

# Adrenal Glands

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# Anatomy

# Adrenal Gland

Anatomy was first described in 1563.

Is located above (or attached to) the upper pole of the kidney.

Is pyramidal in structure and weighs ~ 4 g.

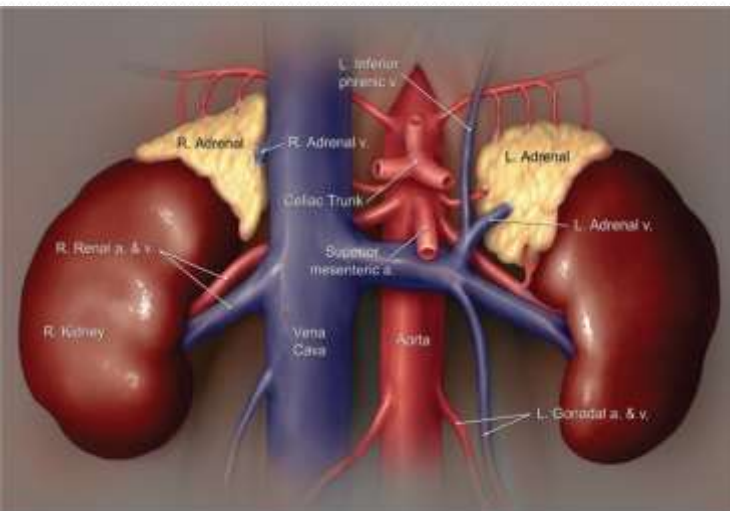
Consists of the adrenal cortex and adrenal medulla

Activities are regulation of fluid volume and stress response

# Adrenal Gland

- Blood supply
  - Arterial - receives 7cc/gram minute
- arterial sources of flow:
  1. Inferior phrenic artery
  2. Aorta
  3. Renal artery
- Venous – single main vein most important surgical structure

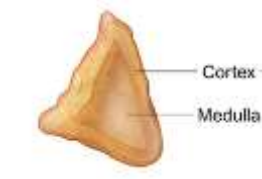

- right → post IVC
- left → renal vein



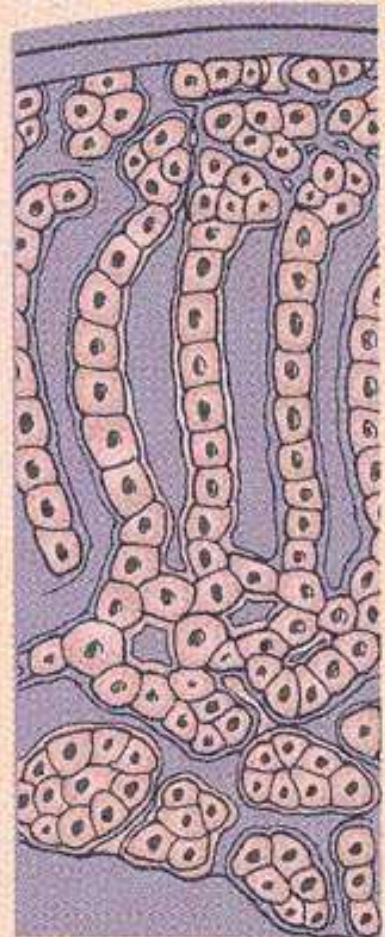
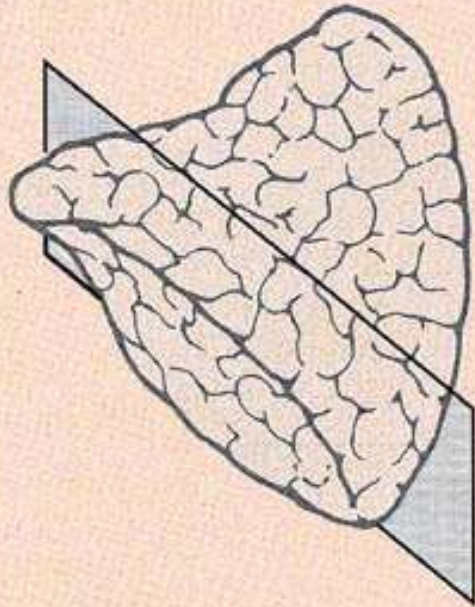
# Adrenal Gland

- Cortex - mesoderm
- Medulla - neuroectoderm
- Renal agenesis, found in normal anatomic position
- Size- 5 x 3 x 1 x 5 cm
- Retroperitoneal structure, contained in its own sub-compartment w/in Gerota's fascia

## Comparison between Rt. & Lt. Suprarenals

Right Suprarenal	Left Suprarenal
	
Triangular (pyramidal)	Crescentic (semilunar)
Does NOT reach the hilum of the right kidney	Reaches the hilum of the left kidney
The hilum is directed upwards	The hilum is directed downwards
Its vein is short and drains to the IVC	Its vein is long and drains to the left renal vein.

Cross section through adrenal gland



Zones	Main secretory product
Capsule	
Glomerulosa	Aldosterone
Fasciculata	Cortisol
Reticularis	Androgens
Medulla	Epinephrine Norepinephrine

# Physiology



## **MINERALOCORTICOIDS**

- ❖ Electrolyte metabolism.
- ❖ Act principally on the renal tubular and gastrointestinal epithelium .
- ❖ Helps in re-absorbtion of sodium & excretion of potassium.

## **GLUCOCORTICIDS**

Increases blood glucose levels by:

- ❖ Glucose metabolism.
- ❖ Protein & fat metabolism.
- ❖ Gluconeogenesis.

# Cortisol

- A glucocorticoid
- Frequently referred to as the ‘stress hormone’
  - Released in response to physiological or psychological stress
  - Examples: exercise, illness, injury, starvation, extreme dehydration, electrolyte imbalance, emotional stress, surgery, etc.

# Cortisol

- Critical actions on many physiologic systems, including:
  - Maintains cardiovascular function
  - Provides blood pressure regulation
  - Enables carbohydrate metabolism
    - acts on the liver to maintain normal glucose levels
  - Immune function actions
    - Reduces inflammation
    - Suppresses immune system

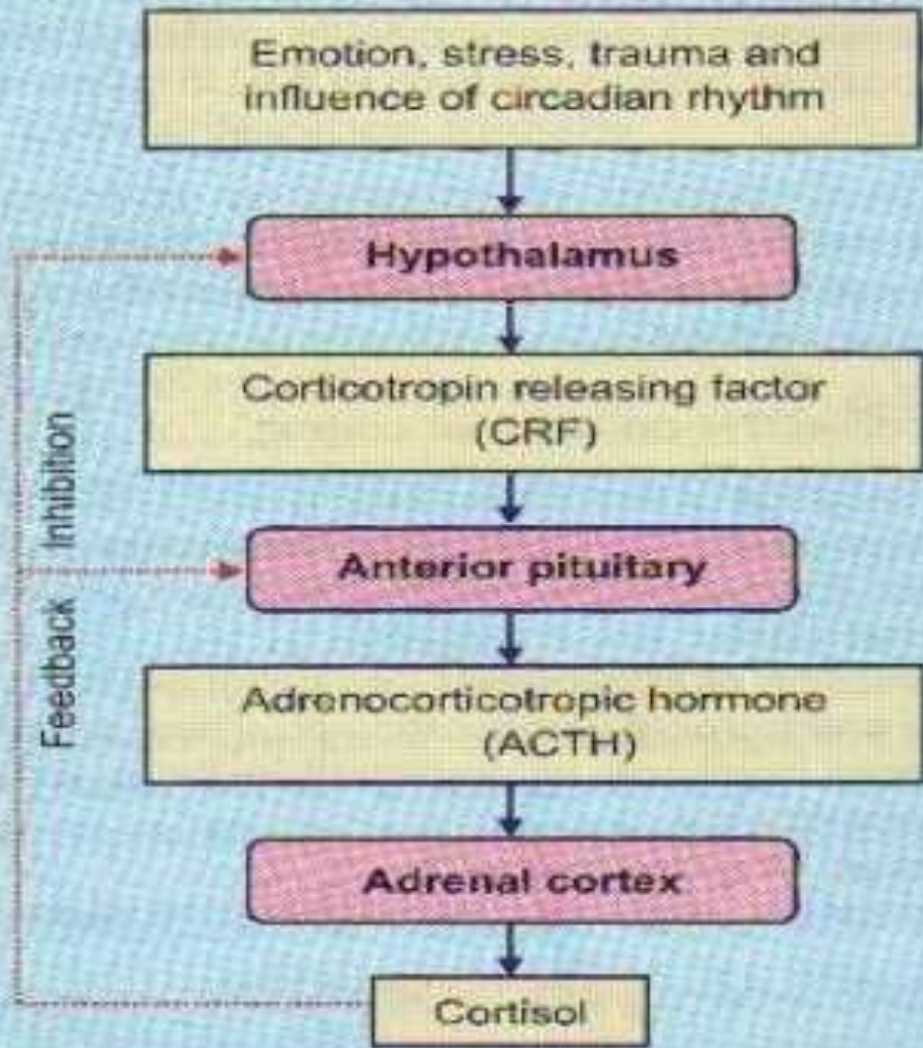
# Cortisol

- When cortisol is not produced or released by the adrenal glands, humans are unable to respond appropriately to physiologic stressors
- *Rapid deterioration* resulting in organ damage and shock/coma/death can occur, especially in children

## **ADRENAL SEX HORMONES (ANDROGENS)**

- ❖ Probably have little effect in normal amounts.
- ❖ Exert effects similar to those of male sex hormones.
- ❖ When in excess, cause masculinization.

