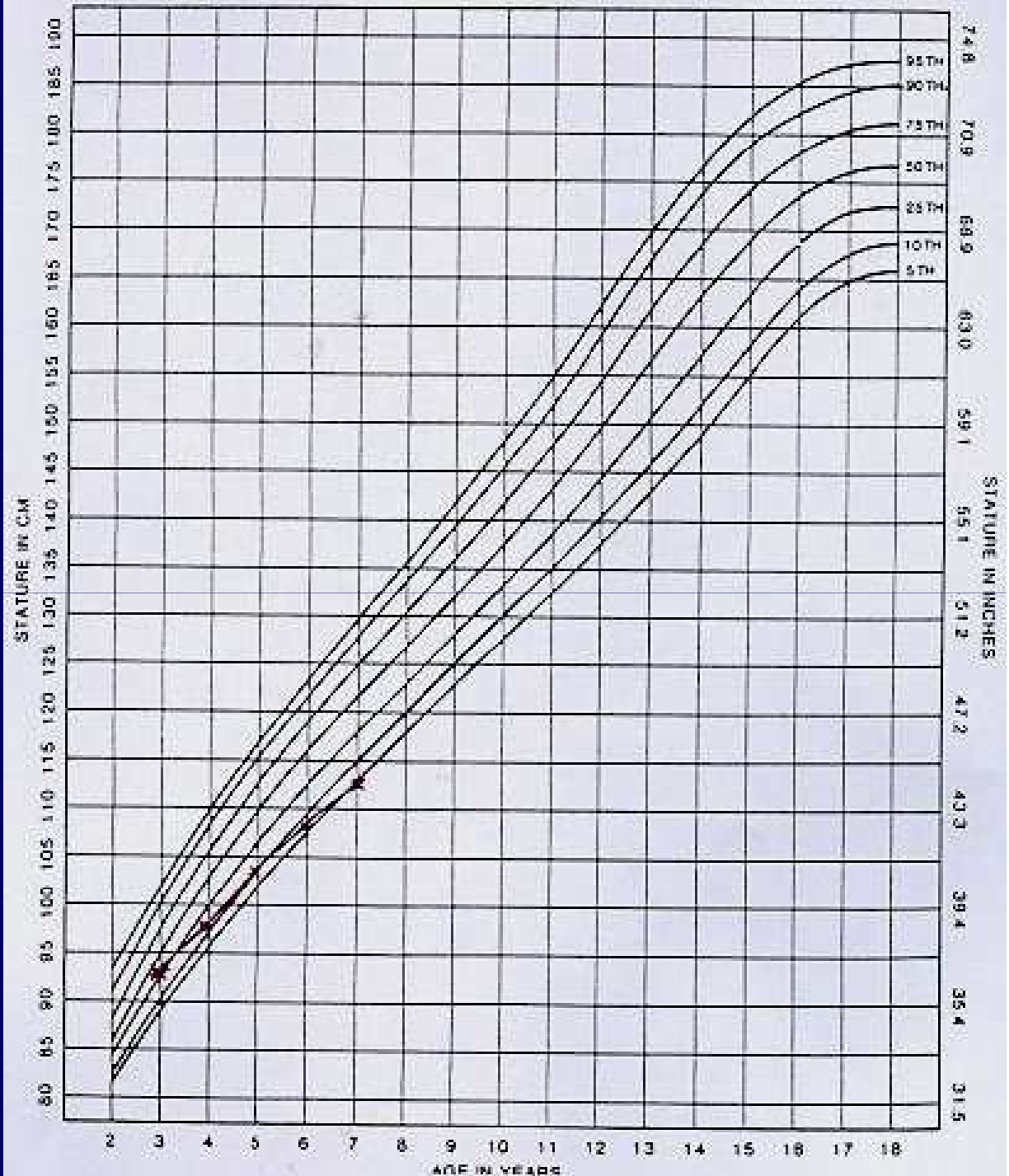
Important

- Incorrect diagnosis of HT e.g. poor technique → anxiety
- Miss a treatable condition

Need to know patient's:

