Diaphragm

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- A dome-shaped musculofibrous septum that separates *the thoracic* and *peritoneal* cavities.
- The diaphragm is the most important muscle of respiration.
- It is dome shaped and consists of *a peripheral muscular part*, which arises from the margins of the thoracic opening, and *a centrally placed tendon*.

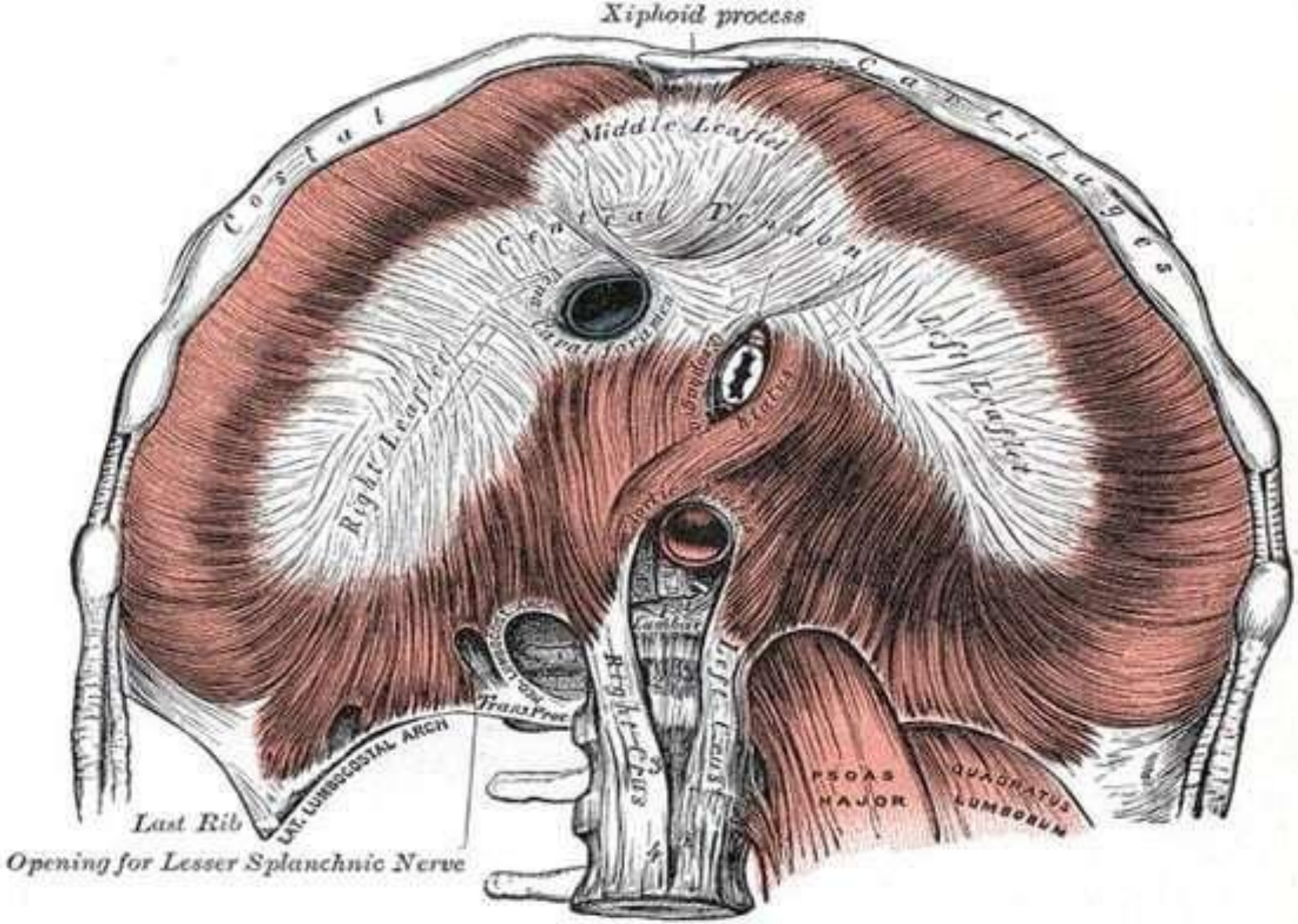
- The origin of the diaphragm can be divided into three parts:

A sternal part arising from the posterior surface of *the xiphoid process*

A costal part arising from the deep surfaces of *the lower six ribs and their costal cartilages*