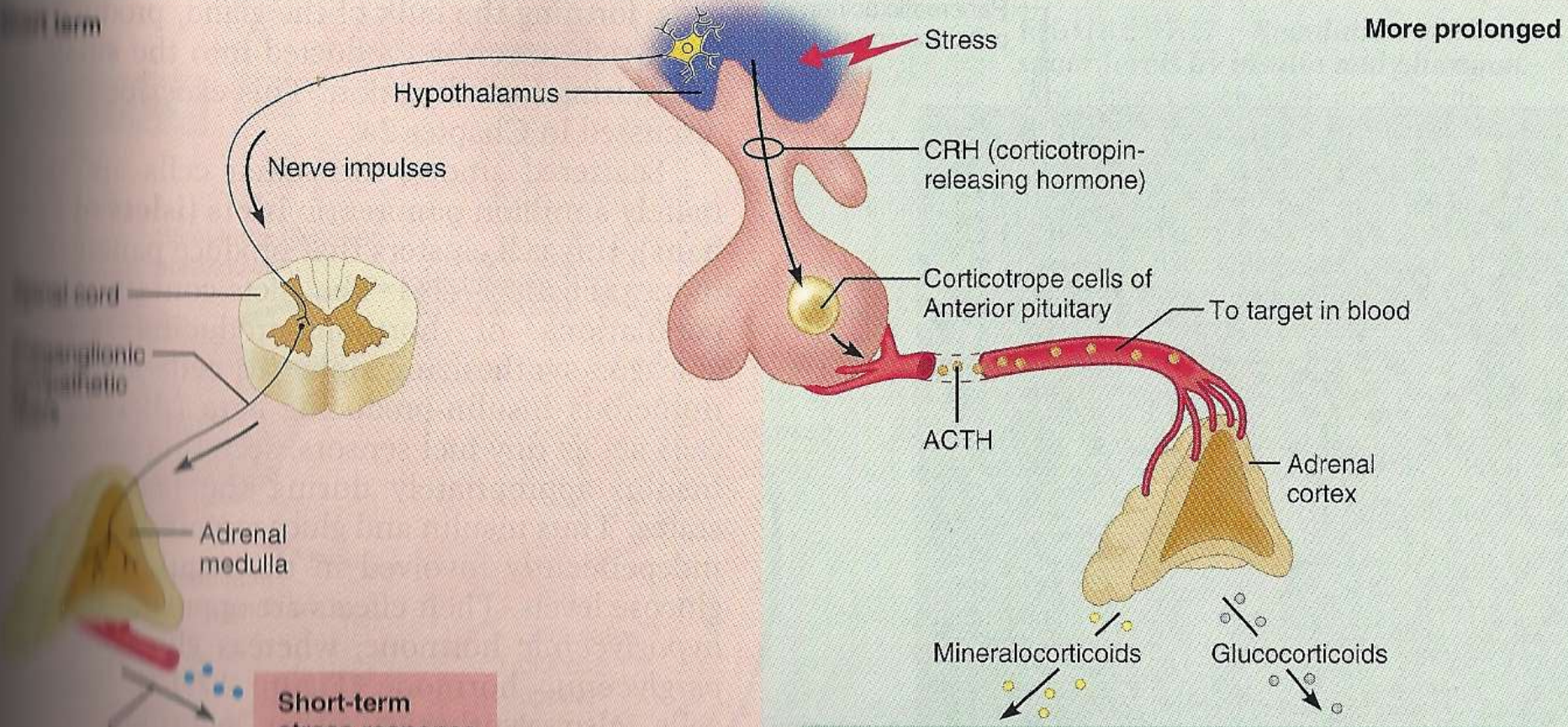




Regulation of cortisol secretion

Short term

More prolonged



**Short-term stress response**

1. Increased heart rate
2. Increased blood pressure
3. Liver converts glycogen to glucose and releases glucose to blood
4. Dilation of bronchioles
5. Changes in blood flow patterns leading to increased alertness, decreased digestive system activity, and reduced urine output
6. Increased metabolic rate

**Long-term stress response**

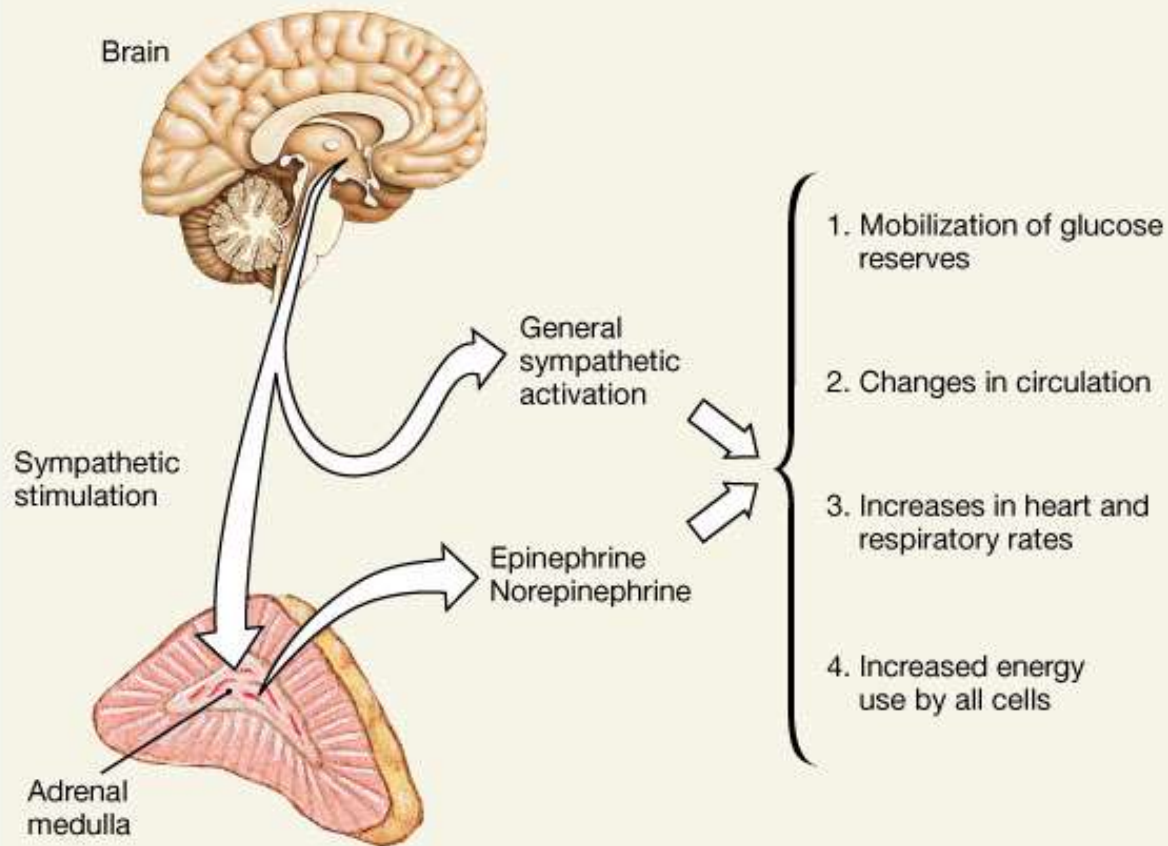
- |   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. Retention of sodium and water by kidneys</li> <li>2. Increased blood volume and blood pressure</li> </ol> | <ol style="list-style-type: none"> <li>1. Proteins and fats converted to glucose or broken down for energy</li> <li>2. Increased blood sugar</li> <li>3. Suppression of immune system</li> </ol> |
|---|--|



