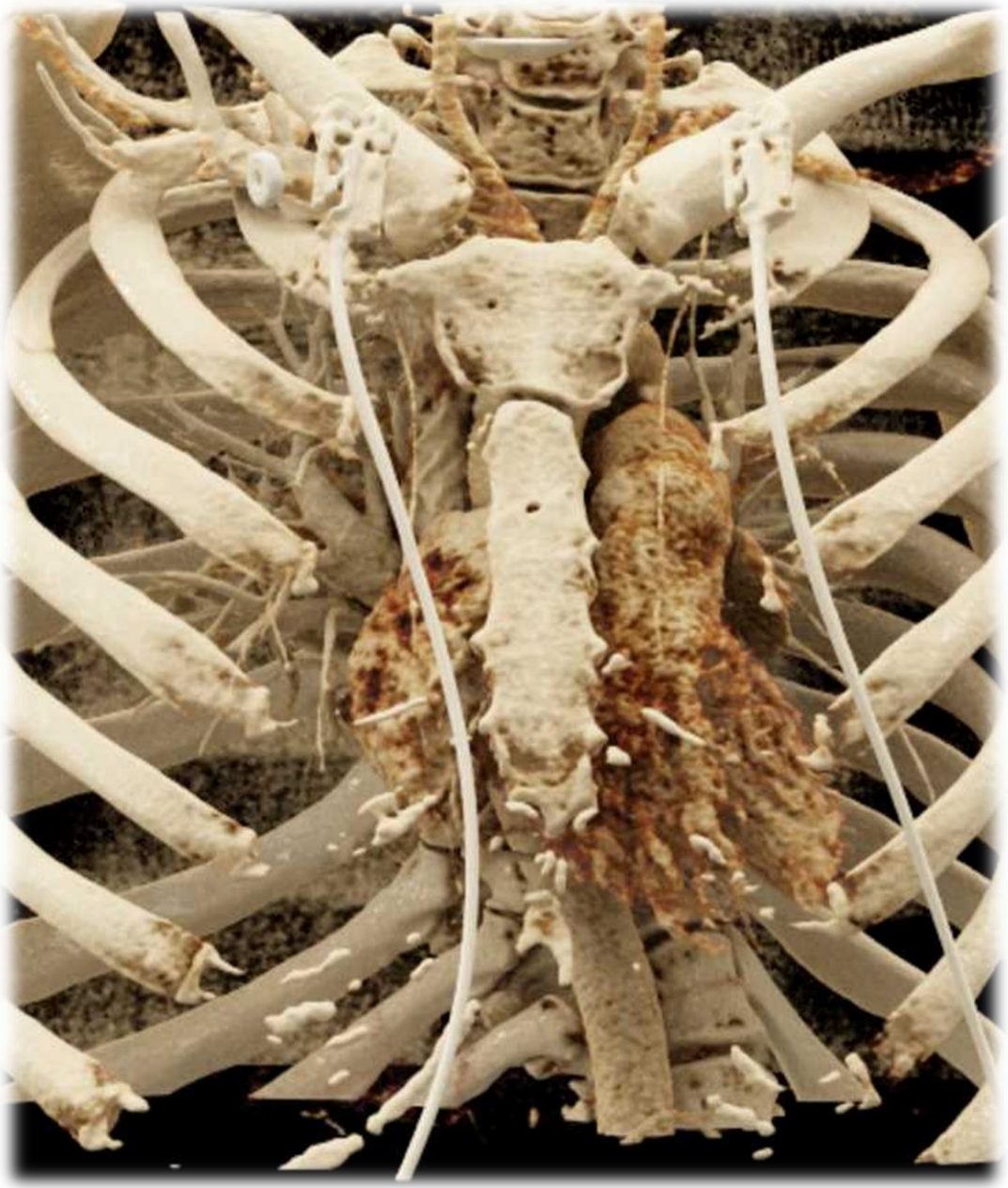


CHEST WALL Deformity AND CHEST WALL TUMORS

DR SAIF ALMUDHAFFAR

DEPARTMENT OF SURGERY /COLLAGE OF MEDICINE / AL MUSTANSIRYIA UNIVERSITY

Introduction

- Anatomy Review
- Chest Wall Deformities
- Chest Wall TumorsClinical Evaluation of Chest Wall Lesions
- Management Principles

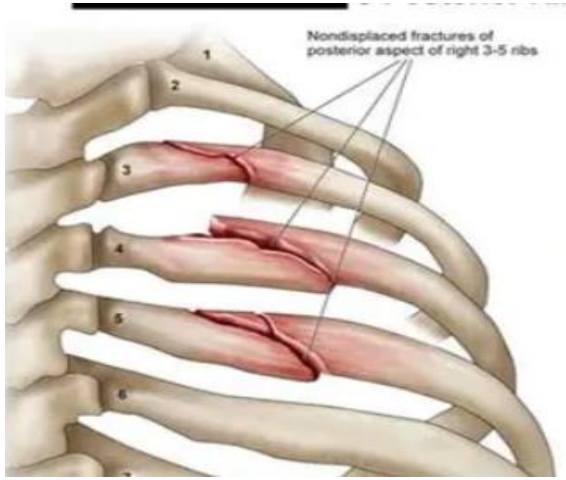
Anatomy review

- The chest wall consists of bones, muscles, and connective tissues that provide structural support, protect intrathoracic organs, and participate in respiration.
- Chest wall deformities and tumors may impact respiratory mechanics, cardiac function, and cosmetic appearance.

Surgical Anatomy

Bony Structures :

- **Ribs (Example: 5th rib in thoracotomy)**: surgical : **Posterolateral thoracotomy** commonly uses the **5th intercostal space** between the 5th and 6th ribs
- **Sternum (Example: Median sternotomy for CABG)**: Manubrium, body, xiphoid process. Sternal angle (Angle of Louis) — landmark for the 2nd rib. Clinical example: **Median sternotomy** used to access the heart and great vessels.
- **Thoracic Vertebrae (Example: Costovertebral joint in rib fractures)**: Articulation with ribs via costovertebral and costotransverse joints. Clinical example: posterior rib fractures near the vertebrae may injure segmental vessels.



Muscular Anatomy

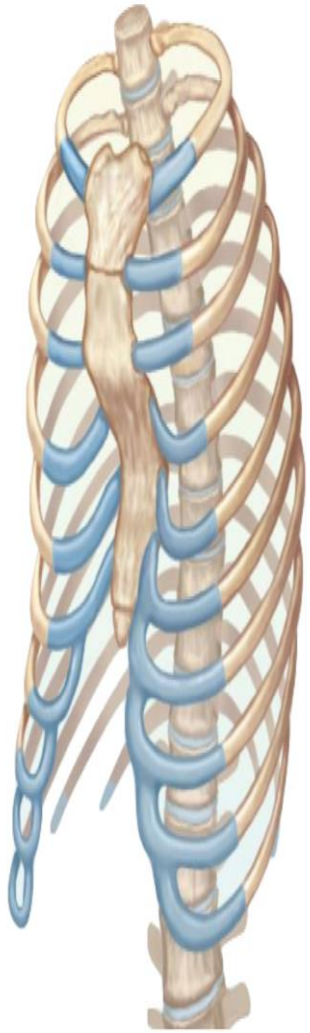
- **Intercostal Muscles (Example: Cutting intercostals during thoracotomy)**: External (inspiration), internal (expiration), innermost. Clinical example: Intercostal muscles are divided during **thoracotomy**, and must be preserved when possible to reduce postoperative pain.
- **Pectoralis Major/Minor (Example: Pectoralis flap for sternal wound)**: **pectoralis major flap** used for **sternal wound reconstruction** after cardiac surgery. **Serratus Anterior (Example: Winged scapula from long thoracic nerve injury)**: **Latissimus Dorsi (Example: Latissimus flap for chest wall defects)**: Broad muscle used in reconstruction. Clinical example: **Latissimus dorsi muscle flap** for large posterolateral chest wall tumors.