- Age
- Sex
- Height

Plot height on percentile chart



## 95th Percentiles of Blood Pressure for Boys for Age & Height Percentiles

Age	Systolic Blood Pressure by Percentile of Height, mmHg+							Diastolic Blood Pressure by Percentile of Height, mmHg+						
	5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1	98	99	101	103	104	107	106	54	54	55	56	57	58	58
2	101	102	104	106	108	108	110	59	59	60	61	62	63	63
3	104	105	107	109	110	109	113	63	63	64	65	66	67	67
4	106	107	109	111	112	111	115	66	67	68	69	70	71	71
5	108	109	110	112	114	112	116	69	70	71	72	73	74	74
6	109	110	112	114	115	114	117	72	72	73	74	75	76	76
7	110	111	113	115	117	115	119	74	74	71	76	77	78	78
8	111	112	114	116	118	117	120	75	76	72	78	79	79	80
9	113	114	116	118	119	119	121	76	77	74	79	80	81	81

Age	BP Percentile*	Systolic Blood Pressure by Percentile of Height, mmHg+							Diastolic Blood Pressure by Percentile of Height, mmHg+						
		5%	10%	25%	50%	75%	90%	95%	5%	10%	25%	50%	75%	90%	95%
1	95 <sup>th</sup>	98	99	101	103	104	107	106	54	54	55	56	57	58	58
1	99 <sup>th</sup>	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	95 <sup>th</sup>	101	102	104	106	108	108	110	59	59	60	61	62	63	63
2	99 <sup>th</sup>	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	95 <sup>th</sup>	104	105	107	109	110	109	113	63	63	64	65	66	67	67
3	99 <sup>th</sup>	111	112	114	116	118	119	129	71	71	72	73	74	75	75
4	95 <sup>th</sup>	106	107	109	111	112	111	115	66	67	68	69	70	71	71
4	99 <sup>th</sup>	113	114	116	118	129	121	122	74	75	76	77	78	78	79

## Clinical manifestations of HT in neonates + infants

- Failure to thrive
- Irritable
- Feeding problems, vomiting
- Seizures
- Respiratory failure, cyanosis or apnoea
- Cardiac failure



## HT in neonates and infants

- Low incidence in healthy term infants 0.2 to 3%
- So unusual - routine BP determination is not advocated
- Not so for preterm and high-risk newborns in NICU:
- HT more common in infants (9%) with
  - BPD (Chronic lung disease)
  - PDA
  - Intraventricular haemorrhage
  - Indwelling umbilical arterial catheters
  - Antenatal steroids
  - Maternal HT
  - Postnatal acute renal failure

## Presenting features of HT in toddlers/older Children

- CNS: Convulsions (25%), coma, facial palsy (12%) , hemiplegia (8%)
- Visual symptoms (27%): blurring, blindness
- Renal: Oedema, haematuria, proteinuria, polydipsia, polyuria, enuresis, acute renal failure
- CVS: Acute heart failure and pulmonary oedema, LV hypertrophy
- Respiratory: Acute respiratory distress
- Other: poor growth, vomiting, abdominal pain, epistaxis
- Some may be asymptomatic

## Presenting features of HT in this toddler

- Abdominal distension
- Polydipsia
- Polyuria
- FTT
- Left renal hypoplasia



## Core Messages

- Likelihood of identifying a secondary cause is
  - Directly related to level of BP and
  - Inversely related to age of the child
- In the majority of children HT is due to an identifiable cause
- Severe elevation of BP, regardless of age, warrants urgent evaluation and referral

# Core Messages

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Severe hypertension suggests renal disease

Acute onset of HT suggests acute renal disease  
e.g. Acute post streptococcal glomerulonephritis