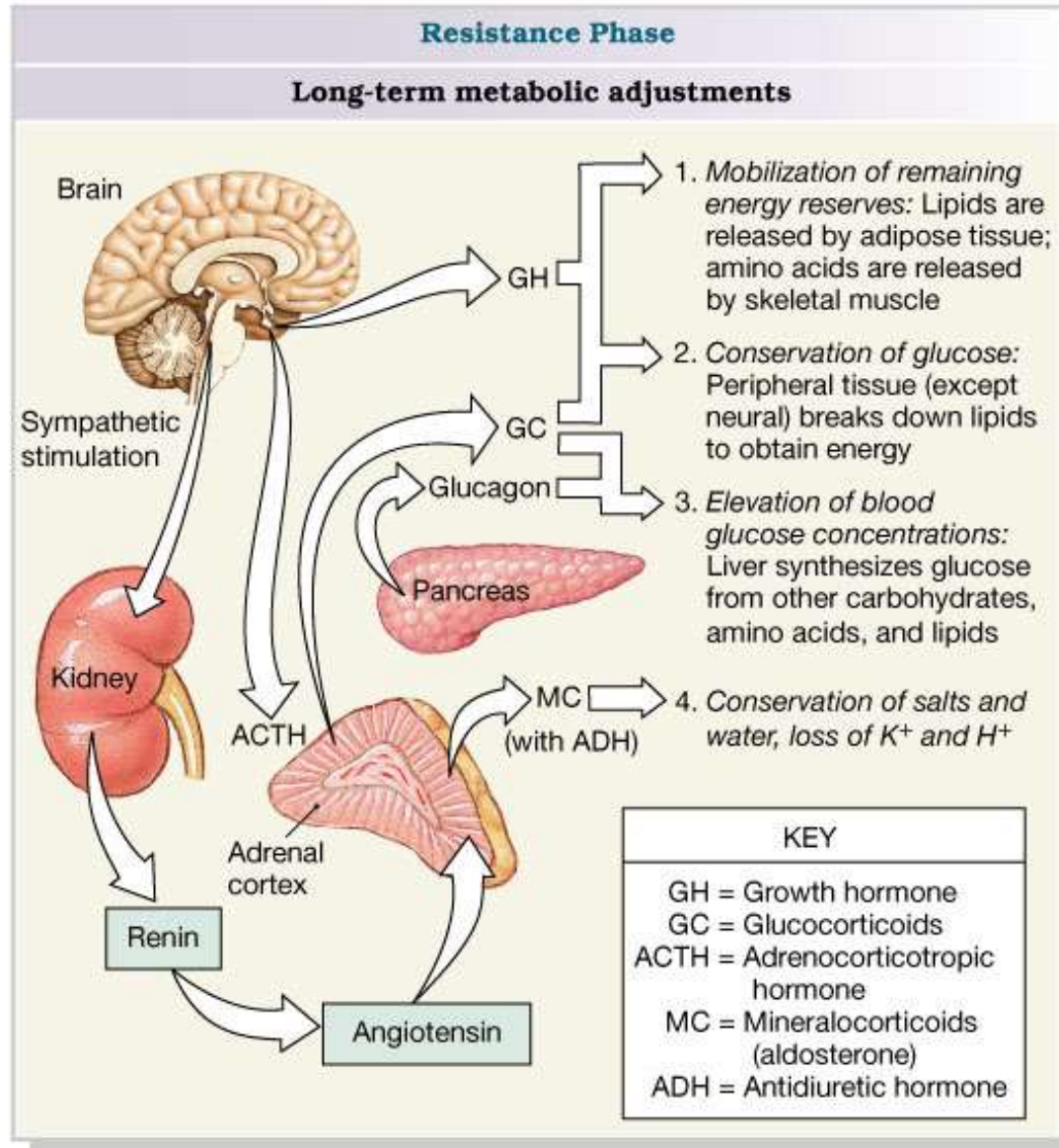
# The General Adaptation Syndrome

## Alarm Phase

**"Fight or Flight"**  
Immediate short-term responses to crises



# The General Adaptation Syndrome



# Disorders of the adrenal gland

# Disorders of Adrenal glands:

- **A- Abnormal anatomy:** ( diffuse or localized swelling)
- **B- Abnormal physiology:** ( hyper or hypo secretion of hormones)

# Neoplasms arising from cortex and metastases

- Adenoma
- Carcinoma
- Myelolipoma
- Metastatic carcinoma

# Cortical Adenoma

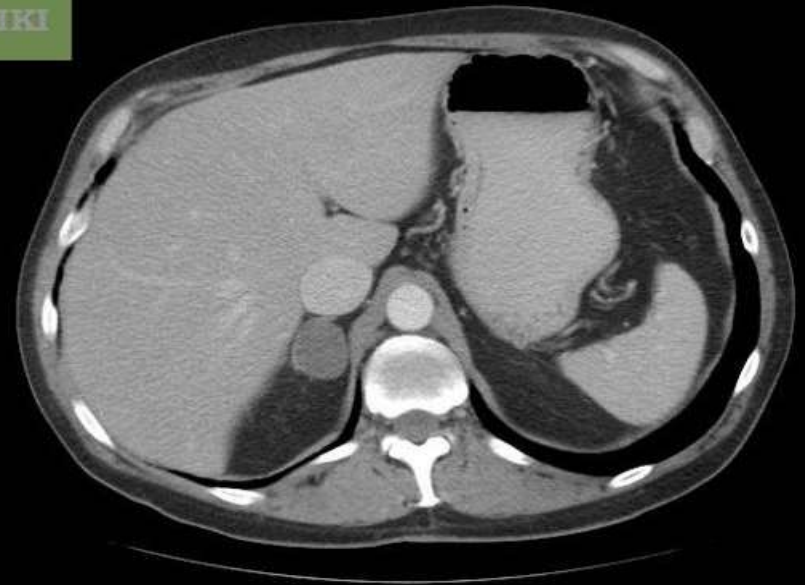
- Solitary nodule
- Usually encapsulated by rim of connective tissue
- **Usually small:** <50 gm, < 5cm diameter  
(on the average, much smaller than cortical carcinomas)
- Yellow color (majority, because of lipid-laden cells)
- Black color (minority, due to excess lipofuscin pigment)
- Cured by surgical excision
  
- Endocrine function is *unpredictable*; 3 syndromes are
  - no hyperfunction (“silent”)
  - hypercortisolism
  - hyperaldosteronism

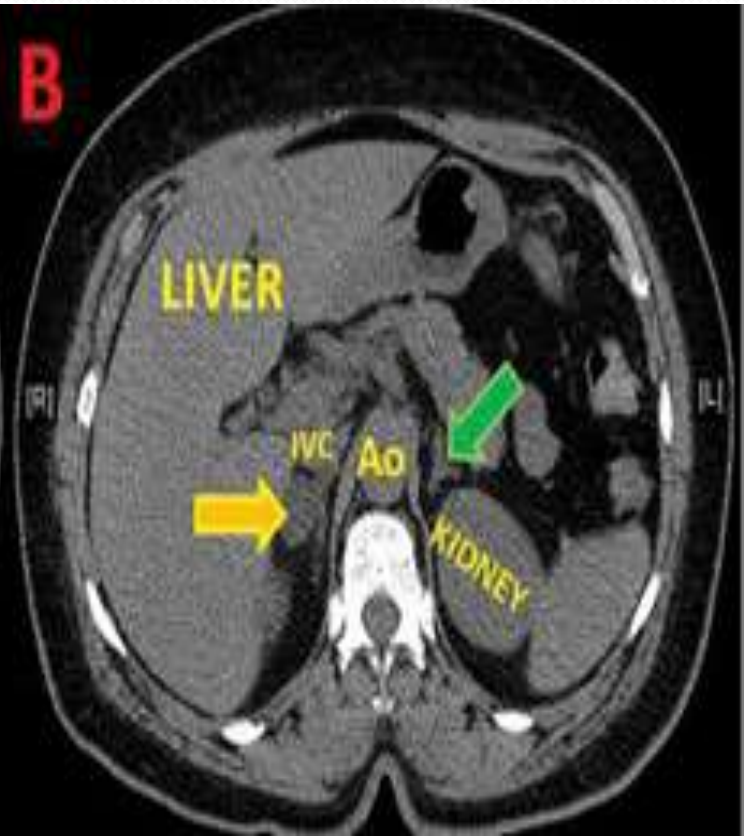
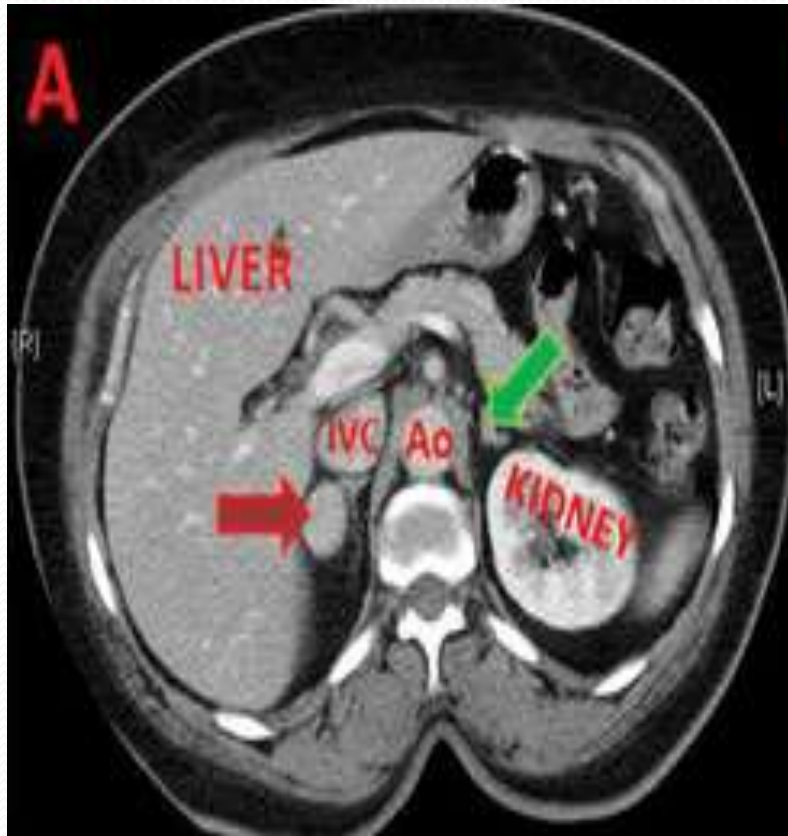
# CT Adenoma Characteristics

