Pediatrics Notes

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12.1 Anatomy, physiology and Pathology

The heart is located in the mediastinum of the chest, bounded anteriorly by the sternum, posteriorly by the spine and laterally by the lungs. Externally, the right ventricle is anterior. Most of the left ventricle, left atrium and right atrium are posterior. internally the right and left atria are separated by the tricuspid and mitral valves respectively. The arterial supply of the heart is through the coronary arteries while venous drainage is through the coronary sinus. The aorta and pulmonary arteries arise from the left and right ventricles. The heart has three layers:

1. Endocardium: Inner epithelial layer of the heart
2. Myocardium: Muscular part of the heart
3. Pericardium: Outer layers of the heart. Divided into the visceral and parietal pericardium.

Venous blood enters the right atrium through the inferior and superior vena cavae. It empties in atrial systole into the right ventricle through the tricuspid valve. It then moves on through the pulmonary valve in ventricular systole, to the pulmonary artery and the the lungs. Blood returning from the lungs enters the right atrium through the four pulmonary veins. In atrial systole, it moves onto the left ventricle through the mitral valve. Finally, it empties into the aorta through the aortic valve.

The heart has an inherent electrical system that automatically depolarises it. The parts are:

1. The SinoAtrial (SA) node: This is the pacemaker of the heart and depolarises the two atria.
2. AtrioVentricular (AV) node: Receives impulses from the SA node, delays a bit before propagating it further
3. His-purkinje fibre system. Responsible for the spread of electrical impulses to the ventricles

Heart as a pump
There is a difference in the pumping action of the heart in utero and after birth.

1. Fetal
    - Most work is done by the Right ventricle

- The right Ventricle is therefore relatively hypertrophic
- Only 15% of the cardiac output is pumped into the lungs

2. After birth

    - Gradual transition to Left ventricle dominance
    - Gradual fall in pulmonary pressure (over 6 weeks)
    - The left ventricle does most of the work and becomes thicker than the right

Systolic and diastolic functions

Systole: This is the contractile phase of the heart. It starts with the atrium so it empties into the ventricles before the ventricle's subsequent contract.

Diastole: This is the relaxation phase where the heart relaxes and lets in blood. It also starts with the atrium and then the ventricles.

Compliance: This describes how easily the heart chamber relaxes in response to the inflow of blood.

Cardiac Pressures

The pressures in the heart vary for different ages and individuals. Generally, the pressure in the atria are lower than that in the ventricles. Also, the pea systolic pressure in the left ventricle is higher than in the right. The diastolic pressure in the left ventricle is however lower than the right ventricle. In the typical adult heart, the following pressures are often observed. Also, both systolic and diastolic pressure in the aorta is higher than that in the pulmonary artery.

Systolic pressure in general is generated by the ventricles. In conditions such as coarctation of the aorta, aortic stenosis and pulmonary hypertension, the ventricles end up increasing their workload to generate enough pressure. The diastolic pressure on the other hand is maintained by the closure of the aortic and pulmonary valves. Thus incompetent pulmonary or aortic valve leads to a decrease in diastolic pressure in the the tow vessels respectively.

13 Atrial Septal Defect

13.1

13.2 Introducion

1. Defect in the inter-atrial septum
2. 5-10% of all CHD
3. Types
    - Secundum ASD (most common, 50-70%)
    - Primum ASD (30%)
    - Sinus venosus ASD
    - Coronary sinus ASD

13.3 Pathophysiology

- Left to right shunting and thus acyanotic
- leads to volume overload of the right atrium, ventricle, pulmonary artery and pulmonary oedema
- Consequent dilatation of the right atrium and ventricles
- Minimal pressure transmitted so no significant pressure overload
- Consequently, pulmonary oedema is usually insignificant
- Rarely have overt heart failure
- However, long-standing liaison or a very big lesion with a pulmonary-to-systemic flow ratio of 2 or more will lead to heart failure and pulmonary hypertension after about 15 to 20 years No Reversal of shunt

13.4 Clinical presentatoin

- Usually asymptomatic except for big lesion with high Qp: Qs
- They often have slender bodies

- Auscultation reveals a widely fixed split-second heart sound and a grade 2/6 to 3/6 ejection systolic murmur at the upper sternal border
- Many are almost silent, especially the small lesions which are often detected during an echocardiogram for another reason

13.5 Investigations

- Bedside SpO2 is usually normal and hence an acyanotic heart disease
- In older patients, a chest x-ray may show
  - Cardiomegaly
  - Prominent pulmonary artery
  - Increased vascular markings
- The electrocardiogram may show
  - Right axis deviation due to the right ventricular dilatation
  - Right atrial enlargement
- An echocardiogram is diagnostic as it visualises the defect, and quantifies the shunt and other chamber sizes.
- Cardiac catheterization is often done in long-standing cases to detect complications that may have arisen.