A vertebral part arising by vertical columns or crurae and from the arcuate ligaments

- The right crus arises from the bodies of *the first 3 lumbar vertebrae* and *the intervertebral discs*.
- The left crus arises from the bodies of *the first 2 lumbar vertebrae* and *the intervertebral discs*.
- The medial borders of the two crura are connected by a median arcuate ligament.
- The medial arcuate ligament extends from the side of *the body of the second lumbar vertebra* to *the tip of the transverse process of the first lumbar vertebra*.
- The lateral arcuate ligament extends from *the tip of the transverse process of the first lumbar vertebra* to *the lower border of the 12th rib*.



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Openings in the Diaphragm

- ***The aortic opening*** lies anterior to the body of the 12th thoracic vertebra between the crura. It transmits the aorta, the thoracic duct, and the azygos vein.

- ***The esophageal opening*** lies at the level of the 10th thoracic vertebra in a sling of muscle fibers derived from the right crus. It transmits the esophagus, the right and left vagus nerves, the esophageal branches of the left gastric vessels, and the lymphatics from the lower third of the esophagus.

- ***The caval opening*** lies at the level of the eighth thoracic vertebra in the central tendon. It transmits the inferior vena cava and terminal branches of the right phrenic nerve.

Openings in the Diaphragm

- *The sympathetic splanchnic nerves* pierce **the crura**.
- *The sympathetic trunks* pass posterior to **the medial arcuate ligament** on each side.
- *The superior epigastric vessels* pass between **the sternal and costal origins** of the diaphragm on each side

Openings in the Diaphragm

- On each side of the diaphragm there are small areas where the muscle fibres are replaced by areolar tissue.

1- Between the sternal and costal parts → the superior epigastric branch of the internal thoracic artery and some lymph vessels from the abdominal wall and convex surface of the liver.

2- Between the costal part and the fibres that spring from the lateral arcuate ligament → the posterosuperior surface of the kidney is separated from the pleura only by areolar tissue. (e.g **Postnephrectomy pneumothorax)**

VASCULAR SUPPLY

- The lower five intercostal and subcostal arteries supply the costal margins of the diaphragm
- the phrenic arteries supply the main central portion of the diaphragm.
- *The phrenic veins*

The right phrenic vein ends in the inferior vena cava

The left phrenic vein is often double: one branch ends in the left renal or suprarenal vein, the other passes anterior to the oesophageal opening to join the inferior vena cava

Embryologic note

- **The diaphragm is formed from the following structures:**

a) the septum transversum, which forms *the muscle* and *central tendon*

(b) the two pleuroperitoneal membranes, which are largely responsible for the peripheral areas of *the diaphragmatic pleura and peritoneum* that cover its upper and lower surfaces, respectively

(c) the dorsal mesentery of the esophagus, from which *the crura* develop.

Embryologic note

- The septum transversum is *a mass of mesoderm* that is formed in **the neck** by the fusion of the myotomes of *the third, fourth, and fifth cervical segments*.
- With the descent of the heart from the neck to the thorax, the septum is *pushed caudally*, pulling its nerve supply with it; thus, its motor nerve supply is derived from *the third, fourth, and fifth cervical nerves*

- The central pleura on the upper surface of the diaphragm and the peritoneum on the lower surface are also formed from the septum transversum, which explains their sensory innervation from the phrenic nerve.

- The sensory innervation of the peripheral parts of the pleura and peritoneum covering the peripheral areas of the upper and lower surfaces of the diaphragm is from the lower six thoracic nerves.

Applied Anatomy

❖ Hiccup

- *Involuntary spasmodic contraction* of the diaphragm accompanied by the approximation of the vocal folds and closure of the glottis of the larynx.

- Normal individuals and occurs after eating or drinking as a result of *irritation* of the vagus nerve endings

- Disease such as pleurisy, peritonitis, pericarditis, or uremia.

Applied Anatomy

- Paralysis of the Diaphragm

- Crushing or sectioning of the phrenic nerve in *the neck* e.g during neck dissection → Paralysis of the ipsilateral cupola.
- Treatment of certain forms of lung tuberculosis, when the physician wishes to rest the lower lobe of the lung on one side.