Intercostal Space & Neurovascular Bundle (VAN)

Structure: Vein (superior), artery (middle), nerve (inferior) along costal groove. Clinical example: **Chest tube insertion** must be **above the rib** to avoid damaging the neurovascular bundle. Clinical example: **Intercostal nerve block** targets the inferior border of each rib.

Congenital Deformities of the Chest Wall

- Pectus excavatum : Occurs in **1 in 300–400 births Male : Female ratio = 3–5 : 1**
- Pectus Carinatum (Pigeon Breast) : Occurs in 1 in 1,500 births→ Incidence ~0.06–0.1%Male : Female ratio = 4 : 1Often appears during rapid growth in adolescence Higher incidence in patients with scoliosis
- Poland‘s Syndrome
- Sternal defects
- Congenital bifid ribs



Pectus Excavatum

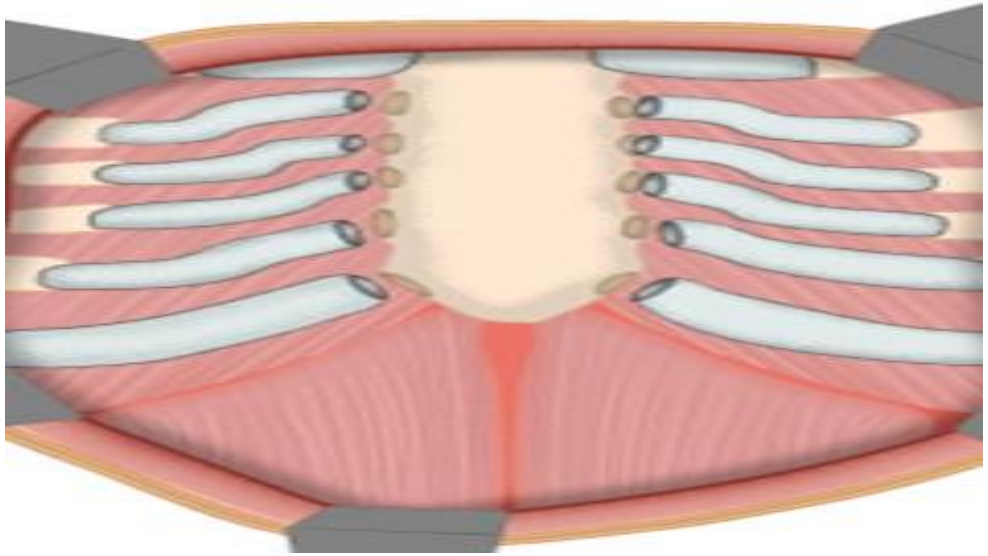
Pectus excavatum, or funnel chest, is the most common of the congenital deformities of the chest wall, accounting for 90% of the defects.

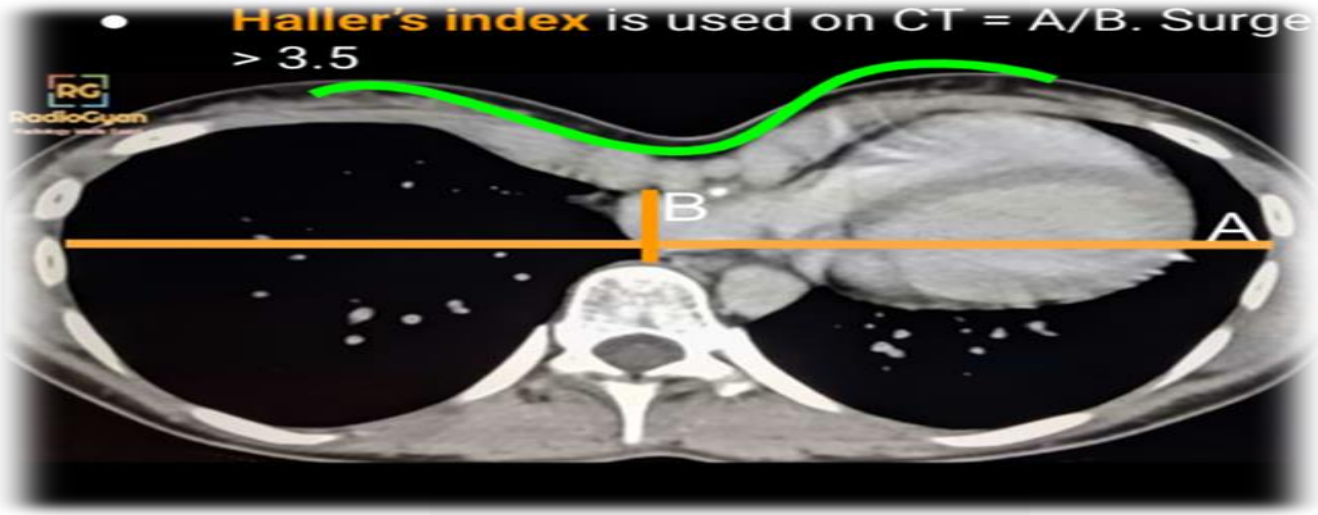
it is characterized by a concave, posteriorly displaced sternum due to overgrowth of the costal cartilages. most commonly the defect begins at the junction of the manubrium and the body of the sternum and becomes progressively deeper toward the xiphoid.

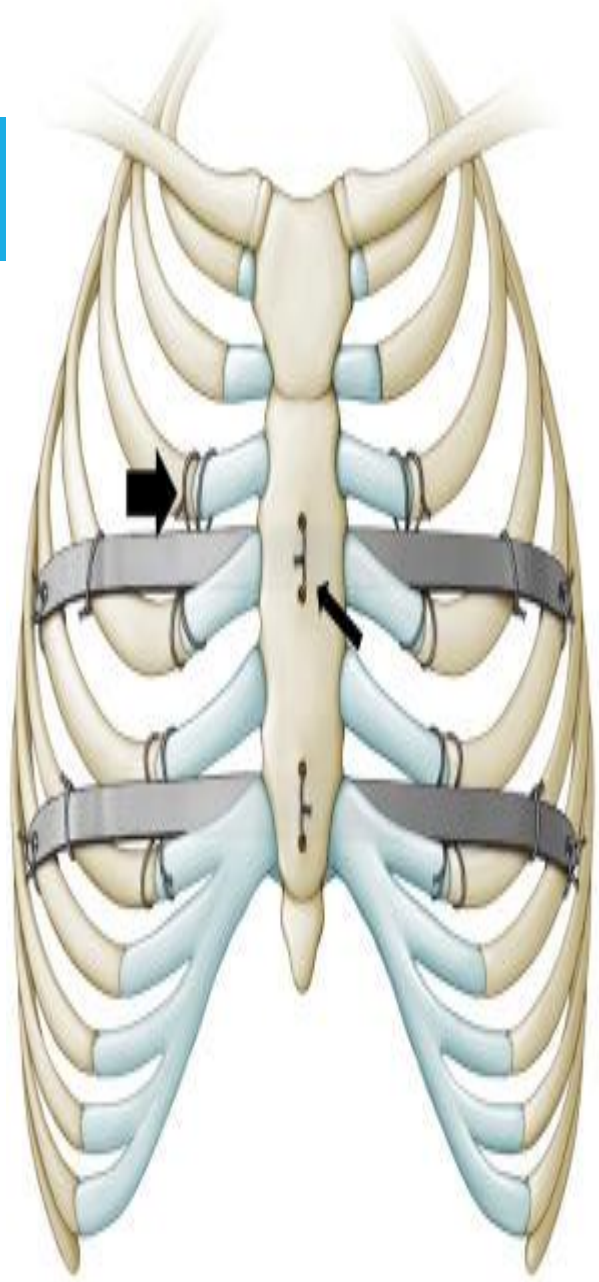
The best time of correction obtained at the age of 2-3 years. Ravitch reported a technique at 1949 ,that includes

- excision of all deformed costal cartilages , with the perichondrium
- division of the xiphoid from the sternum
- division of the intercostal bundle from the sternum
- a transverse sternal osteotomy .
- Securing the sternum in an over corrected position .

