* Short Stature

* Normal Growth pattern → pulsatile in nature!

I C P Concept of Growth

- Infantile phase → Insulin like Growth
- childhood → GH, thyroxine
- puberty → GH, sex steroid

---

* Nelson-Weech's Formula: For expect height / 2-12 yrs

(Age x6) + 77

---

* Mid parental Height (MPH) → For comparsion with own's child genitic potential

$$\frac{(\text{Mother's HT} + \text{Father's HT})}{2} \pm \begin{cases} 13 & \text{Boy} \\ 13 & \text{Girl} \end{cases} \pm 8.5$$

- 95% of individuals within 2SD of MPH (±8.5)
- if pt was below -8.5 of MPH Next step?

Check GH deficiency, Chromosomal cause

→ other: Bone age, Growth velocity!

Growth pattern → Normal → Growth parameters Expected HT within MPH → proportionate, follow closely to per curve

→ Abnormal → deviate ≥2 SD from mean
→ cross ≥ 2 major per within 6ms - 1Y
→ deviate > 8.5 from MPH
→ Disproportionate Growth parameter

* Short Stature: HT is 2SD or more below mean HT for individuals of the same sex/ chronologic age or < 5th percentile !

- MCC of SS in first (1–2) yrs ⇒ Familial SS / Constitutional SS ⊕
  ↳ normal non-pathological variants

- SS classified → Non-pathological - pathological
  → Disproportionate - proportionate

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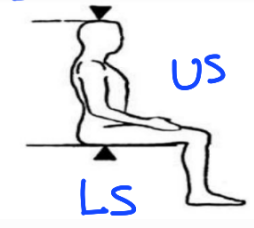
* Assessment Body proportions By US/LS ratio !

Normally at birth (1.7)
1 at 7–10 yrs



* ↑↑ (US > LS):

① Achondroplasia
② Skeletal dysplasia
③ Untreated hypothyroidism

* ↓↓ (LS > US):

① Short neck (Turner syndrome)
② Short trunk (Scoliosis)
③ Arachnodactyly (Marfan S)

---

* Normal variant SS: → Normal HT velocity

① Familial SS
② Constitutional SS
③ idiopathic SS
④ SGA infants with catchup growth.

* Management: Reassurance !

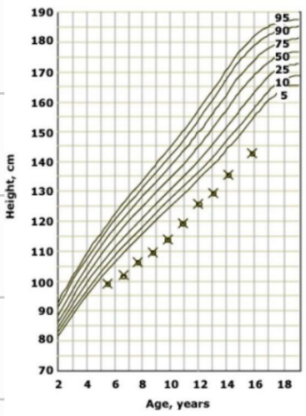
① Familial SS → MCC of proportionate SS

→ Final adult HT < 3rd percentile

→ Within MPH → Family Hx of SS

→ Normal Bone Age!

→ In the absence of any Cause!



② Constitutional Growth Delay

→ Temporary delay in growth and onset of puberty

→ Hallmark is Delayed Bone Age

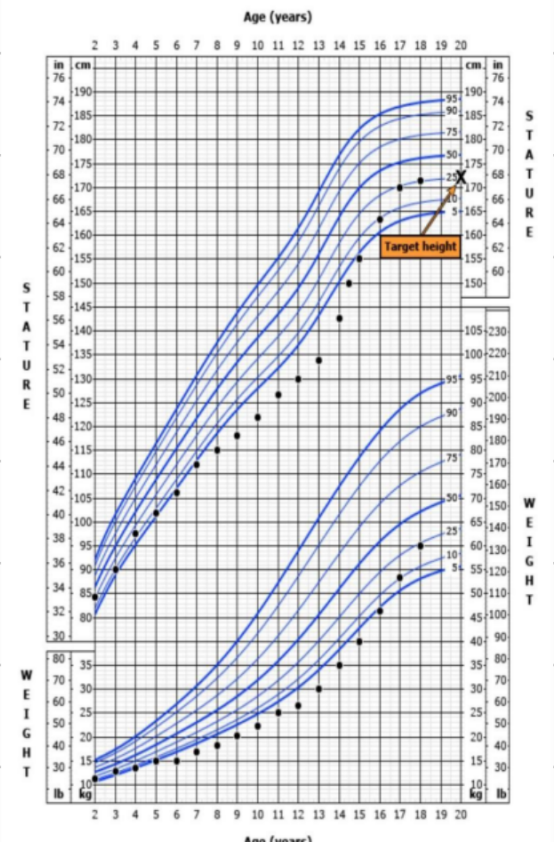
→ Normal adult HT

→ Family Hx of delayed growth and puberty

→ Difficult to differentiate it from GH deficiency

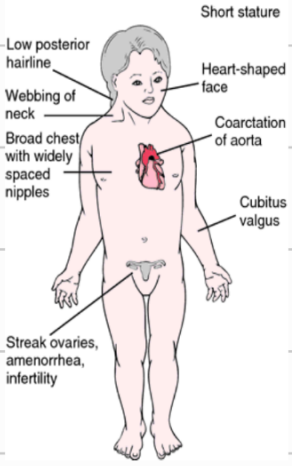
So Stimulation test, GH Secretagogus ⇒ Necessary!