13.6 Natural history

- Most ASDs will close spontaneously by 4 years, with smaller ones having a higher closure rate than bigger ones. A long-standing large defect however leads to chronic heart failure and pulmonary hypertension in early adulthood.
- Arrhythmias may arise because of the dilated right atrium.
- Though there are reported cases of paradoxical strokes in patients with ASDs, it remains an uncommon occurrence.
- Infective endocarditis is also rare in ASDs.

13.7 Treatment

There is no need for exercise restriction or prophylaxis for endocarditis. If there is no sign of heart failure, a device closure is often done after infancy or a surgical closure at 2-4 years of age. However, if there is heart failure, Medical treatment for heart failure is immediately instituted. Then a planned device closure or surgical closure can be done within the first year of life.

13.8 Prognosis

Prognosis is generally good with many living into adulthood even without corrective surgery. Post-surgical mortality i currently less the 0.5%. The patient will need very little long-term follow-up after the corrective surgery.

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23 Hypertension

23.1 The Concept of Blood Pressure

Blood pressure is the force exerted by the blood against any unit area of the vessel wall. Physiologically,

$$BP = CO \times TPR = SV \times HR \times TPR$$

Where:

- HR is the Heart Rate
- BP is the Blood Pressure
- TPR is the Total Peripheral Resistance
- CO is the Cardiac Output
- SV is the stroke volume

23.2 Ways of measuring blood pressure

1. **Direct intra-arterial** measurements by placing a catheter into the vessel and measuring the pressure "in line" with the vessel (end-on-pressure). This method is used by physiologists and Intensivists. The principle is employed in the measurements of central venous pressure and intracranial pressure in clinical practice.
2. **The auscultatory method** is done with the use of a sphygmomanometer (either mercury or aneroid) and a stethoscope. This is the gold standard in clinical practice. Korotkoff sounds 1 and 5 sounds are measured for systolic and diastolic bleed pressures respectively. Values obtained are generally lower than direct & oscillometric measurements.
3. **The palpation method** (flush technique) is performed with the use of a sphygmomanometer and palpating finger. Largely unreliable. Only systolic blood pressure can be measured with this technique. The palpated pulse is generally lower than Korotkoff sound 1 by 10mmHg.
4. **The oscillometric method** uses a sphygmomanometer and a monitor e.g. digital blood pressure devices and Dynamap. Here, pulsatile blood flow through arterial wall oscillations is transmitted to the cuff encircling the extremity. Korotkoff sound 1 is recorded at the point of rapid increase in oscillation amplitude. Korotkoff sound 5 is recorded as

the point of a sudden decrease in oscillation amplitude. Values obtained by oscillometric measurements are generally higher than auscultatory.

5. **Doppler ultrasound technique**: Here a Doppler ultrasound is held over the pulse to magnify the sound so that it is audible without a stethoscope. The sound detected may be 5mmHg higher than Korotkoff sound 1.
6. **Ambulatory blood pressure measurements**. Here, multiple measurements are recorded over time (e.g. 24 hours) with digital devices attached to the limb whilst the patient engages in normal activities outside the hospital. Results are analysed on a computer or paper tracer built into the device using the mean of the readings. It provides a truer picture of blood pressure trends useful in diagnosing "white coat hypertension" and nocturnal hypertension (absence of a normal physiological drop in blood pressure during sleep).

23.3 Definition of Hypertension in children

In adults, the epidemiological definition is based on the risk of adverse events (e.g. Stroke) being>140/90mmHg. **In children**, hypertension is defined statistically based on normative data: 95th centile for age, height, and gender (Refer to height centile chart and blood pressure levels). By this statistical definition, 5% of children will be classified as hypertensives. Other definitions include:

- **Normal blood pressure**: < 90th centile for age, height, and sex.
- **Pre-Hypertension**: 90th – <95th centile for age, height, and sex
- **Stage 1 Hypertension**: 95th - 99th + 5 mmHg
- **Stage 2 Hypertension**: *> 99th centile + 5mmHg*

  A sample of the blood pressure chart is shown below.

23.4 Plotting the blood pressure centile

1. Measure the child's height
2. Determine the height centile. If the height centile falls between 2 centiles, use the closest centile. Otherwise, use the lower height centile.
3. Determine the blood pressure centile.
4. Classify blood pressure using the definitions above.