Now a minimally invasive repair of Pectus Excavatum (Nuss procedure 1998) for patients under 15-years by placing a convex steel bar under the sternum and anterior to the heart through small ,bilateral thoracic incisions. The bar left in position for 2- years before removal .




Haller's index is used on CT = A/B. Surge
> 3.5
RG
RadioGyan
B
A




AUG 23 2

Pectus Carinatum

(Pigeon Breast) Less common consists of anterior protrusion of the sternum or the chest wall ,caused by an upward curve in the lower costal cartilages , generally 4th. To 8th. Cartilages pushing the sternum forward .It is less frequent than Pectus Excavatum

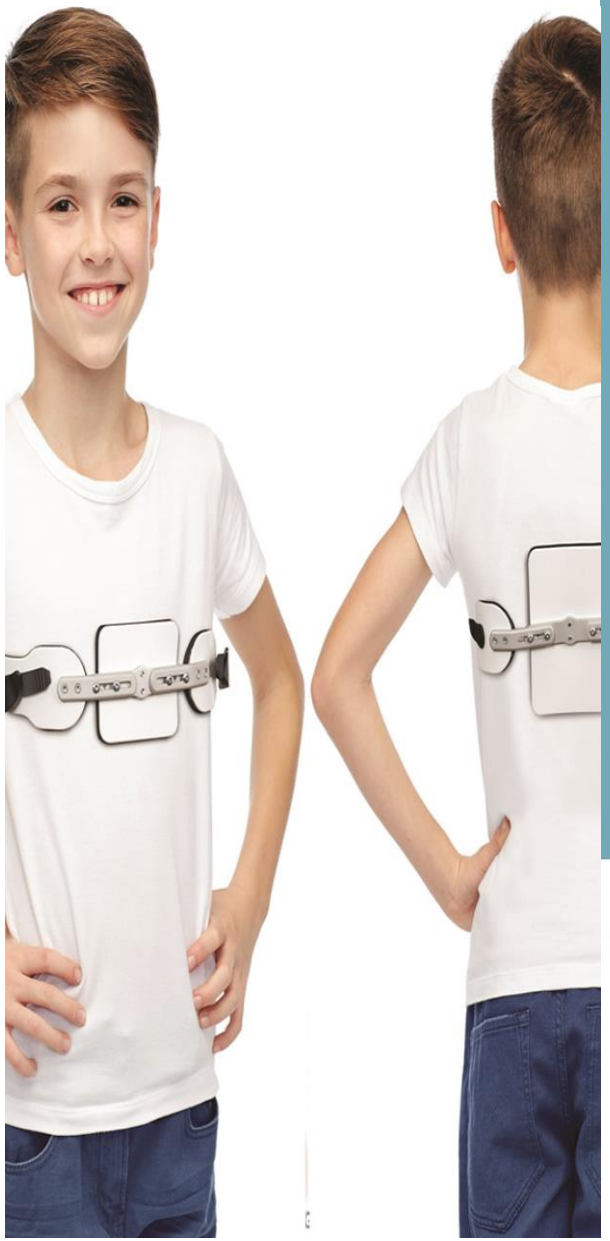
Surgery is the treatment of choice in symptomatic patients. Etiology not well understood ,

As an overgrowth of the costal cartilage , with forward bucking of the cartilages and anterior displacement of the sternum .

Increased family incidence suggests a genetic basis. More frequent in boys than girls. Scoliosis is the most common associated musculo-skeletal anomalies.

The first repair done by Ravitch in 1952 .Robicsek and associates described repair by

- sub-perichondrial resection of costal cartilage,
- transverse sternal osteotomy
- resection of the protruding lower portion of the sternum .
- The xiphoid and rectus muscles are reattached to the new lower margin of the sternum., pulling it posteriorly .
- Recent attempts at treating children with Pectus Carinatum by orthotic bracing have been reported, and success has been achieved in younger children.

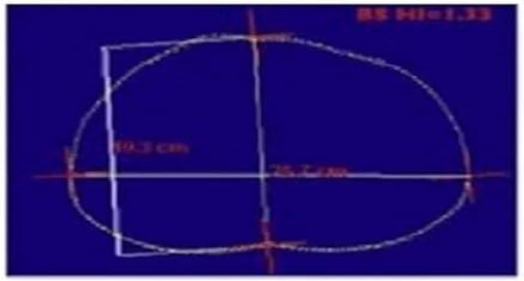


PECTUS CARINATUM ORTHOSIS BRACE TREATMENT PRINCIPLE

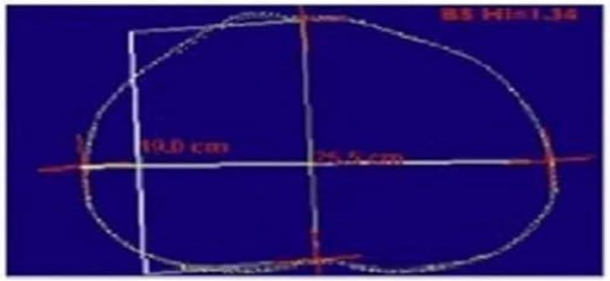
- Use the corrector to continuously exert reasonable pressure on the protruding sternum.After a period of time, the sternum can slowly return to its normal shape

- It has few side effects and basically does no harm to the skin and bone tissue of the chest.