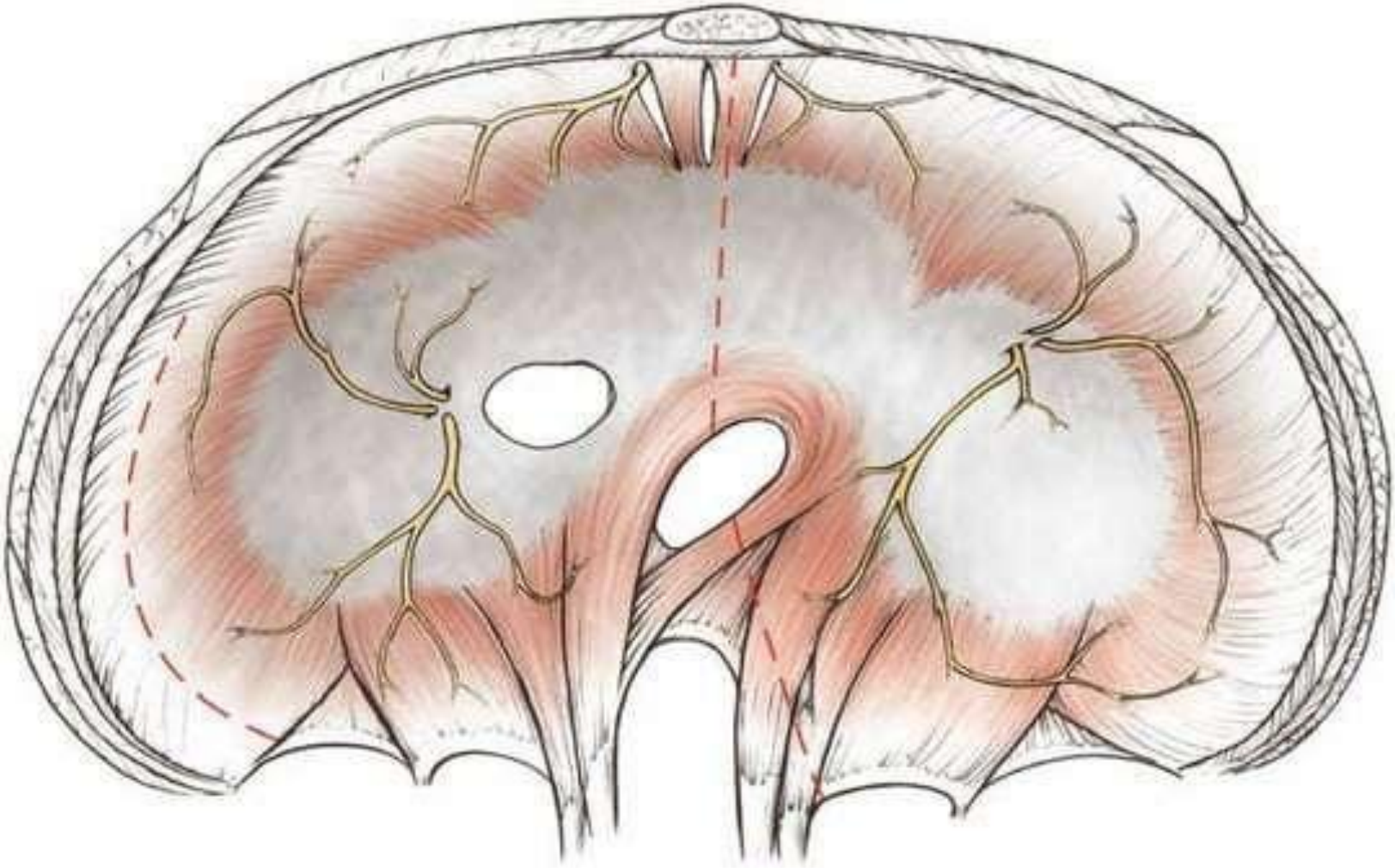
- The accessory phrenic nerve (C5)

- Occasionally, the contribution from the fifth cervical spinal nerve joins the phrenic nerve **late** *as a branch from the nerve to the subclavius muscle*.

Applied Anatomy

- Because of the topography of the phrenic nerves, when *incision of the diaphragm* is required to expose organs in the pleura or peritoneal cavity, a radial incision from the hiatus to the posterior chest wall or to the paraxiphoid region, or a curvilinear incision about 2 cm from the diaphragmatic attachment to the ribs, will result in *the least impairment of diaphragmatic function*.