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# Work-up for Hypertension

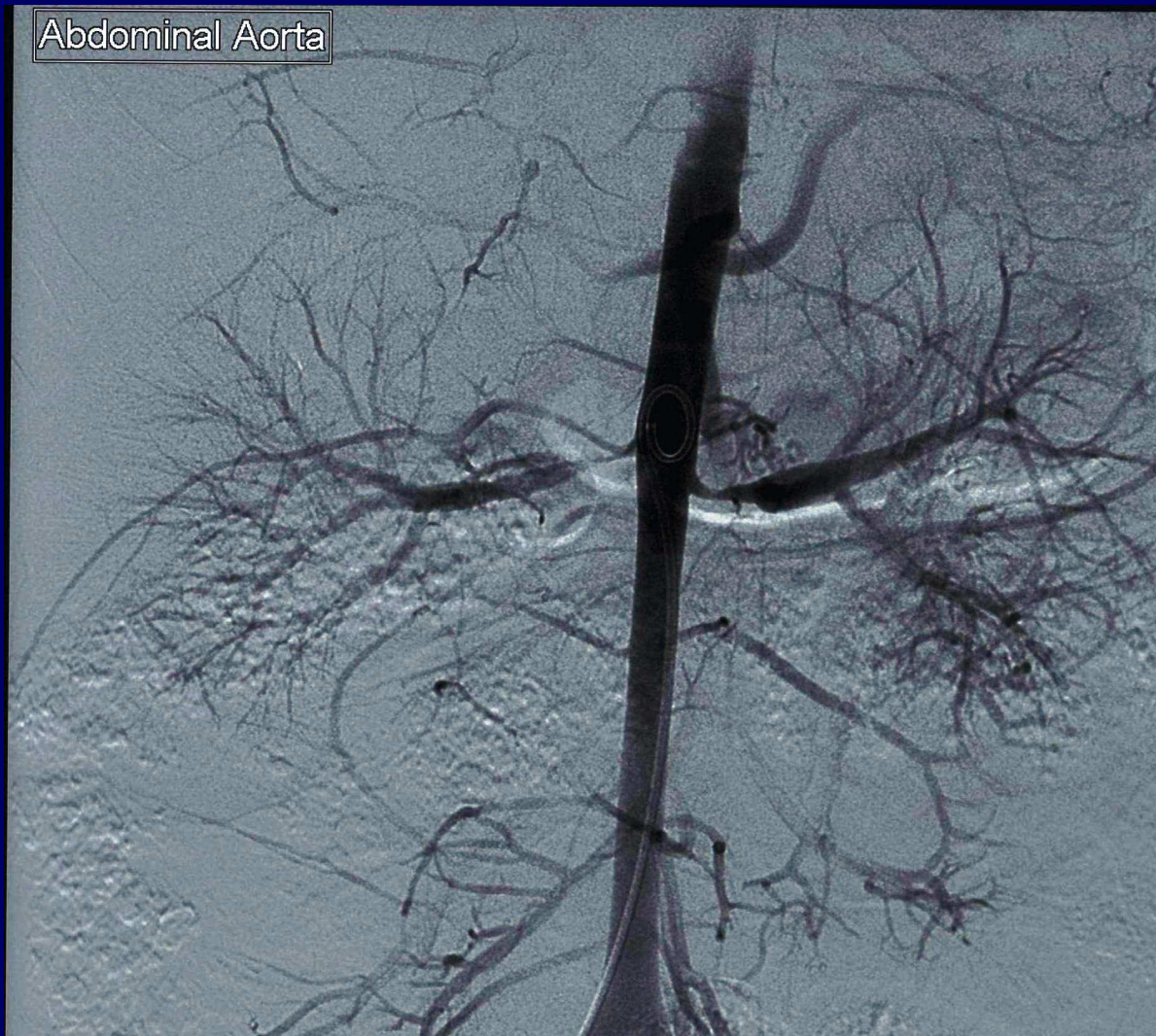
- Start with complete history
- Physical examination - ? Evidence of an underlying cause or end organ damage
  - Anthropometry
  - Body habitus (pattern of obesity)
  - Skin: café au-lait spots, striae
  - Pulses in all extremities
  - Measure BP in all 4 limbs (at least right arm and right leg)
  - Cardiac and neurological examination
  - Fundi (arteriolar narrowing)
  - Abdominal mass, palpable bladder, flank bruits, oedema
  - Examine thyroid