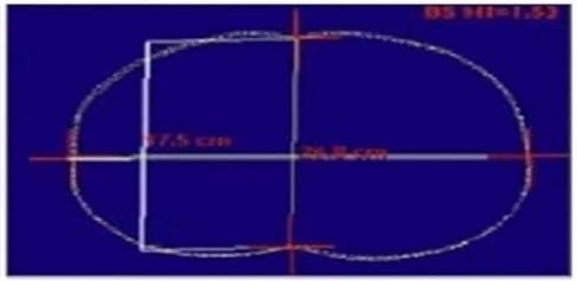
Before use



After 2 months of use



After 15 months of use



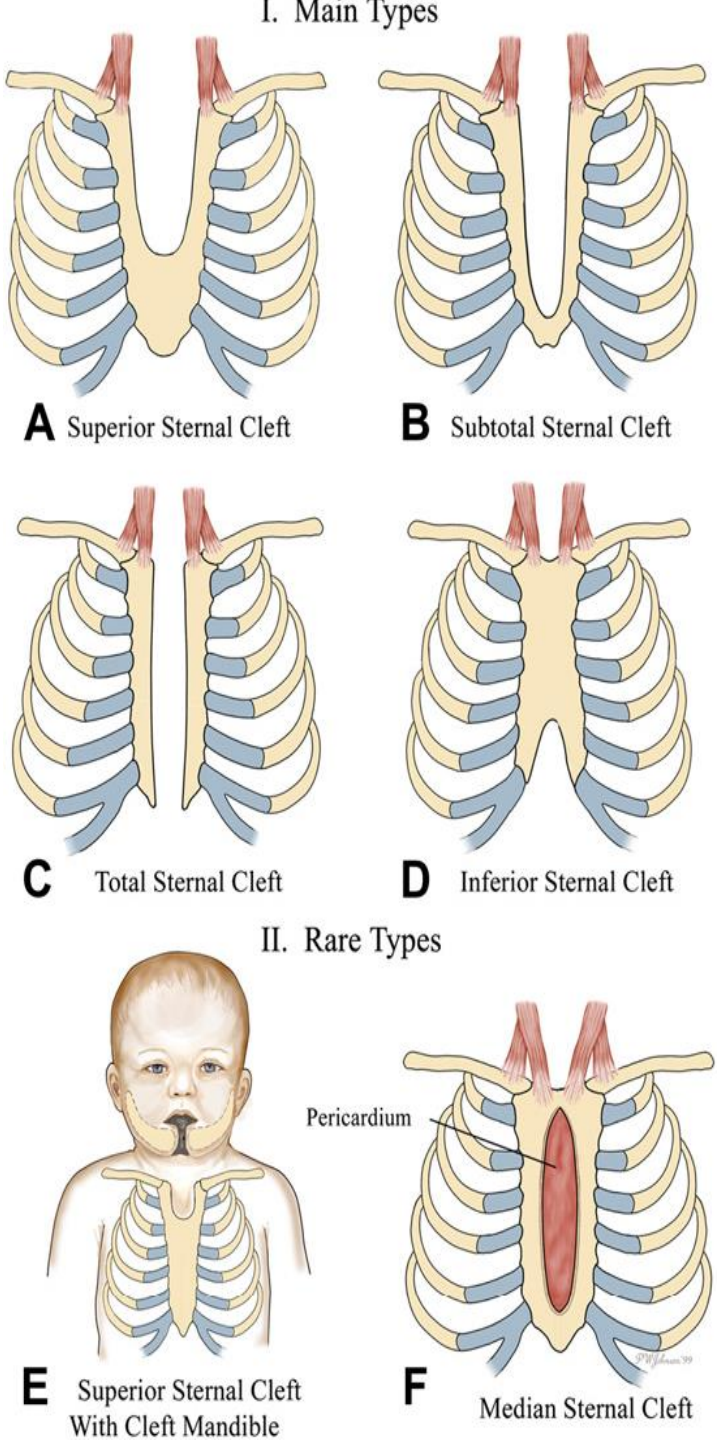
Poland‘s Syndrome

Poland was a medical student and described in 1841 a congenital absence of pectorals major and minor muscles associated with syndactyly .Subsequent reports have described other components of the syndrome , including absence of the ribs , chest wall depression , and abnormalities of the breast (from mild hypoplasia to complete absence of the breast (amastia) and nipple (athelia).

Treatment for Poland syndrome primarily involves reconstructive surgery, physical therapy, and psychosocial support to address physical deformities and improve quality of life.

Surgical Options:
reconstructive Surgery: This is the most common treatment for Poland syndr ome. It aims to correct physical deformities, particularly in the chest wall.

- **Pectoral Implants**: For men, pectoral implants can help create a more bala nced appearance. This may involve liposuction of the unaffected side and f at grafting to the affected side.
- **Fat Grafting**: This technique involves transferring fat from other parts of th e body to the affected area to improve symmetry and appearance.
- **Muscle Grafts**: In some cases, muscle grafts from other areas of the body, such as the latissimus dorsi, may be used to reconstruct the chest wall



Sternal defects

Are rare .The deformities resulting from failure of the ventral fusion of the sternum can be divided into four types :Cleft sternum , thoracic ectopia cordis , thoracoabdominal ectopia cordis , and cervical ectopia cordis. The heart is in a normal position in the cleft sternum but displaced in the other three entities.

- Cleft Sternum :-An infant with cleft sternum has a complete or partial separation of the sternum but a normally positioned intra thoracic heart .It results from failure of fusion of the sternal bars, which should occur about the 8th. Week of gestation .Normal skin covering is present , with an intact pericardium and normal diaphragm with no abdominal wall defect. An increase in the protrusion of the deformity occurs with crying or Valsalvas‘s maneuver. These patients rarely have intrinsic congenital heart disease. Repair can be done in which the cartilages are divided laterally and swung medially to cover the defect. Autologous graft of costal cartilage , split ribs , and segments of the costal arch have been used. Using prosthetic material are less satisfactory because of the risk of infection and inability of these tissues to grow with the child .It is better to treat these infants early as simple direct closure is possible.

- Congenital bifid ribs:- I have encountered few cases of congenital bifid ribs , most of them were asymptomatic and two of them were bulging and visible swelling of the chest was apparent so resected for cosmetic reasons .

Thoracic ectopia cordis

is a rare congenital condition where the heart is partially or completely outside the thoracic cavity, often associated with other severe birth defects.

Ectopia cordis is an extremely rare condition, occurring in approximately 7 out of 1,000,000 live births. It results from the failure of the chest wall to form properly during fetal development, leading to the heart being located outside the thoracic cavity, often covered only by skin or serous membrane.

Causes: The exact cause of ectopia cordis is not fully understood, but several theories exist:

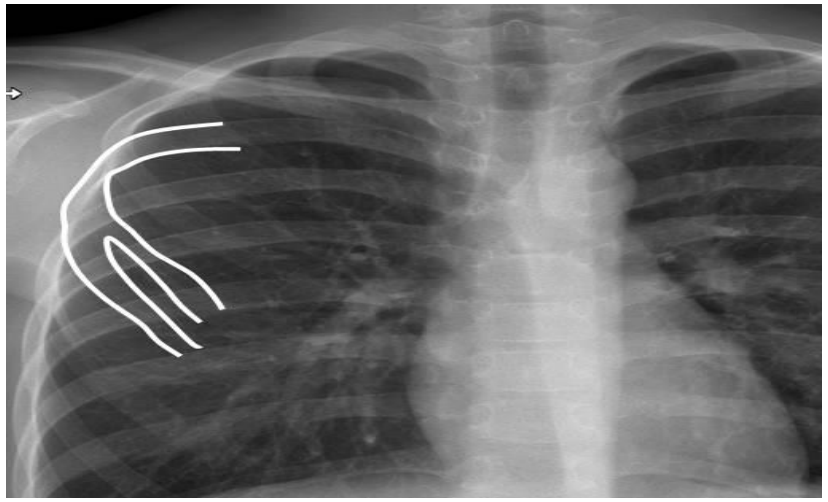
- Developmental Abnormalities: Abnormal formation of the chest and abdominal wall structures during pregnancy can lead to this condition.
- Genetic Factors: Some studies suggest that a lack of certain genes, such as BMP2, may hinder normal heart and chest development

Symptoms: The primary symptom of ectopia cordis is the heart being located outside the body. Depending on the severity, the heart may be positioned: Thoracoabdominal: Lower in the chest toward the abdomen (18% of cases). Abdominal: In the lower half of the body (15% of cases). Cervical: Near the neck (3% of cases).

Diagnosis : Ectopia cordis can often be detected during routine prenatal ultrasounds, typically in the first or second trimester. Further imaging, such as MRI or echocardiography, may be used to assess the condition and plan for delivery and treatment.

Treatment: Treatment for ectopia cordis is complex and typically involves surgical intervention.