- Sharp margins
- Smooth, homogenous, lipid rich
- Most <10 Hu on noncontrast images
- Washout >50% @ 15 min



RADS  
WIKI







- Secreting tumors:
- 1- Hyperaldosteronism ( Conn`s syndrome)
- 2- Hypercortisolism ( Cushing syndrome)
- 3- Hyperandrogenism ( Precocious puberty)
- 4- Pheochromocytoma

# *Primary Hyperaldosteronism*

## *(Conn's syndrome)*

- 1. Solitary adrenal adenomas (80-90%)**
- 2. Bilateral adrenal hyperplasia (10-20%)**
- 3. Adrenal Carcinoma (rare)**
- 4. Unilateral Adrenal Hyperplasia (very rare)**

## **Clinical features of Conn's syndrome**

- **Often asymptomatic**
- **Frontal headache**
- **Muscle weakness to flaccid paralysis  
decreased muscle strength (because of low  
potassium level)**
- **Polyuria and Polydipsia**
- **Hypertension**

## Investigation of Conn's syndrome

### **A. *Serum Electrolytes***

- 1. Serum Potassium decreased**
- 2. Serum Sodium increased (Mild)**
- 3. Metabolic Alkalosis**

***B. Increased serum level of aldosterone***

***C. Greatly decreased serum level of renin***

***D. Sodium loading test***

# Localization

- Ultrasound.
- CT Scan.
- MRI
- Angiographic Blood Sampling.

# Treatment of Conn's syndrome

## A. Adrenal Adenoma

*Surgical excision (unilateral adrenalectomy)*

## B. Adrenal Hyperplasia

*Spironolactone (Aldactone)*

# Cushing's syndrome

*Endogenous :*

*ACTH dependent 85%*

- Cushing's disease (pituitary)
- Ectopic ACTH syndrome (small cell lung carcinoma)
- Ectopic CRH syndrome (bronchial carcinoid tumours)

*ACTH independent 15%*

- Common: Adrenal adenoma, adrenal carcinoma
- Less common: Micronodular hyperplasia, macronodular hyperplasia

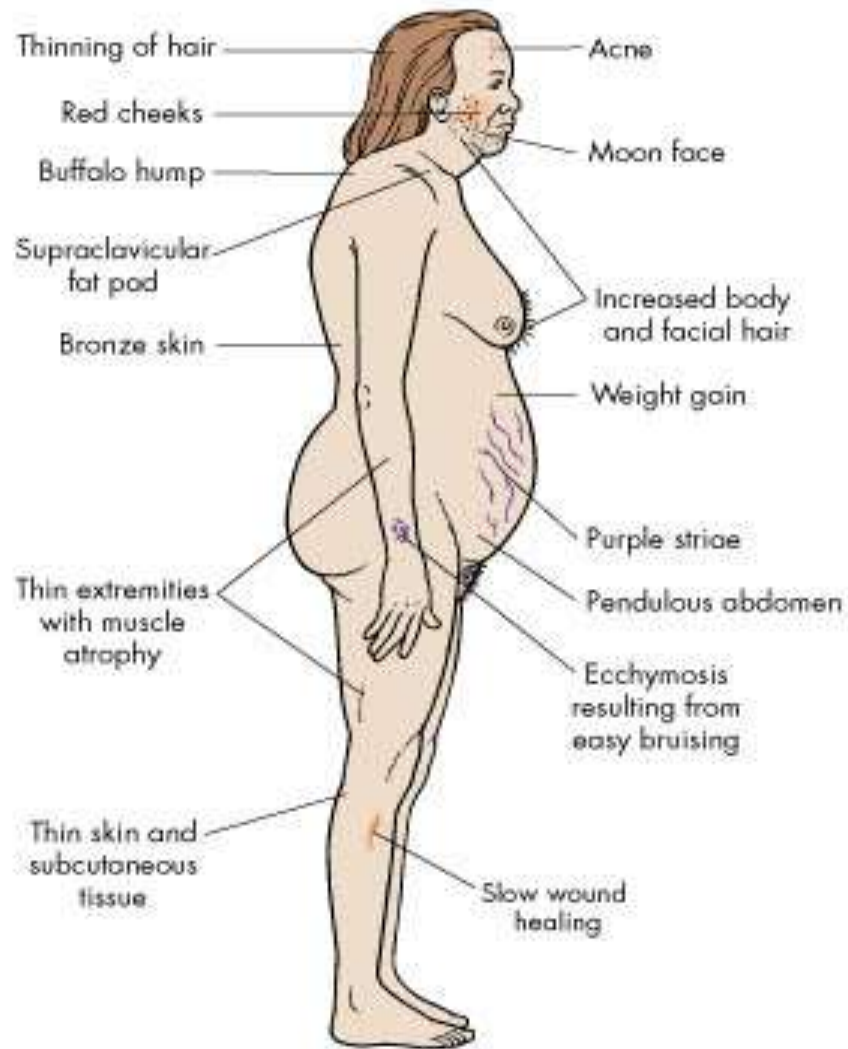
## *Exogenous*

- **Glucocorticoid treatment**

## *Pseudo-Cushing's syndrome*

- **Major depressive disorder**
- **Alcoholism**
- **Obesity**





**Figure 47-9** Common characteristics of Cushing's syndrome.

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# Investigation of Cushing's syndrome

## *Screening tests*

- **Urinary free cortisol**

The measurement of 24 hour excretion of cortisol in urine integrates the variations in plasma free cortisol concentrations seen during the entire day; three consecutive 24 hour urine specimens.

- There is a false negative rate of 5.6%, with false positives of 1% in normal people and 5% in obese individuals.

- **Dexamethasone suppression tests**

In normal subjects, administration of a supraphysiological dose of glucocorticoid results in suppression of ACTH and hence of cortisol secretion (cortisol  $<50$  nmol/l). This is the basis of dexamethasone suppression tests, of which there are several types.

# Treatment of Cushing's syndrome

- **Transsphenoidal surgery**
- **Pituitary radio-therapy**
- **Bilateral or unilateral adrenalectomy**
- **Medical therapy**

# Pheochromocytoma Rule's of 10

- Bilateral
- Familial (non-sporadic)
- Pediatric
- Malignant
- Normotensive
- Extra-adrenal
- Multiple
- \*Childhood presentation breaks the rules- 25% bilateral, multiple, extra-adrenal

# Pheo

- Triad: **headache, tachycardia, diaphoresis**
- Other symptoms: Pallor, flushing, palpitations, abd/chest pain, weakness, N/V, psychosis
- Small tumors more likely symptomatic

# Pheo- The Diagnosis

- Plasma free metanephrines : most sensitive test seen 99% of patients
- 24 h urinary catecholamines (2x normal is diagnostic)
- VMA
- Clonidine suppression test (0.3mg oral, test 3 hrs later)  
>50% reduction catecholamines NO pheo

# Pre-op Management

- Early alpha blockad
- Goal to control hypertension- phenoxybenzamine
- Do NOT use b-blocker before alpha
- IV hydration
- Prevent cardiac arrhythmias



# Adrenal Cortical Carcinoma

- Mean age 50 years
- **Larger:** typically > 100 gm; mean weight 900 grams (BIG!)
- Gross clues for malignancy (some apparent by imaging)
  - Large size, hemorrhage, necrosis, invasion of adrenal vein
- ***Absolute criteria for malignancy:*** invasion & metastasis
- 5 year survival: 20-30%; most tumor-related deaths occur within first two years after diagnosis