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

Figure 23.1: Blood Pressure Centile Chart

23.5 Hypertensive emergency

This is an acutely elevated blood pressure with evidence of threatening end-organ damage involving the following organs:

- Brain (severe headache, visual changes, cranial nerve palsy, papilloedema)
- Heart (acute chest pain and tightness, shortness of breath)
- Kidney (decreased urine output acutely, proteinuria and haematuria on dipstick)

It is thus a symptomatic, severe Hypertension.

23.6 Hypertensive Urgency

This is severe hypertension without evidence of end-organ damage or symptoms. The blood pressure should nevertheless be treated urgently but not aggressively like in a hypertensive emergency to prevent progression into a hypertensive emergency. If possible, the patient should be managed as in-patient.

23.7 Rules of blood pressure measurement

1. Select the right cuff size
    - The length of the inflation bladder should be at least 80% of the mid-arm circumference.
    - The width of the inflation bladder is at least 40th of the mid-arm circumference.

2. The child should rest for at least 5 minutes in a comfortable environment and position.
3. Arm resting and supported at heart level (The reference level. Values outside this reference level are higher). The lower edge of the cuff is 2cm above the cubital fossa.
4. Bladder tubings should lie over the brachial artery.
5. Bell of the stethoscope is used
6. Korotkoff sounds 1 and 5 are used for systolic and diastolic respectively.
7. Multiple measurements are made (preferably at different settings) and the lowest reading is taken. For research purposes, 3 measurements are taken and an average of the last 2 used.

Blood pressure readings obtained in the legs are 10-20mmHg higher than the arm pressure in any individual. Arm blood pressure higher than leg blood pressure occurs in aortic coarctation distal to ductus arteriosus.

23.8 When to suspect hypertension

Suspect hypertension in any child with any of the following conditions:

- Alteration in consciousness including aggressive behavior and convulsion
- Oedematous
- Known kidney disease or evidence of abnormal urinalysis
- Heart failure
- Obesity
- Failure to thrive
- Stroke or other palsies including cranial nerve palsy
- History of Low Birth Weight (small number of nephrons)
- Unexplained anaemia, or blurred vision
- Neurofibromatosis
- Other syndromes like Turner & Williams

23.9 Aetiology of hypertension

Generally, childhood Hypertension is considered to be of secondary cause until proven otherwise. This is particularly so among the very young and the severely hypertensive. The majority (~80%) are of renal origin. However, the number of children with essential Hypertension is on the rise, particularly among obese adolescents and those with a positive family history.

Broadly, aetiology can be categorized into:

- Renal disease
- Vascular disorders

- Endocrine causes
- Neurologic causes
- Renal tumours
- Catecholamine-secreting tumours
- Drug-induced
- Miscellaneous causes

However, since these are often age-specific categorizations are done by age as below:

23.9.1 Neonate to one-year

Congenital

- Congenital lesions of the vasculature
  - Renal Artery Stenosis
  - Aortic coarctation
- Congenital lesions of renal parenchyma
  - Polycystic Kidney disease
  - Dysplastic kidneys
  - Obstructive uropathy
- Congenital Adrenal Hyperplasia
  - 11- hydroxylase deficiency
  - 17- hydroxylase def

Acquired

- Renal artery or vein thrombosis secondary to umbilical artery or vein catheterisation
- Bronchopulmonary dysplasia
- Medications
  - Theophylline/caffeine
  - Phenylephrine and Ephedrine Nasal Drops in cold medications
  - Steroids
  - Vitamin D intoxication
- Total Parental Nutrition (high Ca2+)
- Maternal drug use: Cocaine, heroin

23.9.2 One- to five years

- Renal Artery Stenosis
- Glomerulonephritis
- Renal vein thrombosis
- Wilms tumour
- Neuroblastoma
- Phaeochromocytoma
- Cystic kidney disease
- Monogenic Hypertension (e.g. Liddle's syndrome)

23.9.3 Five- to ten-years

- Glomerulonephritis
- Renal scars from reflux nephropathies or Urinary Tract Infections
- Renal Artery Stenosis
- Cystic renal disease
- Endocrine tumours
- Essential Hypertension
- Obesity

23.9.4 Ten- to twenty-years

- Obesity
- Essential hypertension
- Reflux nephropathies with repeated Urinary Tract Infections
- Glomerulonephritis
- Renal Artery Stenosis
- Endocrine tumours
- Hyperthyroidism
- Drugs (Oral Contraceptive Pill, illicit drugs)

23.10 Evaluation of the Hypertensive Child

- Patient's history
- Symptoms of renal disease (haematuria, oliguria, evidence of bodily swelling, polyuria, enuresis)
- Symptoms of vasculitis or rheumatology (Joint swelling & rash)
- Past medical history (umbilical artery/vein catheterisation, previous renal disease e.g. Previous swelling)