- Surgical Repair: The primary goal is to place the heart back into the thoracic cavity and close the chest wall. This is often done in multiple stages, depending on the infant's health and the severity of associated defects.
- Multidisciplinary Care: A team of specialists, including pediatric surgeons, cardiologists, and other healthcare professionals, is essential for managing the condition and providing support to families



Congenital bifid ribs

A **bifid rib** is a congenital abnormality of the rib cage and associated muscles and nerves which occurs in about 1.2% of humans.

The sternal end of the rib is cleaved into two. It is usually unilateral.

- Bifid ribs are usually asymptomatic, and are often discovered incidentally by chest X-ray. Effects of this neuroskeletal anomaly can include respiratory difficulties

Chest wall tumors

- It includes a variety of uncommon bone and soft tissue tumors. Primary and metastatic neoplasms of both bony skeleton and the soft tissues as well as primary neoplasms that invade the thorax from adjacent structures , such as the breast , lung . pleural and mediastinum.
- Malignant lesions slightly outnumber those that are benign, and most are primary rather than metastatic.

- **INCIDENCE**

➢ The incidence of malignancy in primary chest wall neoplasms varies and ranges from 50 to 80%.

	BENIGN	MALIGNANT
	Bone Tumors	
Bone	Osteoid osteoma	Osteosarcoma
	Aneurysmal bone cysts	
Cartilage	Enchondroma *	Chondrosarcoma *
	Osteochondroma *	
	Chondroma	
Fibrous	Fibrous dysplasia	Fbrosarcomas *
Marrow	Eosinophilic granuloma	Plasmacytoma
Vascular	Hemangioma	Hemangiosarcoma
	Soft Tissue	
Adipose	Lipoma	Liposarcoma
Muscle	Leiomyoma	Leiomyosarcoma
	Rhabdomyoma	Rhabdomyosarcoma *
Neural	Neurofibroma	Neurofibrosarcoma
	Neurilemoma	Malignant schwannoma
Fibrous	Desmoid *	Fibrosarcoma

Clinical presentations

Symptoms

A. Localized Pain : Most Common Symptom Dull, aching, or sharp pain over the affected area Pain may increase with :Respiration Movement Coughing Pressure or palpation Malignant tumors typically cause more persistent and progressive pain.

B. Palpable Chest Wall Mass: Often firm, fixed, or tender mass Could be: Painless (common in benign tumors like lipoma)Painful (common in malignant tumors or those invading bone)

C. Visible Chest Wall Deformity : Local swelling or bulge Asymmetry of the chest cage Rib destruction may cause localized flattening or collapse

D. Respiratory Symptoms: Occur when a tumor compresses or invades the pleura or lung: Dyspnea Cough Wheezing Reduced chest wall expansion Pain on breathing

E. Systemic Symptoms : More common in malignancy : Weight loss Fever Fatigue Night sweats Example: Ewing sarcoma and chest wall lymphomas may present with constitutional symptoms

F. Neurological Symptoms: Especially in tumors involving intercostal nerves, brachial plexus, or spine : Radicular chest pain Numbness or sensory deficits over dermatomes Upper limb weakness (in apical/chest wall extension tumors)

Investigations aim

1. Nature of the tumor (benign vs malignant)
2. Origin (bone, cartilage, soft tissue)
3. Extent of local invasion
4. Presence of metastasis
5. Operability and surgical planning

IMAGING STUDIES

1. Chest X-Ray (CXR)

- Usually the **first imaging test**.
- Shows:
  - Rib destruction
  - Calcifications
  - Soft tissue shadow
  - Pleural involvement
- Limited in defining soft-tissue extent.

2.MRI

Superior for soft-tissue tumors, neurogenic tumors, and local spread. MRI shows : Marrow involvement Muscle and fascial plane invasion Neurovascular bundle involvement Chest wall vs pleural vs pulmonary extension Indications: Tumors near the spine Suspected brachial plexus involvement Differentiating tumor from inflammation

3. CT SCAN (CONTRAST-ENHANCED CT

Investigation of Choice Best for:

Bone detail: rib, sternum, vertebrae Detecting cortical destruction Calcification patterns Tumor relationship with: Pleura Lung Mediastinum Diaphragm Why CT is essential

Provides surgical planning and 3D reconstruction Shows involvement of intercostal vessels, nerves

4.PET-CT (FDG-PET)

Useful for:

- Distinguishing malignant vs benign lesions
- Staging sarcomas
- Detecting distant metastases
- Assessing treatment response

High SUV value → suggests malignancy.

5. Bone Scan (Technetium-99m)

Especially helpful for:

- Rib lesions
- Suspected metastases (breast, prostate, lung)
- Multifocal bony involvement

6. Tissue Diagnosis

Needle Biopsy

Core Needle Biopsy (Tru-Cut) — Gold Standard Preferred method Done under CT or US guidance Gives adequate tissue for histopathology & immunohistochemistry Minimizes contamination of surrounding tissues

Fine Needle Aspiration (FNA)Limited value Used for metastatic lesions or recurrent tumorsNot adequate for primary sarcomas

B. Incisional Biopsy Indications: Large tumors where core biopsy inconclusive Deep or infiltrative lesions Tumors requiring wide excision Principle: Biopsy incision should be placed along the future surgical resection line to avoid tumor seeding.

C. Excisional Biopsy Indications: Small, superficial soft-tissue masses Benign-appearing lesions (e.g., lipomas)Not recommended for suspected sarcomas.

7.Laboratory Tests

CBC → anemia, leukocytosis

ESR/CRP → inflammation or malignancy (non-specific)

LDH → elevated in Ewing sarcoma

Calcium/alkaline phosphatase → bone-forming tumors

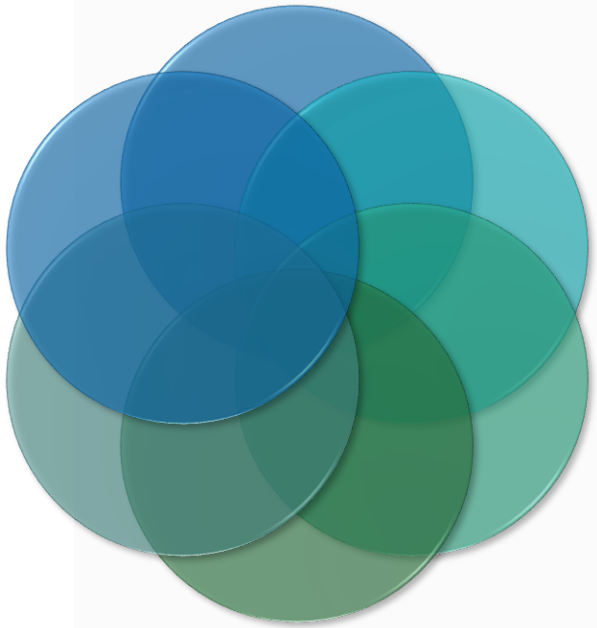
Tumor markers (optional):

- AFP, β-hCG → if germ cell tumor suspected
- SPEP → if plasma cell tumor (solitary plasmacytoma)

Surgical Management of Chest Wall Tumors

Oncologic control

Management varies for **benign** vs **malignant** tumors.



Adequate margins

Preservation of respiratory mechanics

Functional chest wall stability

Good cosmetic outcome

Indications for Surgery

A. Benign Tumors

- Symptomatic lesions
- Large or growing tumors
- Cosmetic deformity
- Diagnostic uncertainty

B. Malignant Tumors

- *Definitive treatment is surgical resection with adequate margins.*
- Primary chest wall sarcomas
- Chondrosarcoma (most common primary malignant tumor)
- Osteosarcoma
- Ewing sarcoma
- Desmoid tumor (locally aggressive)
- Metastatic tumors with isolated chest wall involvement

Principles of Surgical Resection

A. Wide Local Excision : Standard for **solid tumors**:**1–4 cm margin** of healthy tissue depending on tumor type

- Soft tissue sarcoma: **2–4 cm**
- Chondrosarcoma: **2–3 cm**
- Osteosarcoma: **wide bony margin** including entire rib segment

Include: (Involved ribs (usually 1–2 ribs above and below) , Overlying soft tissues , Adjacent pleura if invaded)

B. En Bloc Resection : All involved structures removed together: Bone (rib/sternum) Soft tissue and muscle Pleura or lung (if infiltrated) Pericardium or diaphragm (rare extensions) Avoid piecemeal dissection → prevents tumor spillage.