## 4. The adrenal “Incidentaloma”

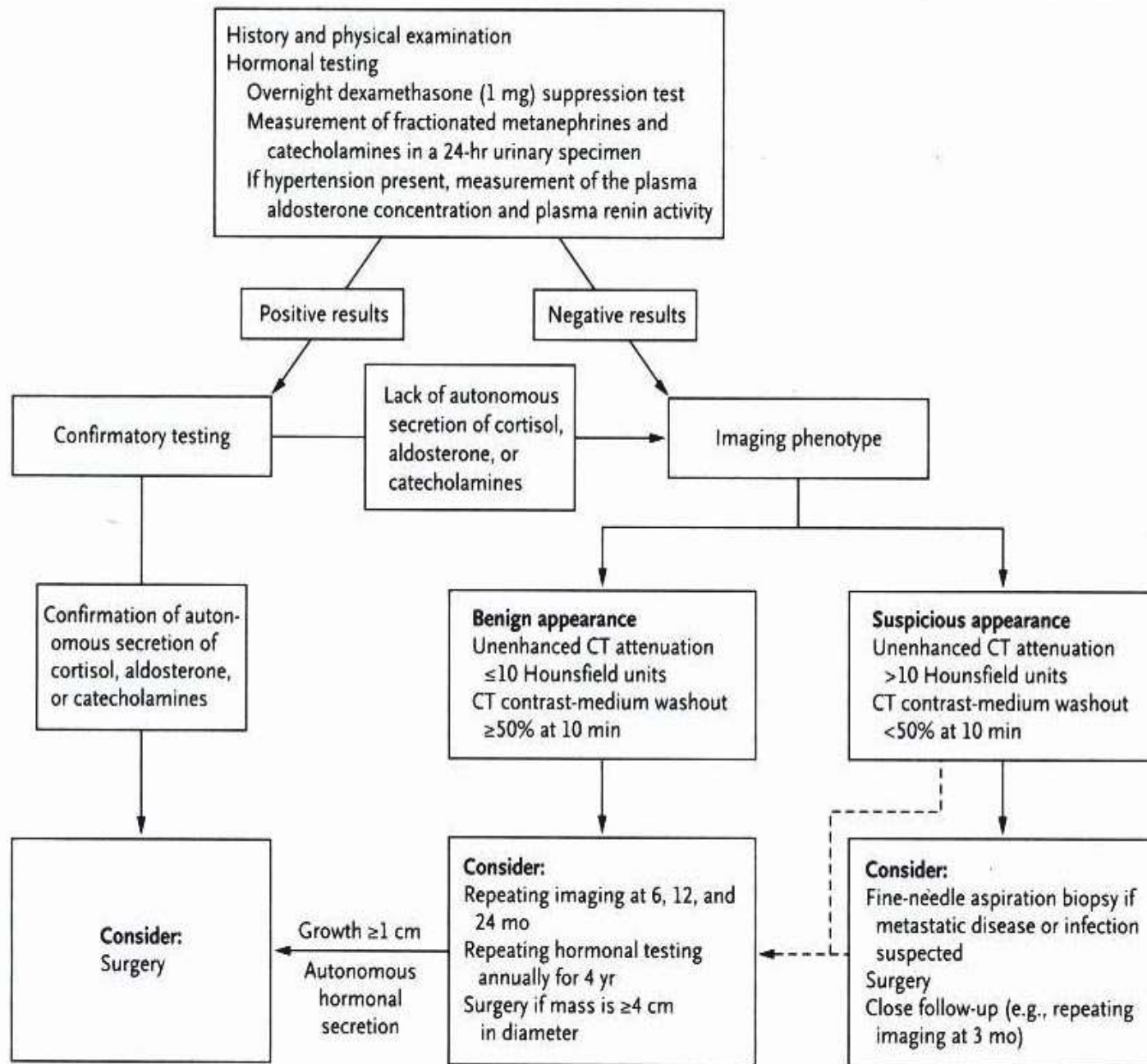
- **Definition:** *“an adrenal mass, generally more than 1 cm. diameter, that is discovered accidentally during a radiologic examination performed for indications other than an evaluation for adrenal disease.” \**

# Nature of Incidentally Found Adrenal Masses

- Review of 2,005 incidentally-discovered adrenal masses:
  - Nonfunctioning adenoma 82%
  - Functioning: Cushing's 5%
  - Pheo 5%
  - Aldosteronoma 1%
  - Malignancy: Metastasis 3%
  - ACC 4%
- Young WF, et al. Endocrinol Clin N Am. 2000

# Incidental Adrenal Mass Management

- Hormonally active → surgical removal
- > 5 cm → removal (with a scalpel)
- < 3 cm observe
- Surveillance Recommendations:
  - Old: CT at 6 months then Annual endocrine eval for 4 years
  - New: If mass stable on scans @ 3m and 1 yr then no further workup



Young, WF;  
New England  
Journal of  
Medicine,  
356:601-610,  
2007, fig. 1

Figure 1. Algorithm for the Evaluation of Patients with an Adrenal Incidentaloma.

# Surgical approach

# Surgical Management of Adrenal Neoplasms

- Before the era of laparoscopic procedures, conventional open adrenalectomy was the only surgical approach to adrenal neoplasms
- Since the introduction of laparoscopic adrenalectomy by *Gagner* et al. in 1992, the majority of benign adrenal lesions have been removed by various laparoscopic techniques.

# Indications

- The choice of approach will depend on size, location, possibility of malignancy, and surgeon experience with the different techniques.
- The open approach to adrenalectomy is considered the gold standard for masses suspected of being adrenal carcinoma



# Indications

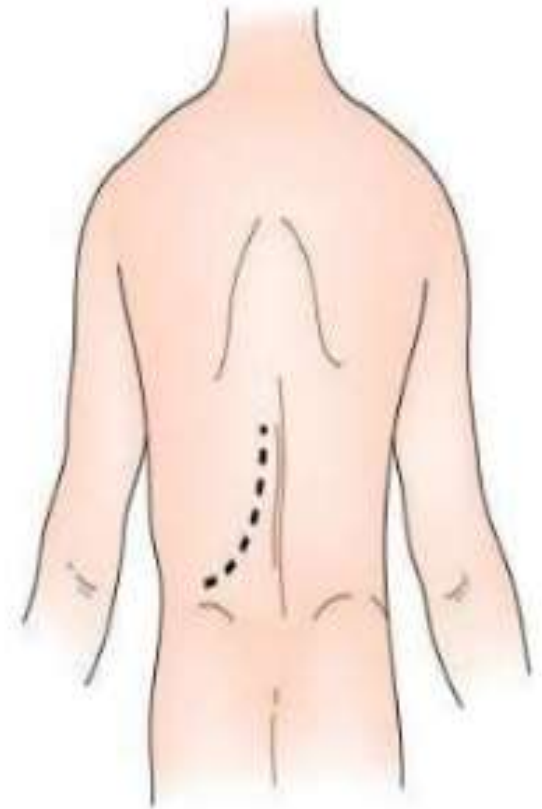
- Conn syndrome
- Cushing syndrome
- pheochromocytoma
- large myelolipoma
- metastatic tumors
- adrenocortical carcinoma
- neuroblastoma

# Conventional Open Methods

- The flank or posterior
- The anterior or transabdominal
- The transthoracic or thoracoabdominal

- The standard approach has the patient in the prone position with arms extended over the head
- The incision is made over the 11th or 12th rib, with or without a “hockey stick” extension cephalad

## POSTERIOR APPROACH (Retroperitoneal)



# Posterior Approach

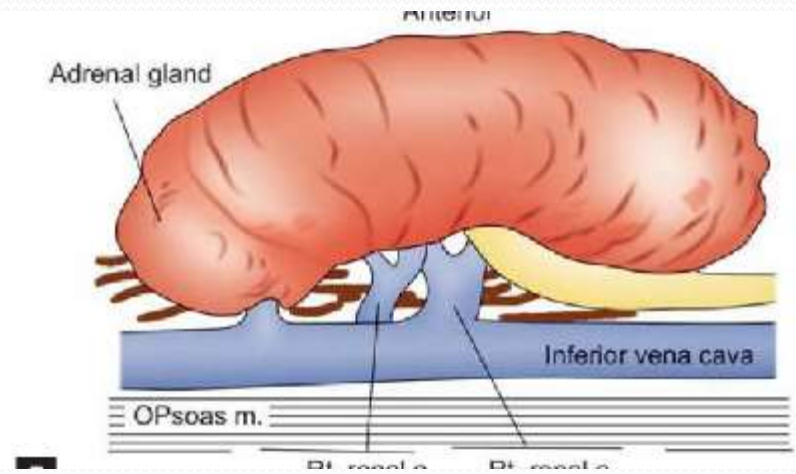
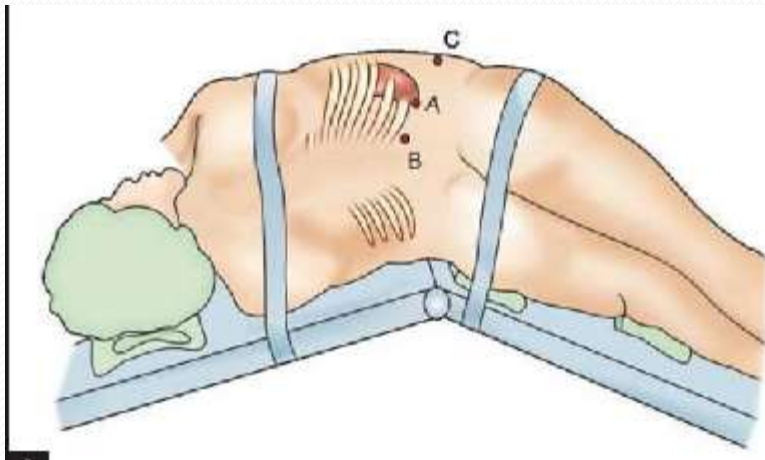
- Also referred to as the lumbodorsal approach
- The advantage of this approach is allowing the surgeon to both remain in an extraperitoneal dissection plane and offers access to both adrenal glands
- The incision is made through the bed of the twelfth rib