Followed by catchup growth!



* Genetic Causes

① Turner Syndrome

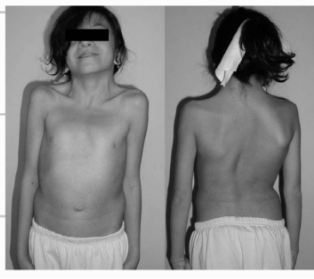


→ Diagnosis By → Karyotype → 45, XO
→ Clinical presentation:

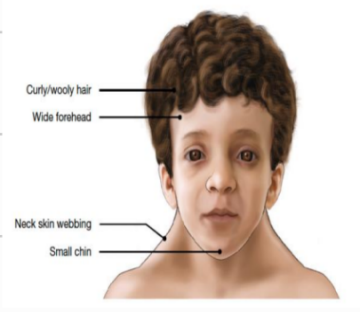
Webbed neck / widely spaced nipples, gonadal dysgenesis absent or very delayed puberty, Coarctation of Aorta Bicuspid aortic valve (MC), **Short stature** (↳ in All girl ↳ 20 cm shorter MPH), horseshoe kidney

→ Treatment: GH, estrogen

② Noonan Syndrome



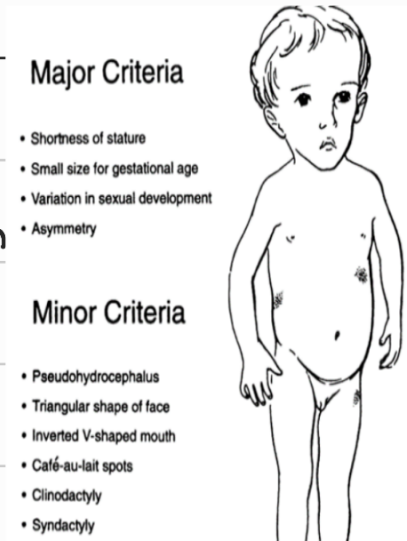
- AD (male version of Turner $)
- Diagnosis → Family hx
  → Genitic testing
  → Clinical presentation:



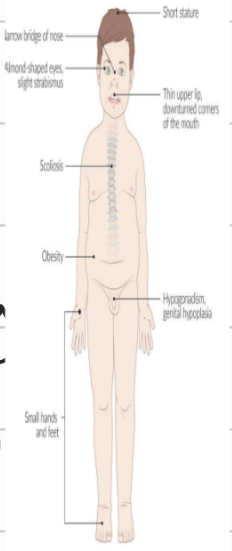
- Short stature → treated by GH
- CHD → Mostly pulmonary stenosis
- Hypertelorism - low set ear

③ Silver Russell Syndrome

- SGA at birth / postnatal growth retardation
- Defect in IGF-2
- Feeding difficulties / Body Asymmetry triangular face / prominent forehead

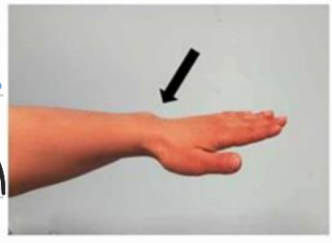


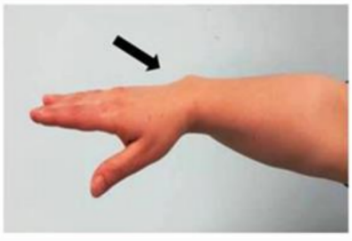
④ Prader Willi Syndrome



- Characterized by severe hypotonia, developmental delay, hyperphagia, morbid obesity, hypogonadism, hypothyroidism, feeding difficulty
- Short stature due to GH deficiency
- ↑ Risk of DM2, OSA