C. Margins and Frozen Section : Intraoperative **frozen section** may confirm tumor-free margins , Final margins determined by histopathology

3. Extent of Resection Based on Location

A. Rib Tumors: Remove involved rib plus **2–3 cm** margin, Include **adjacent ribs** if periosteal spread suspected, Resection typically involves **a full rib segment** from costovertebral to costochondral junction

B. Sternal Tumors: Partial or complete sternotomy, Requires rigid reconstruction due to risk of flail chest

C. Clavicular Tumors: Partial claviculectomy; usually no need for rigid reconstruction

D. Scapular Region: Complex resections with musculocutaneous flap coverage

Chest Wall Reconstruction

Reconstruction is required when

- Defect > **5 cm**
- More than **2 ribs** resected
- Sternal resection
- Anterior or lateral chest defects causing instability
- Large soft tissue defects → exposed lung, mediastinum, or prosthetic mesh

Goals of Reconstruction

- Maintain **rigid stability**
- Restore **respiratory mechanics**
- Protect **intrathoracic organs**
- Provide **soft tissue coverage**
- Achieve acceptable **cosmesis**

Tissue Reconstruction

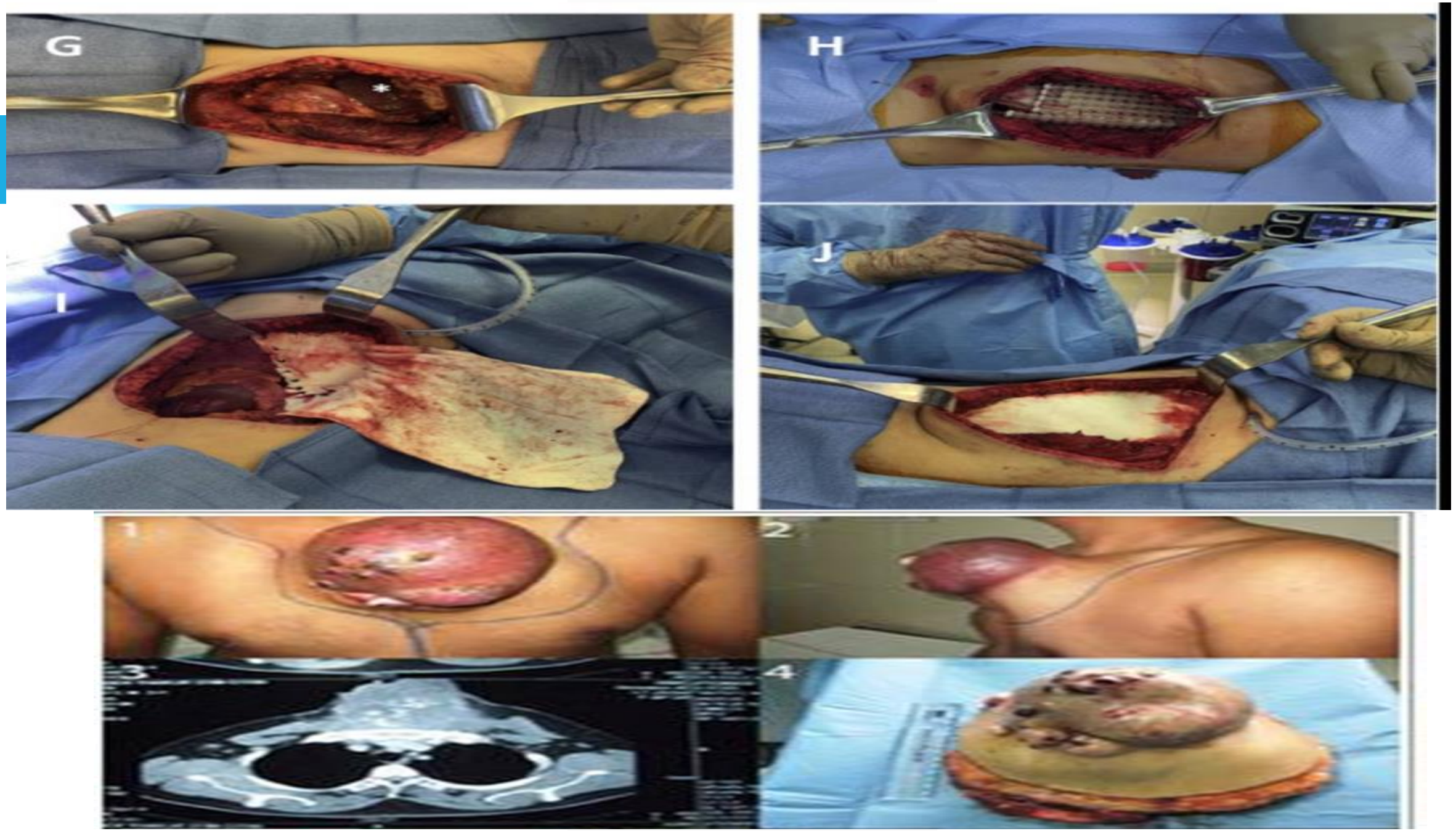
Prosthetic Mesh (Synthetic)Polypropylene mesh (Prolene)PTFE (Gore-Tex) Advantages: Easy to use Durable Allows tissue ingrowth (except PTFE)Used for : Large soft tissue support Posterolateral defects

Rigid Chest Wall Reconstruction Used for major defects or sternal reconstruction .Materials : Titanium plates Titanium rib implants Methyl methacrylate (sandwich technique) 3D-printed custom implants Indications:

ribs resected Sternal resection Anterior defects (high risk of flail chest)Large (>10 cm) defects

4. Soft Tissue Reconstruction Muscle and Myocutaneous Flaps Most commonly used

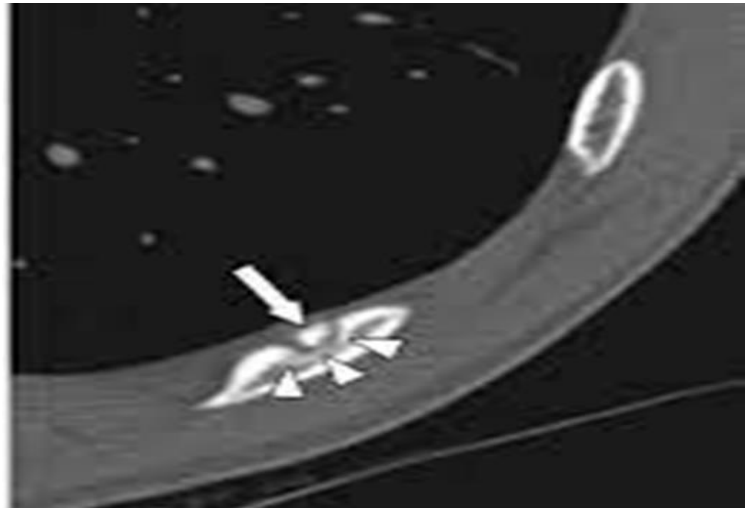
- Pectoralis major flap Anterior chest, sternum
- Latissimus dorsi flap Lateral & posterior chest
- Rectus abdominis flap Lower chest
- Trapezius flap Upper posterior chest
- Serratus anterior flap Lateral chest
- Omental Flap Excellent vascularity Used when infection risk is high Good for mediastinal and sternal defects