# Posterior Approach

Disadvantages :

- Since exposure with this approach is limited, it should only be used to remove tumors up to 5 cm in size
- Intra-abdominal exploration for other pathology or metastases is impossible
- Two separate incisions are required for bilateral adrenalectomy

# Flank Approach



# Flank Approach

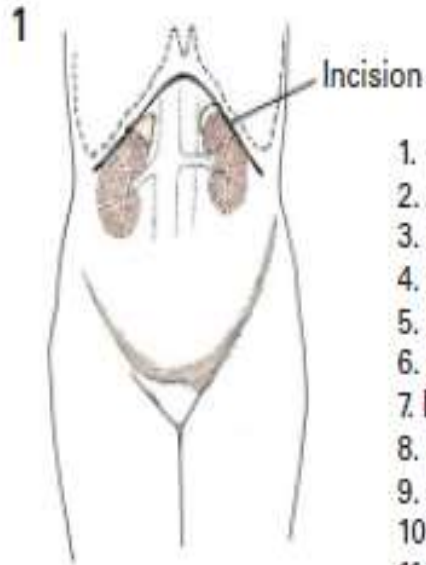
- Incision is made over the 11th rib and carried down through the muscle and fascial layers over the 11th rib
- The rib is mobilized posteriorly taking care to avoid injuring the neurovascular bundle
- The rib is then resected and entry is made into the retroperitoneal space through the lumbodorsal fascia.

# Flank Approach

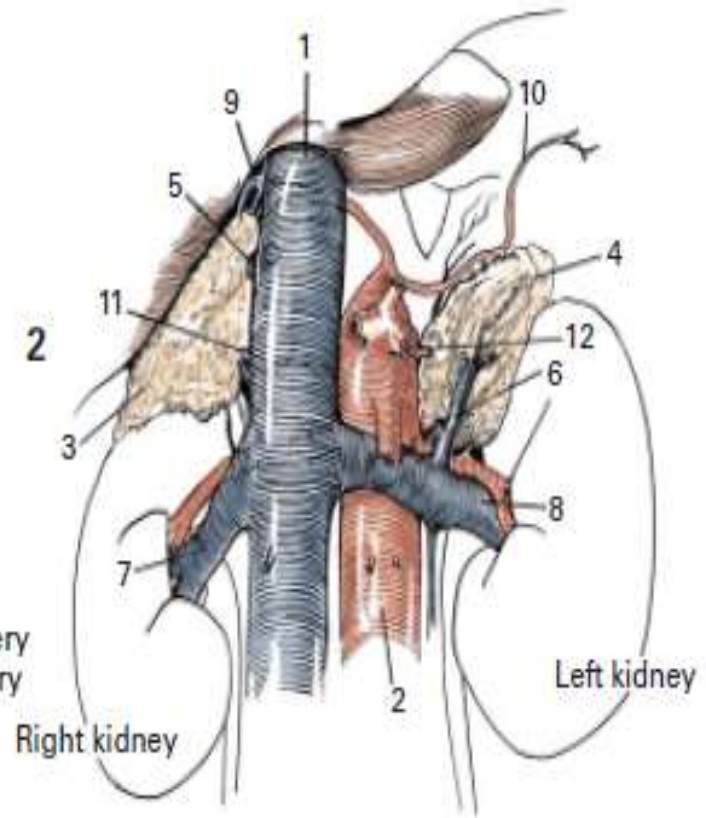
- This approach offers excellent exposure in obese patients
- there is a risk of injury to the pleural reflection at the level of the 11th rib in the midaxillary line and inadvertent entry into the pleural cavity or lung injury.



# Anterior Subcostal Approach



1. Inferior vena cava
2. Aorta
3. Right adrenal gland
4. Left adrenal gland
5. Right adrenal vein
6. Left adrenal vein
7. Right renal vein
8. Left renal vein
9. Right inferior phrenic artery
10. Left inferior phrenic artery
11. Right adrenal artery
12. Left adrenal artery



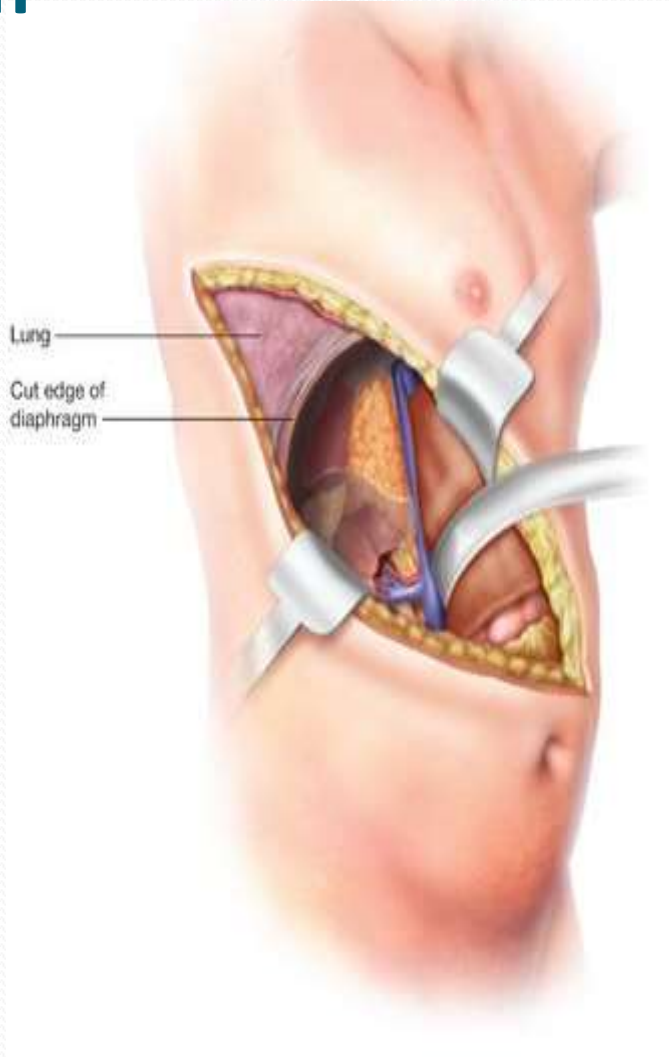
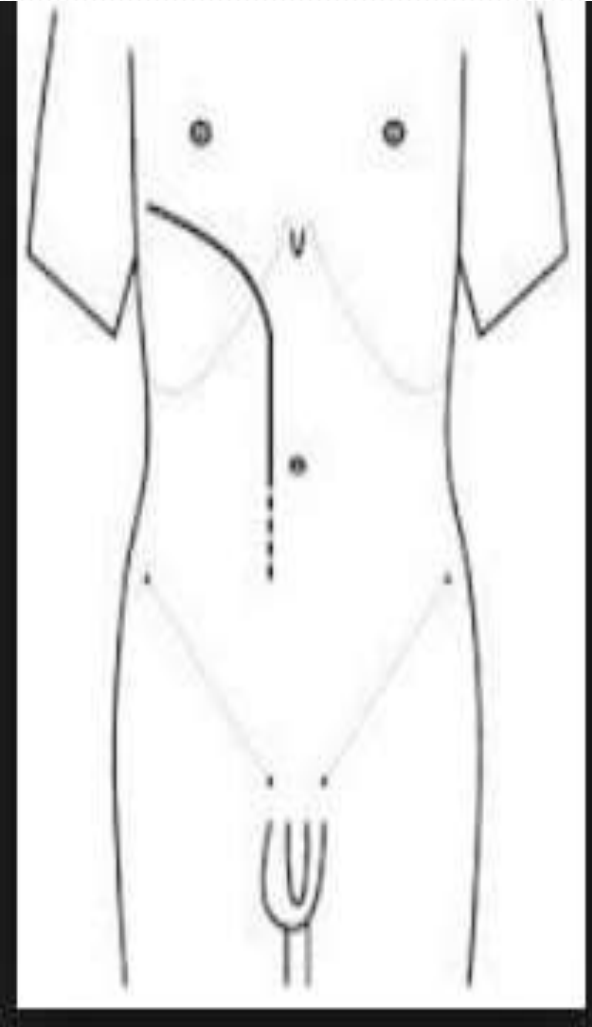
# Anterior Subcostal Approach

- The subcostal approach is initiated with the patient supine and the incision is made two fingerbreadths below the costal margin.
- The adrenal is identified by its characteristic yellowish color, lobulated appearance, and clearly definable blunt lateral edge.
- The vascular attachments are usually on or near the medial and superior edges of the gland rather than on its broad surfaces.