⑤ Shox Gene variants





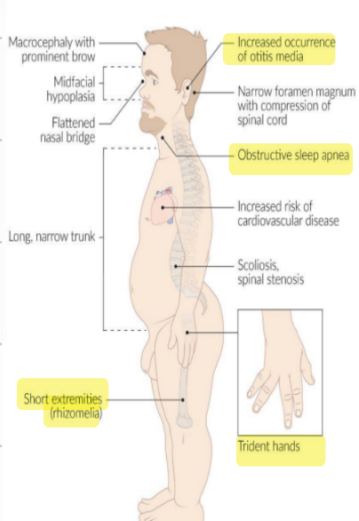
- Short stature, severe in girl
- Shorter forearm and lowers leg
- Madelung deformity of forearm, cubitus valgus

⑥ Laurence-Moon-Bardet-Biedl Syndrome

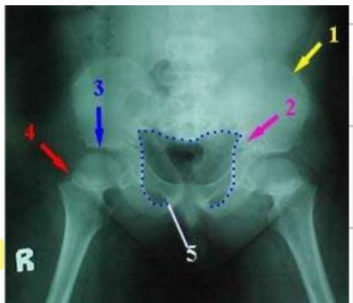
* pentad of: obesity / Hypogonadism, intellectual impairment / polydactyly / Retinitis pigmentosa AD

⑦ Achondroplasia

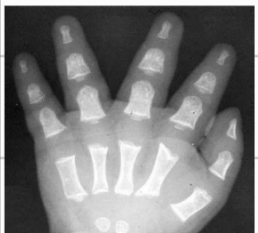
- MCC of disproportionate SS (90%)
- MC skeletal dysplasia in human
- AD, caused by mutation in FGFR3
- large head
- Frontal bossing



1. Dysplastic or square iliac bones
2. Narrow sacro-sciatic notches
3. Flat bilateral acetabular roofs
4. Short both femoral necks
5. Champagne glass-shaped pelvic cavity



Trident hand



* Endocrine Causes

① GH

- GH (growth hormone, somatotropin)
  - Direct effects
    - ↓ Glucose uptake into cells (↑ insulin resistance)
    - ↑ Lipolysis
    - ↑ Protein synthesis in muscle
    - ↑ Amino acid uptake
  - Indirect effects: mediated by IGF-1 (insulin-like growth factor 1; originally called somatomedin C)
    - Growth stimulation
    - Anabolic effect on body

- GH regulation [5][6]
  - ↑ GH secretion: exercise, deep sleep, puberty, hypoglycemia, CKD, thyroid hormone, estrogen, testosterone, and short-term glucocorticoid exposure
  - ↓ GH secretion: glucose, somatostatin, somatomedin, free fatty acids, and chronic glucocorticoid therapy [6][7]

↳ For long-term

* GH deficiency!

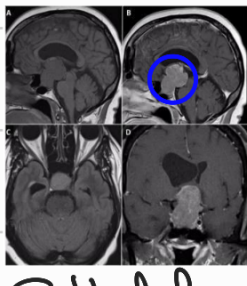
→ Congenital → Laron Syndrome (AR) → ↓ Risk of Cancer

→ growth hormone receptor mutations

→ Characterized by severe SS and inability respond to GH

→ ↓ IGF-1 - Delayed Bone age.

→ Clinical presentations: small head, saddle nose prominent Forehead, small genitalia, osteopenia, obesity hyperlipidemia, hypoglycemia



→ Acquired

→ tumor (Craniopharyngioma → MCC of GH def.

→ trauma, infection

* Children with GH def. or Brain tumor cause GH def. → Rapid Catch up growth during replacement therapy ↑ after surgery

② Thyroid / parathyroid

- Hypothyroidism : Delay bone age / normal growth after treated

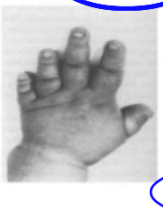
- **Pseudohypoparathyroidism (PHP)**

Pseudohypoparathyroidism (PHP) is characterised by **hypocalcaemia**, **hyperphosphataemia** and elevated levels of serum **parathyroid hormone** (PTH).

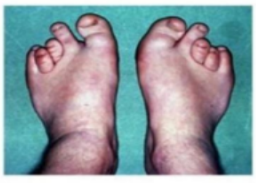
Besides PTH resistance, affected individuals may show distinctive but variable features. These clinical findings are termed **Albright's hereditary osteodystrophy** (AHO).

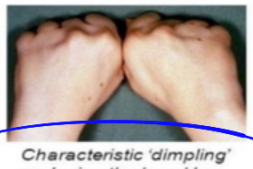
short stature, obesity, short limbs

round face, mental retardation



Brachydactyly- hands/feet





Characteristic 'dimpling' replacing the knuckles

③ precocious puberty → accelerated epiphyseal develop

④ Cushing $ → long term steroid ⇒ growth retardation

Single best growth curve indicator for acute malnutrition → < 5th perc.