# Hypertension



Multiple Café-au-lait spots

# Bilateral renal artery stenosis associated with Neurofibromatosis





- Malar skin rash
- Petechiae and purpura
- CNS symptoms
- SLE



## Iatrogenic HT

- Iatrogenic
- Steroid treatment



# Work-up for hypertension in neonates

- Obtain focused history
  - ? Pertinent prenatal exposures
  - Clinical course
  - Any concurrent conditions
  - Procedures e.g., umbilical catheter
  - Current medication
- Physical examination- focused to assist in narrowing the differential diagnosis
- BP readings should be obtained in all four extremities to rule out coarctation of the aorta

# Diagnostic Evaluation

- Investigations should be tailored to
  - The age of the child
  - The severity of BP elevation
  - Positive findings on history and examination
- Appropriate investigations should be done to
  - Exclude an underlying cause
  - Exclude acute complications and associated diseases
  - Determine effects on target organs

## Special Investigations

A limited number of investigations will often confirm suspected pathology or help to direct further tests:

- Urine dipstix, microscopy and culture
- Blood Urea, Creatinine, Electrolytes
- Full blood count
- Renal ultra sound
- CXR and ECG
- Peripheral Plasma Renin Activity

# HT Crisis = Malignant HT

- Hallmark
  - Fibrinoid necrosis
  - Ischaemia of end organs
- Manifestations
  - Encephalopathy
  - Retinal haemorrhages
  - Cardiac failure
  - Renal complications

# Hypertensive Urgency

- Definition
  - Severe HT without accompanying end organ damage
- Manifestations
  - Headache, blurred vision and nausea, but no evidence of end organ involvement
- The BP level at which these changes occur is not predictable
- Depends on the rate of rise in BP

## Management of severe HT

- Life threatening condition
- Serious sequelae if inadequately treated
- Equally serious complications if over enthusiastically treated
- Rate of BP reduction depends upon starting BP and age of the child



# Management

Hypertensive crises



Treat urgently:  
Reduce BP within minutes to hours in order to avoid life-threatening complications  
Avoid precipitous drop in BP

Hypertensive urgency



Control BP over 72 hours to one week

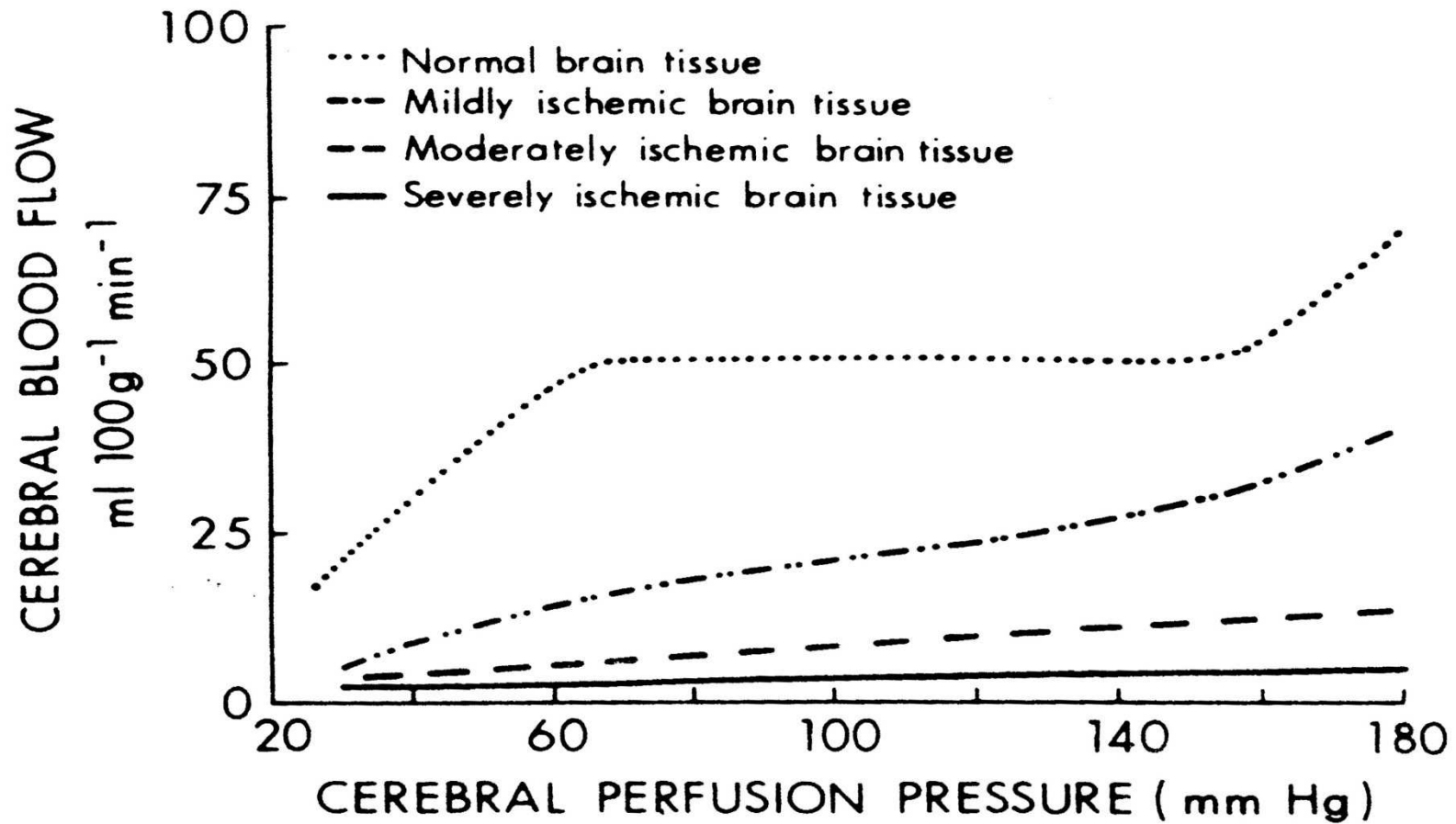
# Management of acute malignant hypertension