## Anterior Subcostal Approach

- This approach offers the advantage of being well known to all surgeons and allows for bilateral exploration.
- However, it carries a higher rate of ileus, and may be difficult with obese patients

# Thoracoabdominal Approach



# Thoracoabdominal Approach

- The incision is then made through the 8th or 9th intercostal space through the muscle layers and carried medially through the costal cartilage
- The incision is carried through the anterior and posterior rectus sheaths and the pleura is entered and the lung packed out of the field
- Care is taken during division of the diaphragm to not be too central as the phrenic nerve can be damaged with careless division

# Thoracoabdominal Approach

- This approach offers excellent exposure to the retroperitoneum and the great vessels.
- However, it has the highest morbidity of all the approaches with risk of prolonged ileus, pulmonary complications, and necessary chest tube
- Most authors reserve this approach for large tumors and adrenal carcinoma

# Laparoscopic approaches

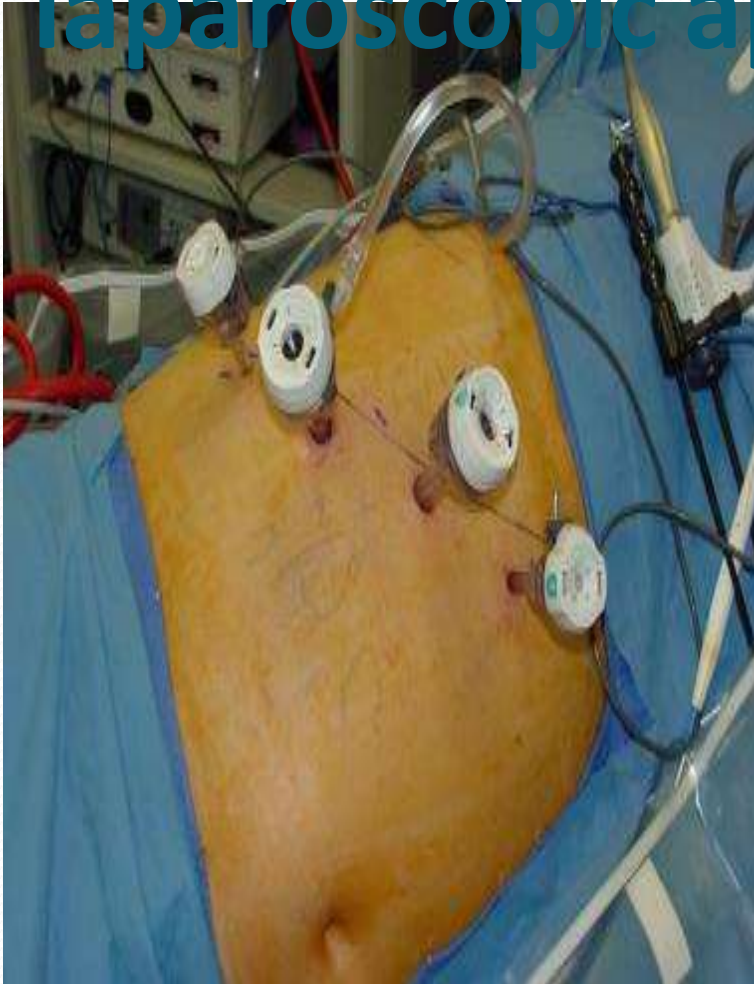
- Lateral transperitoneal (flank)
- Anterior
- Posterior retroperitoneal

# The lateral transperitoneal laparoscopic approach

- Four trocars are inserted in the flank area, one under the subcostal area at the anterior axillary line and three under the twelfth rib along a line lateral to the first one
- This method allows one to inspect much of the abdominal cavity and provides wider exposure for removing relatively larger glands than can be removed with the retroperitoneal approach.



# The lateral transperitoneal laparoscopic approach



# The Anterior Laparoscopic Approach

- four to five trocars are inserted, one above the umbilicus and two subcostally, one at the anterior axillary line and another at the midclavicular line.
- The advantages and disadvantages of the anterior approach are similar to the lateral transperitoneal or flank approach
- more dissection and retraction is required which may lead to more bleeding and other injuries

# The posterior or retroperitoneal laparoscopic approach

- The patient is placed in a semi-jackknife prone position.
- A balloon trocar is inserted 2.5 cm lateral to the twelfth rib into the retroperitoneum to create a working space.
- Three more trocars are introduced into the created retroperitoneal space under direct vision

# The posterior or retroperitoneal laparoscopic approach

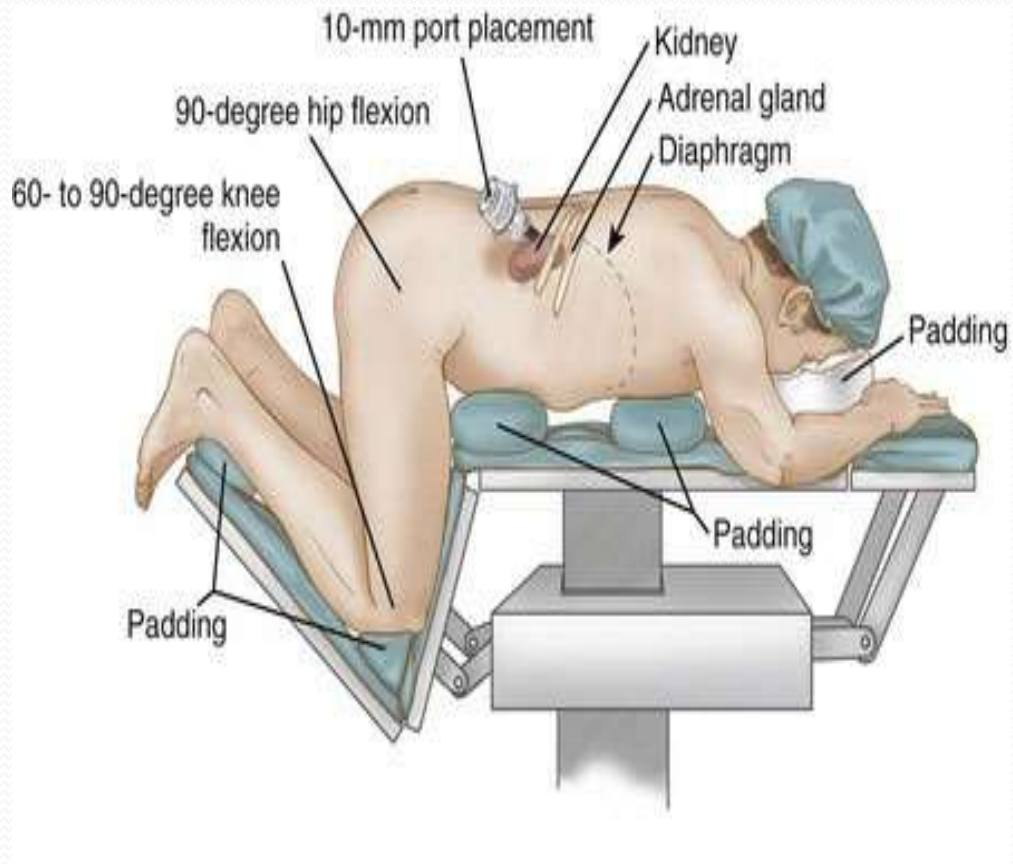
## Advantages

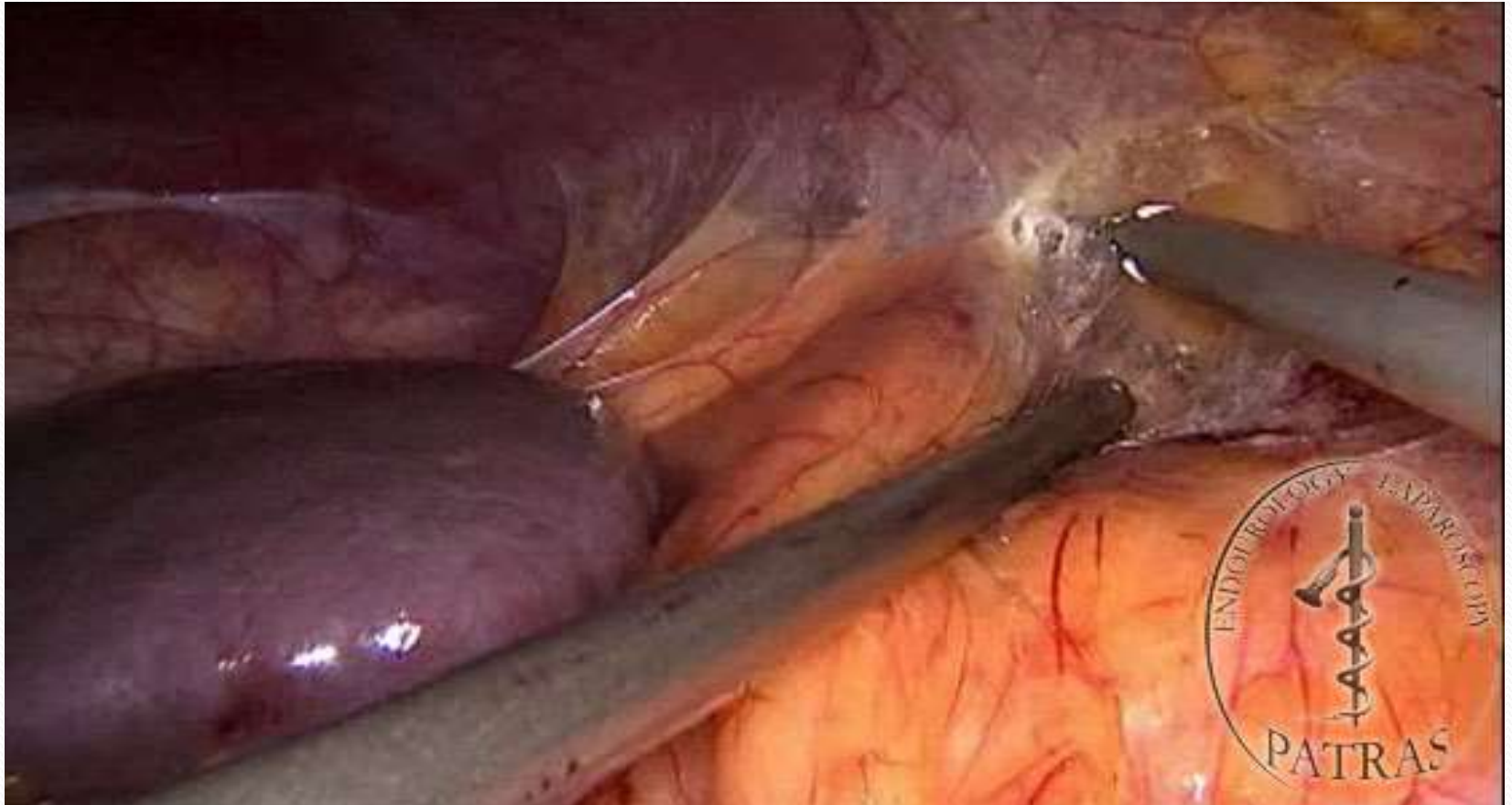
- the retroperitoneal approach allows one to perform a bilateral adrenalectomy without repositioning the patient
- It also avoids adhesions from previous operations and other abdominal conditions that might interfere with the operation