* Systemic Causes

① Undernutrition → The hallmark is ↓ weight for-HT

② Glucocorticoid therapy

③ GI disease → IBD / celiac

④ Rheumatological D. As JIA ↔ due to proinflammatory cytokine / high-dose steroid

⑤ CKD → disturbance GH metabolism

⑥ Cancers

⑦ Pulmonary D. → CF / Asthma

⑧ Metabolic D. (DM 1 → SS, ↓ growth)

⑨ Cardiac D. due to anorexia, ↑ basal energy requirmt.

* Diagnosis

Hx

Ex

GIT	Chronic diarrhea, abdominal pain and GITbleeding	**IBD**
	Diarrhea, weight loss and abdominal distention	**Coeliac disease**
Respiratory	• including severe asthma, recurrent infections	**cystic fibrosis or immunodeficiency**
Renal	Polyuria and edema/ Recurrent UTI	**CKD**
CNS	Headache, vomiting, visual problem	**Pituitary/ hypothalamic Space occupying lesion .**
infections	Recurrent infections and poor wound healing	**Immunodeficiency**

History	Etiology
History of delay of puberty in parents Low	Constitutional delay of growth
Birth Weight	SGA
Neonatal hypoglycemia, jaundice, micropenis	GH deficiency/ Hypopituitarism
Dietary intake	Malnutrition
Headache, vomiting, visual problem	Pituitary/ hypothalamic tumors
Lethargy, constipation, weight gain	Hypothyroidism
Social history	Psychosocial dwarfism
Diarrhea, greasy stools	Malabsorption
Detailed systemic review	Chronic illnesses

Pointer	Etiology
Midline facial defects, micropenis, frontal bossing, depressed nasal bridge, crowded teeth,	GH deficiency / Panhypopituitarism
Signs of Rickets and / deformities	Renal failure, RTA, malabsorption, Hereditary
Pallor	Renal failure, malabsorption, nutritional anemia
Signs of malnutrition , clubbing, wasting	PEM, malabsorption, celiac disease, cystic fibrosis
Short & obese	Hypothyroidism, Cushing syndrome, Prader Willi syndrome, GH deficiency
Metacarpal shortening	Turner syndrome, Pseudohypoparathyrodism
Cardiac murmur	Congenital heart disease, Turner syndrome
Mental retardation	Hypothyroidism, Down, Pseudohypoparathyrodism

* Investigations:

- level 1 (essential):

CBC, CRP, ESR, Bone Age, Urinanalysis, Stool → parasite, steatorrhea, occult blood.

Blood (KFT, Ca^{+2}, PO_4^-, glucose, albumin, ALP, transaminase)

* **Bone Age**: X-Ray of Lt hand and wrist

→ Delayed → Skeletal age younger than Chronolgic A

→ Advanced → Rapid maturation → early cessation of growth

- level 2

TFT, Kanyotype → if normal and HT (2-3 SD) → observe HT velocity

if HT < 3 SD → level 3

- level 3

Celiac serology, Duodenal biopsy, GH stimulation test

⊕ glucagon, insulin, IGF-1

* IGF1, IGFBP3: represent GH production, tissue effect

↳ ① Normally (SD > 0) → unlikely GHD → No further test.

② Low (SD 0-2) → suspicion of GHD → provocation GH test

IGFBP3 → moderate

③ Severe ↓ (SD < -2), delayed bone age → Strong suspicion GHD

* exclude other cause of low IGF-1

As → poor nutrition

* Provocation GH testing

- to confirm a diagnosis of GHD
  - After overnight fasting
    - Clonidine, arginine, glucagon ⇒ * Exclude hypoglycemia

      Common choices as stimuli
      - normal response ⇒ by a serum GH concentration > 10 mcg/L
      - False +ve (low GH) ⇒ Constitutional delay of Growth.

* Indications for Genetic testing!

1. Severe SS (< -3 SD)
2. Multiple pituitary H. ↓
3. Severe GHD
4. unequivocal GH insensitivity.

* Treatment:

- treat underlying cause
- Counsel parent / Reassurance if SS in normal variant
- Discontinuation of growth inhibit medication

GH therapy

- indications: GHD / turner / Noonan / prader-willi
  CKD, SGA who not reached 5th centile by 2 Y/O
- percautions with neoplasms
- Stop? if PTH > 500 (High bone turnover)
- S.Es:

1. pseudotumor cerebri
2. SCFE
3. Worse Scoliosis
4. insulin resistance
5. ↑ nevi
6. Gynecomastia
7. pancreatitis

Automated pen type