Applied Anatomy



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Applied Anatomy

Carcinoma of the Diaphragm

Although diaphragmatic tumors can be *primary* or *secondary*, the majority of malignant tumors are either due to direct extension from a neighboring organ or distant mestatases.

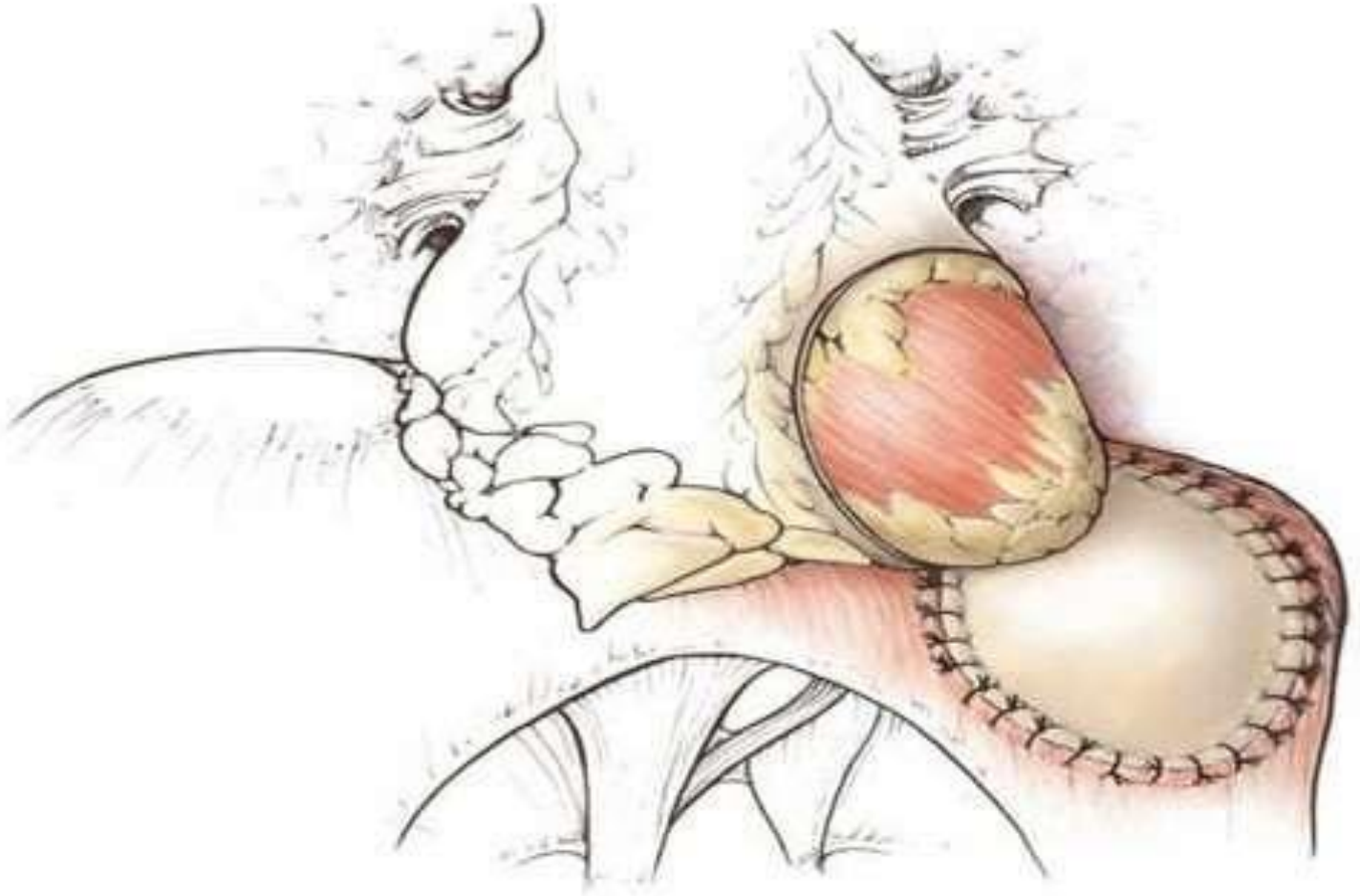
Primary tumors may be *benign* or *malignant*, but all secondary tumors are malignant.