G
H
I
J
1
2
3
4

Osteoid osteomas

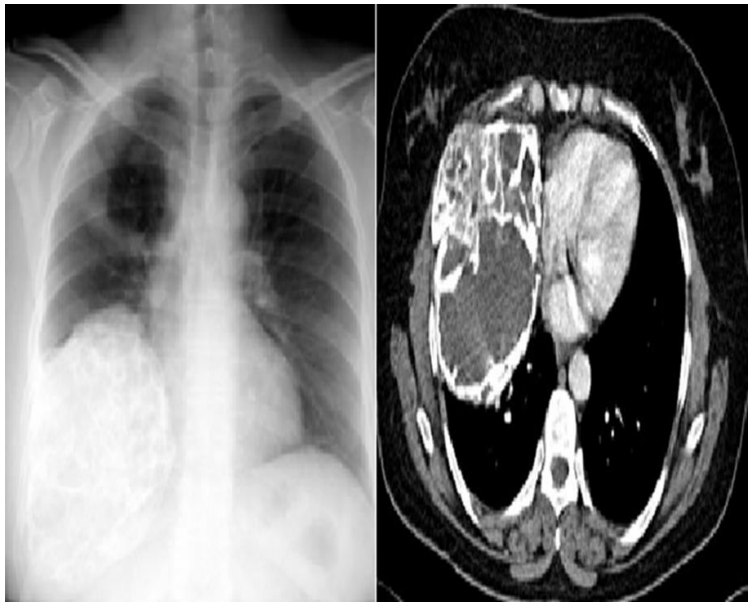
A small radiolucent nidus (typical size of <1 cm) encircled by a sclerotic margin is frequently seen on a chest radiograph.

- Resection of the entire rib is recommended.



Aneurysmal bone cysts

- a highly destructive benign bone tumor
- The term "aneurysmal" refers to the explosive, expansile nature of the bone containing the aneurysmal bone cyst, similar to the enlargement seen with blood vessel or heart aneurysms.
- Complete excision is warranted for relief of pain.



Osteochondroma

This is the most common benign bone neoplasm, constituting nearly 50% of all benign rib tumors (arise from the metaphase) .

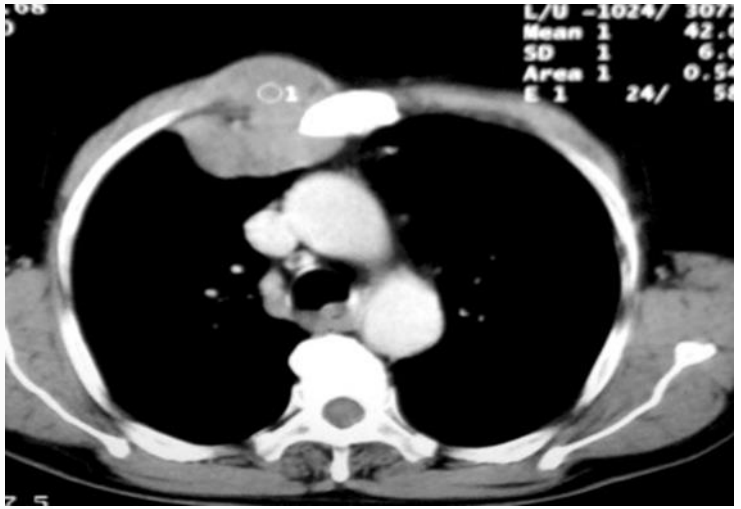
- **All osteochondromas after puberty or in adults should be resected.**
- **Asymptomatic osteochondromas may occur before puberty, but if pain or increase in size occurs, the tumour should be resected.**

Chondroma

The microscopic differentiation between a chondroma and a low-grade chondrosarcoma can be extremely difficult. All chondromas must be considered malignant and should be treated by wide excision.

Desmoid

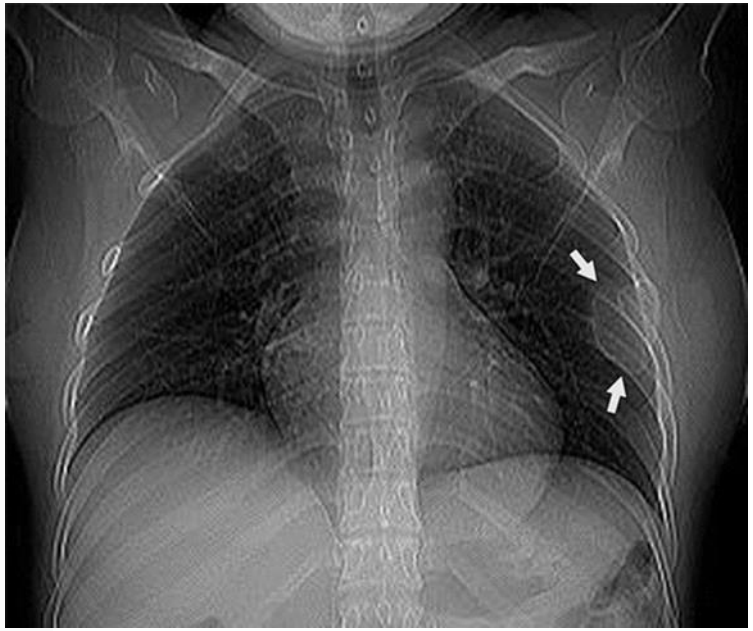
The tumour tends to be recurrent if inadequately excised and should be treated with wide resection.



Fibrous Dysplasia

Pain may develop as the tumor enlarges and causes pressure symptoms or develops pathological fracture.

Excision is indicated for symptoms relief (pain) and to confirm the diagnosis.

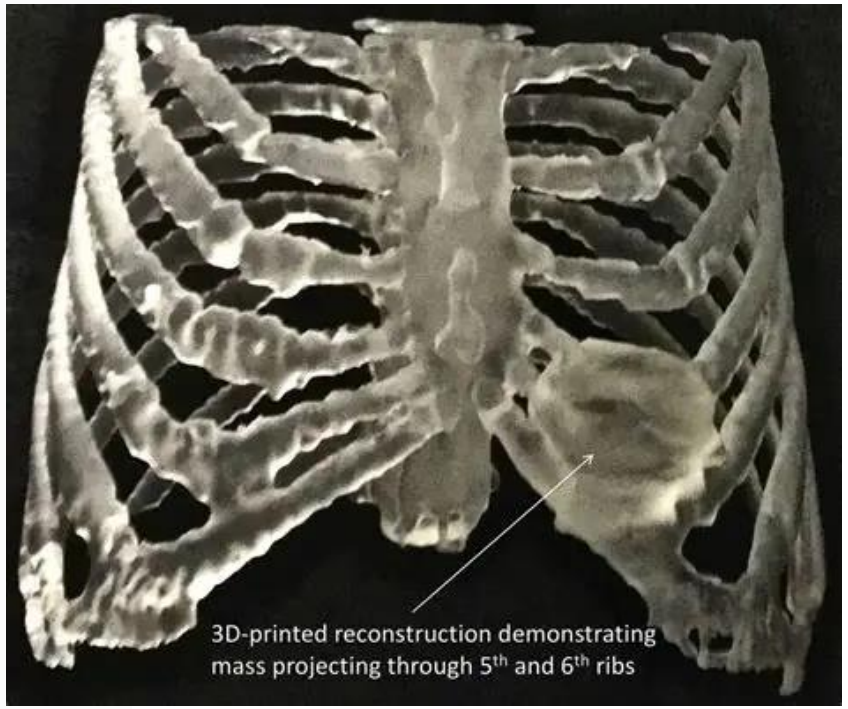


.