- Aim to reduce blood pressure by:
  - 1/3 of total desired reduction in 1<sup>st</sup> 12 hrs
  - Next 1/3 over 12-36 hrs
  - Last 1/3 over 36-72 hrs
  
- Aim to treat the cause –e.g. if fluid overloaded give a diuretic.

## Pathophysiology of chronic hypertension

- In chronic HT the cerebral autoregulatory zone is shifted to a higher BP range compared to normotensive patients
- If the BP is lowered too rapidly below this range, perfusion of the target organs may become compromised
- →cerebral ischaemia, stroke, blindness

## Impaired Cerebral Autoregulation during Ischemia



# Drug Treatment

- Order in which drugs are administered may vary depending on the
  - History
  - Physical examination
  - Laboratory findings
- Oral drugs can occasionally be used
- Use parenteral drugs for altered mental status

# Tailor anti HT drugs according to cause

Renin induced HT  
R type HT



Drugs to:  
Suppress renin  
Reduce Angiotensin II  
Examples:  
 $\beta$  blocker, ACEI, ARB

Volume Na<sup>+</sup> Dependent HT  
V type HT



Drugs to:  
Reduce volume  
Vasodilate  
Examples:  
Diuretics, CCB

# Drugs for treatment of HT crises

1. Furosemide IV

and

2. Labetolol (Trandate) IV

3. Amlodipine oral

May be repeated 6 hours later, then 12 hourly

If repeated doses are required, start and continue oral therapy as soon as possible

## Treatment of chronic hypertension

- For uncomplicated primary HT+ no target-organ damage, BP goal be  $< 95^{\text{th}}$  percentile
- For chronic renal disease, DM or HT target organ damage, BP goal  $< 90^{\text{th}}$  percentile
- Specific classes of antihypertensive drugs should be used according to the underlying pathogenesis or illness