Neurofibromas, *lipomas*, *angiofibromas*, and *mesothelial cysts* are the most common *benign tumors*, and **sarcomas** are the main malignant tumors.

Applied Anatomy

- Local excision of *benign* tumors and wide resection of *malignant* tumors.
- *Lateral decubitus* position, the diaphragm is exposed either through a posterolateral thoracotomy at *the seventh intercostal space* or utilizing a thoracoscopic approach.
- The *malignant tumors* are removed along with 3 cm margins.
- For large diaphragmatic defects, *a mesh prostheses* such as **Gortex** is used. *Pedicled autologous* tissue such as **muscle** or preferably **pericardium** may also be used in selected cases.

Applied Anatomy



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Diaphragmatic Herniae

- Congenital
- Acquired

Congenital Diaphragmatic Herniae

- Posterolateral (Bochdalek)

- Subcostosternal (Morgagni) →

  Uncommon

  Defect in the anterior diaphragm just lateral to the xiphoid process

  Asymptomatic

- Oesophageal (Hiatal) → Rarely Congenital

  Mostly Aqcuired

posterolateral (Bochdalek) hernia

- Defect in the posterior diaphragm in the region of *the tenth or eleventh ribs*.
- More common on *the left*
- Presents with abdominal contents in the left hemithorax at birth
- Hypoxaemia and respiratory failure at birth.

  N.B → The Lumbocostal triangle or Bochdalek's foramen is a defect in the diaphragm normally posterior lateral. It is formed by *the incomplete closure of the pericardioperitoneal canals* by the pleuroperitoneal membrane.

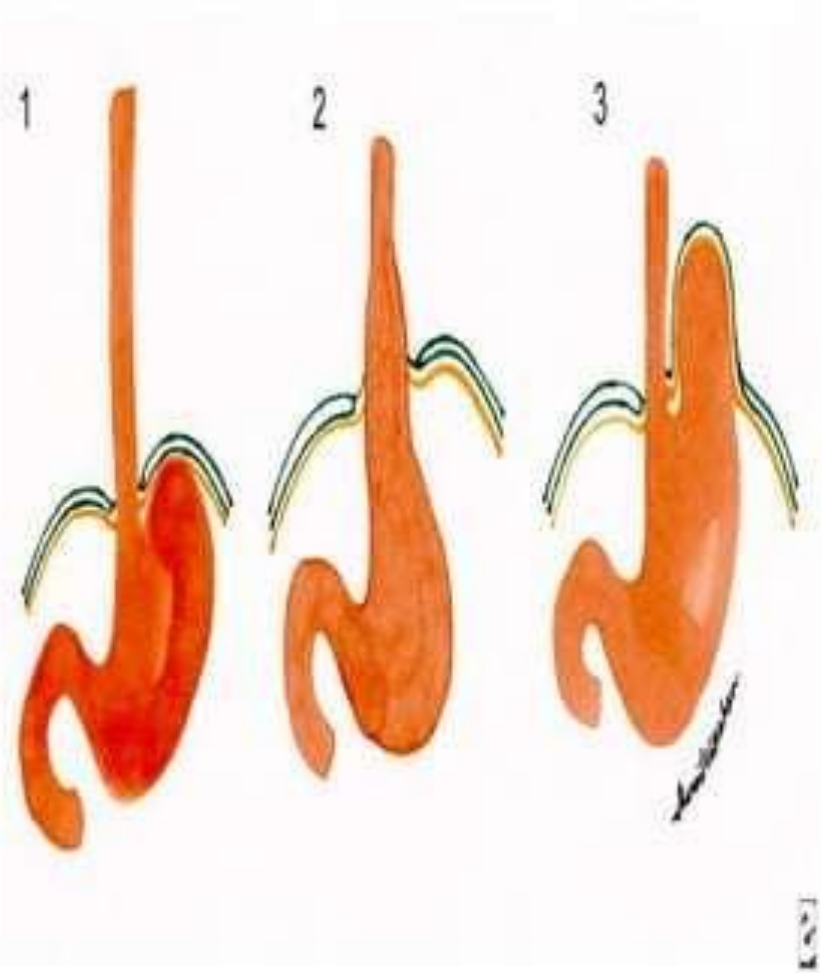
Acquired Diaphragmatic Herniae

- **Sliding, or type I, hiatus hernia** There is laxity of the phreno-oesophageal membrane, which allows the gastro-oesophageal junction to slide into the thorax.(Reflux)