MALIGNANT CHEST WALL TUMORS

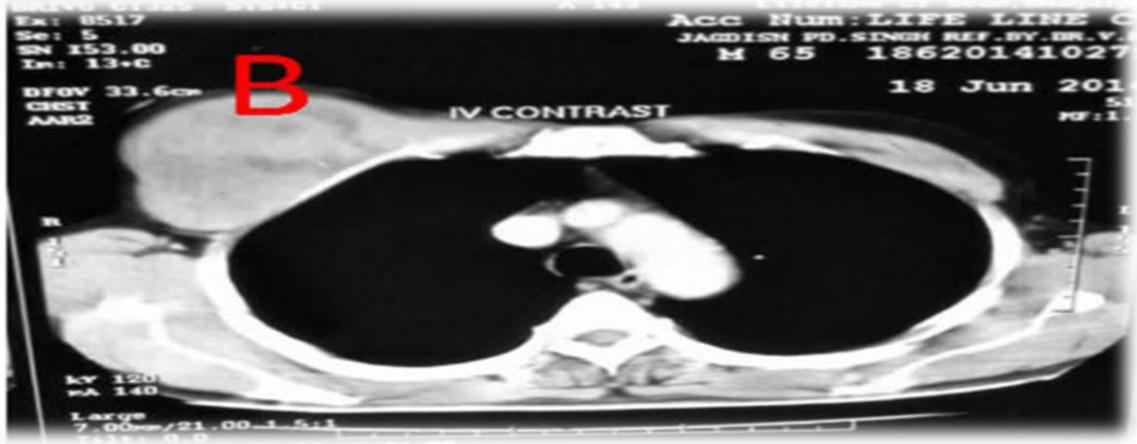
Chondrosarcoma

- *They may be associated with trauma to the chest or represent malignant degeneration of benign chondromas or osteochondromas. <u>It's the most common primary malignant tumor.</u> Wide resection on all sides results in cure in nearly all patients .*



Malignant Fibrous Histiocytoma

The neoplasm is unresponsive to both irradiation and chemotherapy and should be treated by wide resection.



Ewing's Sarcoma

Although Ewing's sarcoma is very radiosensitive, excision and chemotherapy are integral in treatment.

Osteogenic Sarcoma

The tumor is responsive to both chemotherapy and radiation therapy. Surgical resection with wide margins is appropriate for local control of disease.

Solitary plasmacytoma : *Is a rare tumor arising from plasma cells. Multiple myeloma is the same tumor arising in more than one location. More than half of patients with an apparently solitary plasmacytoma of the bone develop multiple myeloma within 10 years.*

The tumor commonly presents as pain without a mass in older men. A diffuse, punched-out appearance of the bone caused by myelogenous deposits is seen on chest radiography. Systemic disease can be confirmed using serum protein electrophoresis, calcium levels, urinalysis (Bence Jones protein), and bone marrow aspiration. If the results of these studies are negative, then a solitary plasmacytoma is diagnosed. Incisional biopsy frequently is used to confirm the diagnosis, although a solitary plasmacytoma is resected completely. Radiotherapy is the primary mode of therapy, with a 5-year survival of 30% reported.

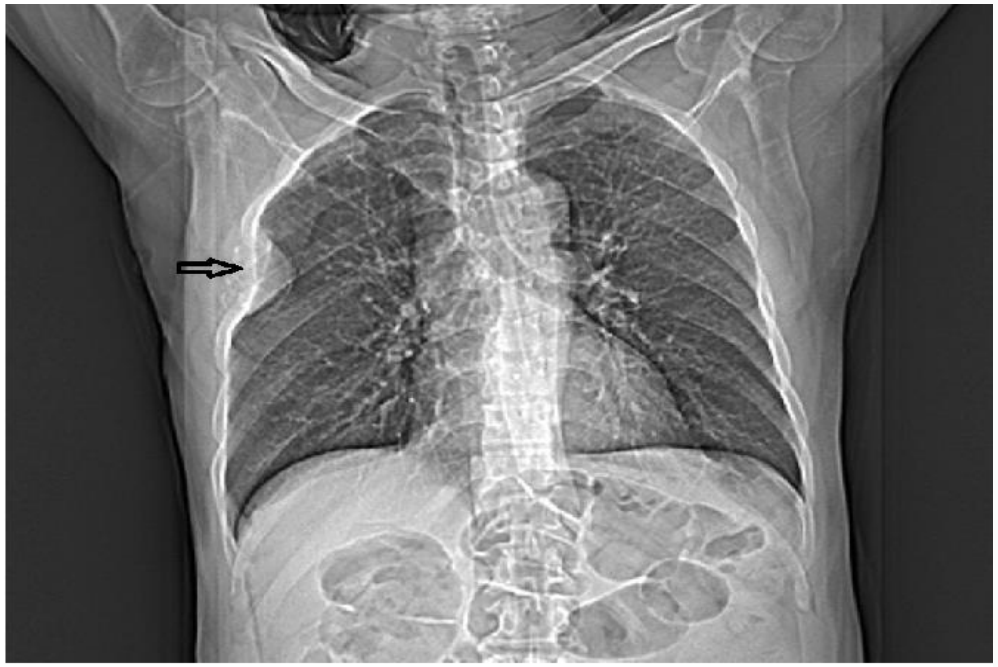
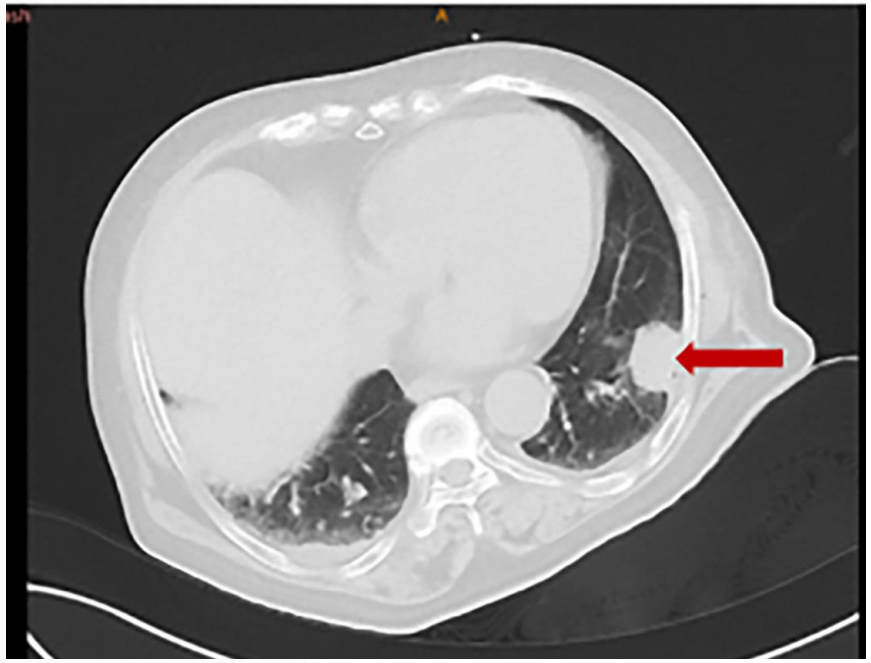


Figure 1. Chest radiograph of the patient, arrow shows the chest wall tumor origi-



Thank you

QUESTIONS?