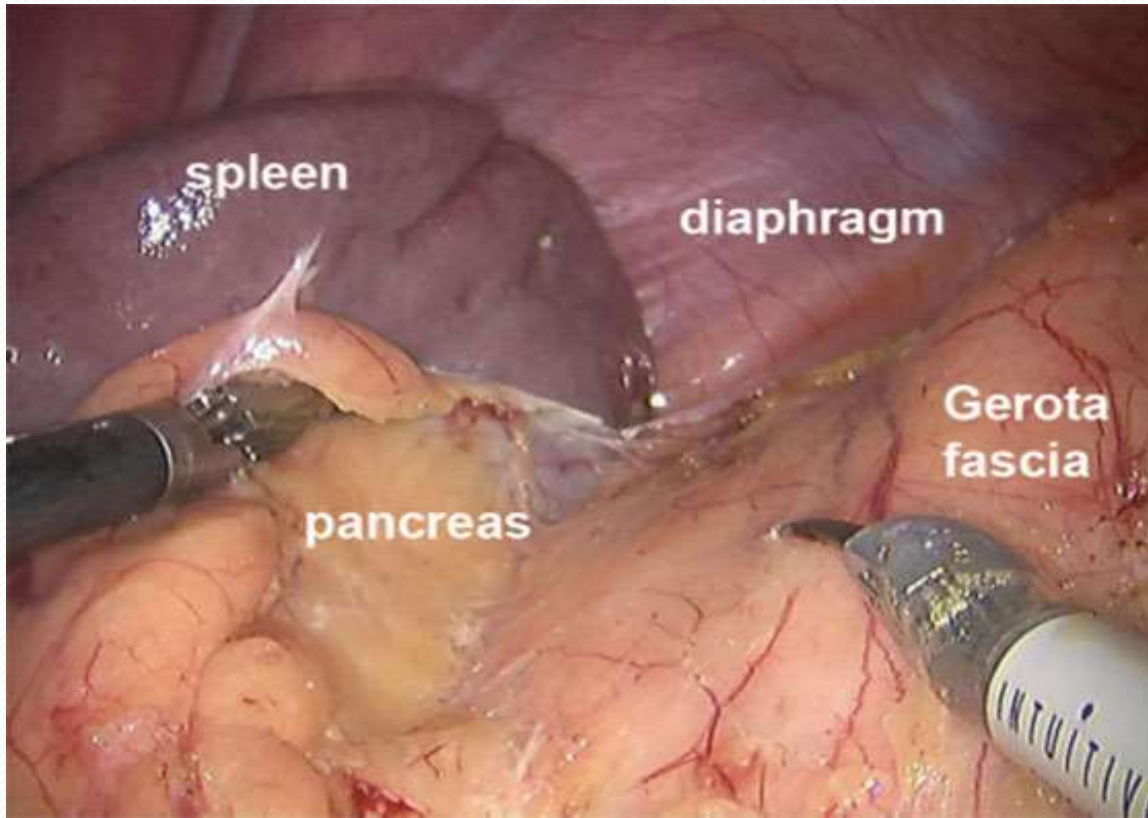
# The posterior or retroperitoneal laparoscopic approach

## Disadvantages

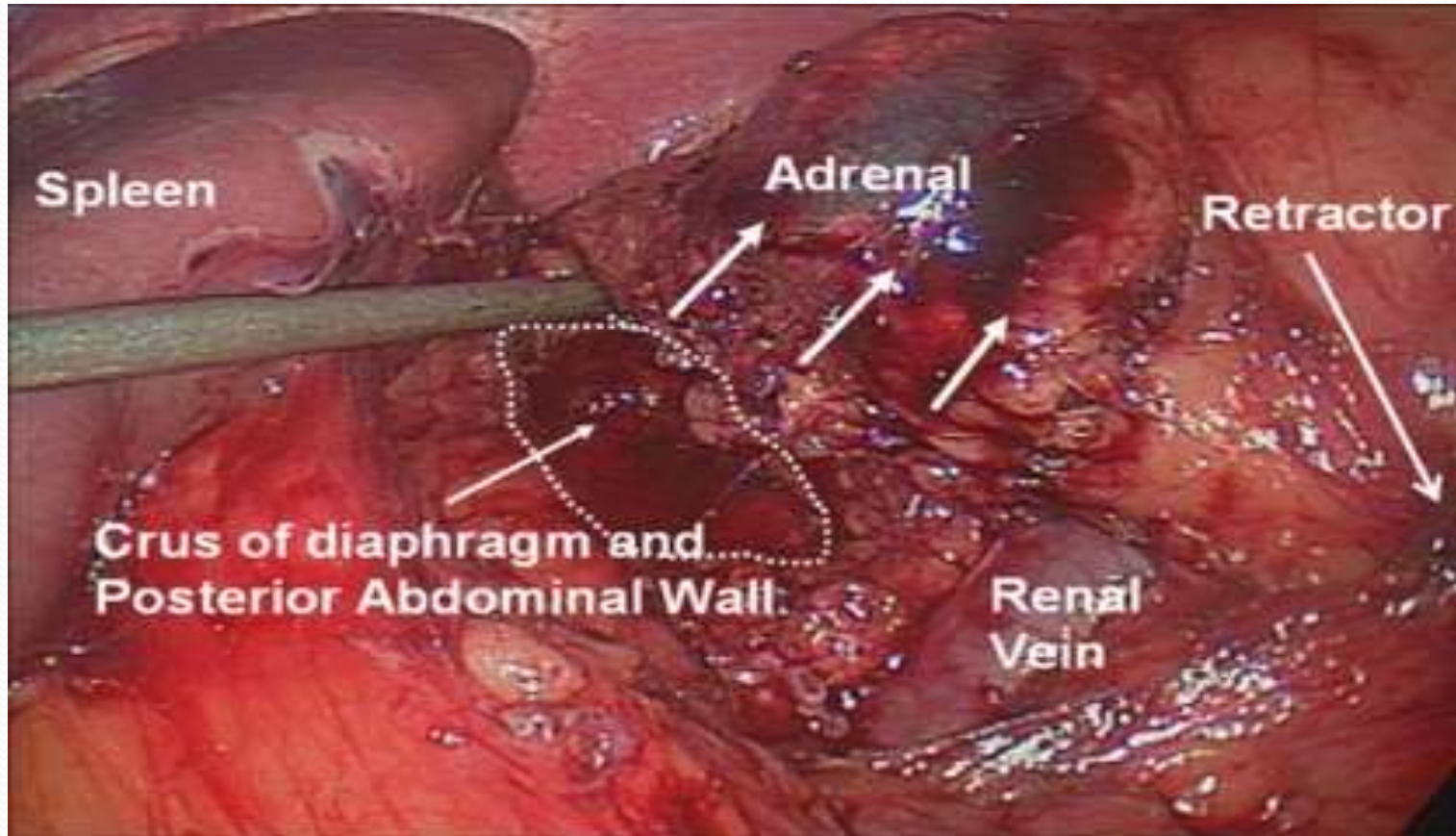
- However, the retroperitoneal approach precludes intra-abdominal exploration.
- Due to its limited working space, large tumors cannot be removed (up to 5 cm).













Thank You