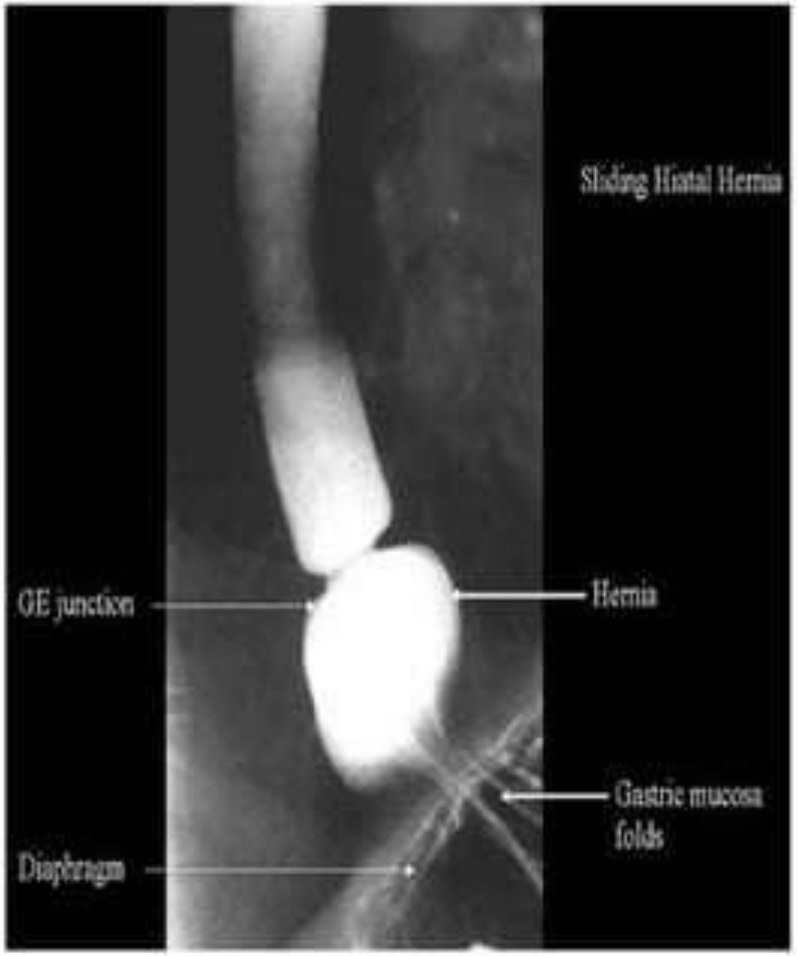
- **Para-oesophageal, or type II, hiatus hernia**: When the stomach herniates into the thorax alongside the oesophagus. (NO reflux)