# Classification of chronic hypertension in children and therapy recommendations

	BP percentile	Therapeutic lifestyle changes	Pharmacologic treatment
Prehypertension	90 <sup>th</sup> to < 95 <sup>th</sup> or BP > 120/80 mm Hg even if < 90 <sup>th</sup> percentile	Introduce physical activity Diet management Weight reduction if overweight	None unless compelling indications e.g. chronic kidney disease
Stage I hypertension	95-99 <sup>th</sup> percentile plus 5 mm Hg	Introduce physical activity Diet management Weight reduction if overweight	Initiate therapy based on indications, e.g. positive family history of cardiovascular disease, essential hypertension, DM etc.
Stage 2 hypertension	> 99 <sup>th</sup> percentile plus 5 mm Hg	Regular physical exercise. Diet management Weight reduction if overweight	Initiate therapy

# Treatment of Chronic Hypertension

- Advise a change in lifestyle
  - Limit TV viewing and increase physical activity
  - Limit junk food
- A weight reduction programme for obese individuals
- Regular aerobic exercise for essential hypertension
- Dietary advice
  - Limit salt and saturated fat intake
  - Increase dietary fibre intake

## Step wise treatment

- For ambulatory patients begin with lowest dose of preferred drug
- ↑dose at each visit until control is achieved
- For patients with persistent HT despite an optimal dose of a 1<sup>st</sup> line drug, add 2<sup>nd</sup> or 3<sup>rd</sup> drug
- There is no specific order in which drugs should be added, however, for some conditions certain drugs are indicated

## Treatment of chronic hypertension

- For uncomplicated 1°HT+ no target-organ damage, BP goal be <95th percentile
- For chronic renal disease, DM or HT target organ damage, BP goal<90th percentile
- Specific classes of antihypertensive drugs should be used according to the underlying pathogenesis or illness

# Treatment of Chronic Hypertension

Chronic kidney disease & proteinuria



Drugs to:

Decrease proteinuria

ACEI, ARB,  $\beta$ -Blocker

# Treatment of Chronic Hypertension

Neuro-secretory cause  
e.g.  
pheochromocytoma



Combined  $\alpha$  &  $\beta$ -  
adrenergic receptor blocker  
Labetolol  
Prazosin and Atenolol

Apparent  $\uparrow$  mineralocorticoid  
or Liddle Syndrome ( $\downarrow$  renin)



Drugs that act on  
collecting tubules  
Triamterene  
Amiloride

## Drugs: Unsafe in Specific Situations

Pheochromocytoma	Dangerous to start with $\beta$ blocker only → unopposed $\alpha$ -stimulation
CNS disease or coma	CCB increase risk of CNS hemorrhage
Acute renal failure or Bilateral renal art. stenosis	ACEI

## Drugs: Unsafe in Specific Situations

Acute cardiac decompensation	CCB <ul style="list-style-type: none"><li>• ↑ risk of cardiac ischaemia</li><li>• ↑ heart rate</li><li>• ↑ catecholamine levels</li></ul>
Asthma	β-blocker



## Reminder

- Measurement of BP is part of routine examination
- Incorrect measurement is worthless
- No point in measuring it, but not interpreting value
- Medical negligence if no action is taken when child has hypertension

## References

1. Paediatrics 2008;121:115-22
  2. Arch Pediatr Adolesc Med 2006; 160:977-81
  3. Wen X, Triche EW, Hogan JW, Shenassa ED and Buka SL. Prenatal Factors for Childhood Blood Pressure Mediated by Intrauterine and/or Childhood Growth. Pediatr 2011;127(3): 713-721
  4. Galobardes, B et al. Epidemiol Rev 2004; 26:7-21
  5. National High BP Education Program Working Group on High BP in Children and Adolescents – 4th Report Paediatrics 2004;114(2):555-576
  6. Easy-to- use childhood BP tables (International Pediatric Hypertension Association) [Http://www.pediatrichypertension.org](http://www.pediatrichypertension.org)
  7. [Http://nhlbi.nih.gov/health/prof/heart/hbp/hbp\\_measure\\_child.htm](http://nhlbi.nih.gov/health/prof/heart/hbp/hbp_measure_child.htm)>(2007)
  8. Chandar J & Zilleruelo G. Hypertensive crisis in children. Pediatr Nephrol 2012;27:741-751
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