- Drug History (steroids, Oral Contraceptive Pill, amphetamines, other illicit drugs)
- Birth History: Low Birth Weight
- Family History of Hypertension

Clues on physical examination include:

- Coarctation of the Aorta & Takayasu:
  - Femoral artery delay or imperceptible
  - Blood pressure discrepancy between arm & leg →COA, Takayasu arteritis
- Neurofibromatosis
  - Caf au lait spots
- RAS, Takayasu arteritis
  - Abdominal bruit
- Congenital adrenal hyperplasia
  - Ambiguous genitalia
- Dysmorphism suggestive of Turner or William syndromes
- Signs of Chronic Renal Failure: Growth failure (stunted), renal rickets, anaemia, oedema
- Bedside urine dipstick positive for protein and blood (± oedema)

23.11 Investigations

The rationale is 2-fold:

1. To define aetiology
2. To assess the presence of end-organ damage

Some of the investigations include:

- Full blood count
- Urine dipstick, microscopy and culture
- BUE, Serum Creatinine, Ca, Mg, PO4, blood gases
- Uric acid
- KUB ultrasound and Doppler studies to rule out Renal Artery Stenosis
- Chest X-ray for cardiomegaly
- Echocardiogram for Left Ventricular Hypertrophy (end organ damage)
- Fundoscopy
- Plasma Renin Activity (PRA) for RAS & renin secreting tumours
- Pre/post captopril nuclear scan

- MRA or CT Angiogram
- DMSA scan for renal scars
- Urine HVA & VMA for catechol amine secreting tumours/MIBG scintigraphy

23.12 Uric Acid and hypertension

Uric acid is increasingly being implicated in the pathogenesis of Hypertension in both adults and children. It is believed to cause endothelial dysfunction leading to microvascular and inflammatory injury to the kidneys. There are also reduced levels of endothelial-derived nitric oxide and associated elevation of the Renin-Aldosterone-Angiotensin System. Elevated uric acid levels in hypertensive individuals are associated with adverse outcomes like stroke. Allopurinol treatment is advocated for such individuals.

23.13 Complication of Hypertension

Some complications of Hypertension are listed below:

- Hypertensive encephalopathy
- Left Ventricular Failure
- Stroke
- Subarachnoid haemorrhage
- Secondary renal damage
- Retinopathy

23.14 Treatment of hypertension

23.14.1 Non-drug treatment

- Reducing salt intake
- Weight reduction for obesity-related hypertension
- Intake of more vegetables on account of potassium richness

23.14.2 Drug Treatment

Principles of anti-hypertensive therapy:

- Long-acting (once-daily medication)
- Maximise treatment dosage before adding on

- Agents used will come from the "ABCD" group:
  - **A**CE inhibitor and ARBs (Avoid if RAS suspected or in hypovolaemia)
  - **B**eta-blocker
  - **C**alcium channel blocker
  - **D**iuretic
  - **E**very other drug (methyl dopa, alpha-blockers, vasodilators like hydralazine

Generally, **A & B** drugs are not combined for Blood pressure control. Rather: **A + C + D** or **B + C + D**

23.15 Hypertensive encephalopathy

Hypertension with changes in mental status and/or seizures. Other manifestations are:

- Facial palsy
- Visual changes→blindness
- Coma

Pathophysiology: Disruption of the normal autoregulatory mechanisms of cerebral blood flow. The inability of cerebral vasculature to constrict appropriately in response to the abrupt increase in cerebral blood flow leads to cerebral hyperperfusion. Generally, short-acting antihypertensives are preferred in the initial instance of treatment so that any potentially harmful drop in blood pressure (which could lead to Posterior Reversible Encephalopathy Syndrome {PRES}) could be reversed. Subsequently, long-acting agents could be used Sublingual nifedipine could cause a precipitous drop in blood pressure so it is best avoided or should be used with extreme caution

Treatment outline:

- Use anti-hypertensive drugs
- Blood pressure should be brought down slowly to a desirable level (?stage I) by 48hrs (though not to normal levels) as follows:
  - 1/3 of total blood pressure reduction in 1st 12-hrs
  - Next one-third of the subsequent 12-hrs
  - Final one-third over 24-hrs
- Alternatively, by a quarter within 6 hours, and the rest in the next 24-36hrs

Commonly preferred drugs include Labetalol infusion, Na nitroprusside infusion, and IV hydralazine infusion. After achieving the desired blood pressure target, oral antihypertensives are then started

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