- **Mixed, or type III:** Both conditions are present

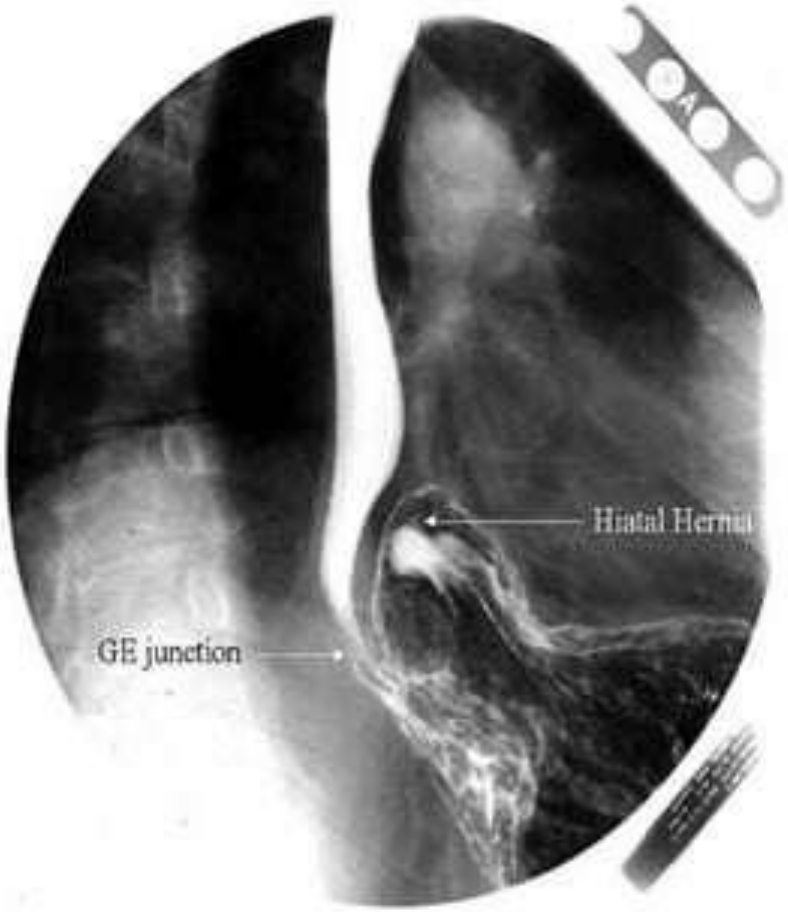
Diaphragmatic herniae

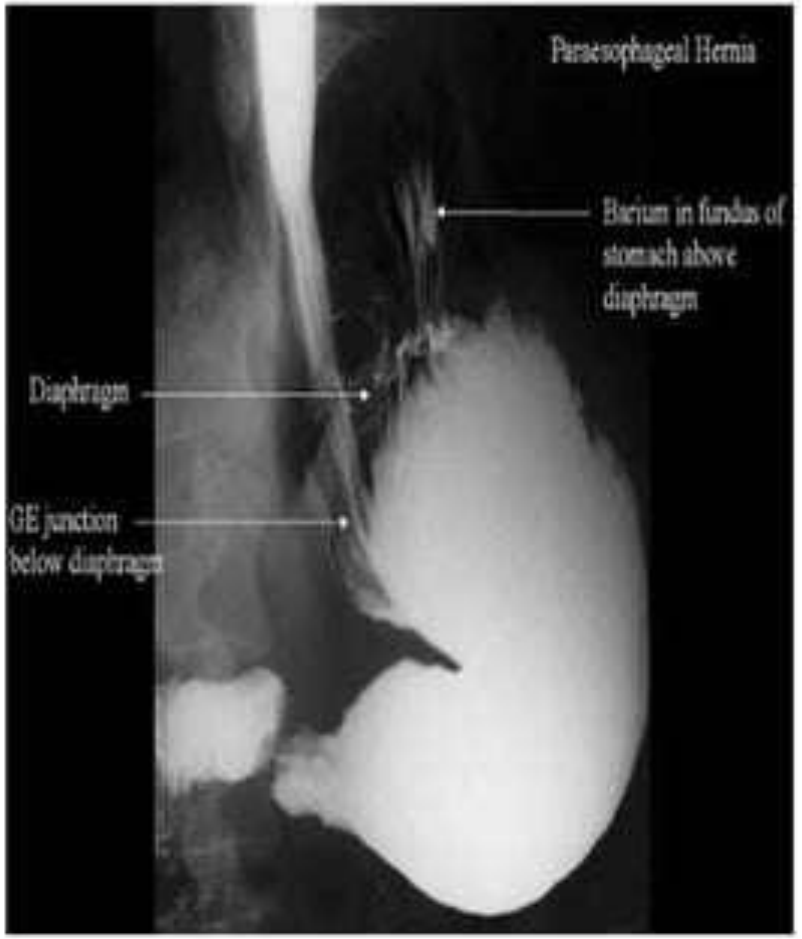


sliding Oesophageal hernia Ba study



Paraesophageal Herniae Ba study





Surgical Management

- **Indications:**

1-Young patients with severe or recurrent complications of GERD, such as strictures, ulcers, and bleeding.

2- Cannot afford *lifelong PPI treatment*

3- Prefer to avoid taking medications long term

4- *Pulmonary complications*, in particular, asthma, recurrent aspiration pneumonia, chronic cough, or hoarseness linked to reflux disease.

5-Paraesophageal herniae : A significant proportion of patients with this type of hernia develop incarceration of the hernia and possible gastric volvulus, which can lead to perforation.

Types of surgery

- Nissen fundoplication 360 degree
- Belsey (Mark IV) fundoplication 270 degree
- Hill repair

N.B → **DeMeester et al** found the Nissen procedure superior to the Belsey and Hill repairs with regard to symptom relief and prevention of reflux postoperatively (as judged by pH monitoring).

Thank You