Adrenal disorders

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Objectives:

1. Understand physiology/diseases and management of Hypoadrenalism
2. Understand physiology/diseases and management of Cushing syndrome
3. Understand physiology/diseases and management of Hyperaldosteronism
4. Understand physiology/diseases and management Pheochromocytoma

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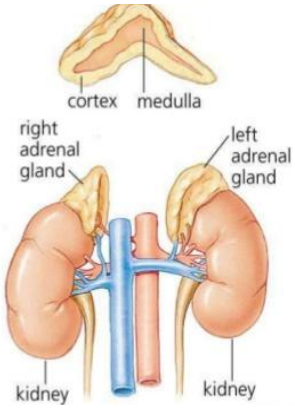
References:
Slides - Black
Doctor's notes - Red
Step up / Davidson - Blue
Extra explanation - Grey

Optional:

p773 to p782

Editing file

❖ Anatomy:



- **Each gland weighs 4-5 g.**
- **Location: in the <u>retroperitoneum</u> above or medial to the upper poles of the kidneys.**
- **Surrounded by a fibrous capsule.**
- **The <u>yellowish outer cortex</u> comprises 90% of adrenal weight.**
- **The <u>inner medulla</u> 10% of adrenal weight.**
- **Richly vascularized**

❖ Physiology:

- **Adrenal gland is divided into: Cortex (90%) & Medulla (10%)**
- **Adrenal cortex is further divided into 3 zones:**
  - **Zona glomerulosa (Mineralocorticoids) → Secrete Aldosterone. Regulated by Renin& Angiotensin system And potassium level**
  - **Zona fasciculata (Corticosteroid)**
  - **Zona reticularis (Sex steroid)**

  Secrete Cortisol & Androgen
- **The last two zones are considering as <u>One functional unit</u>. Meaning that they both secreting same hormones (Cortisol & Androgens) and under control of ACTH**
- **Adrenal medulla contains chromaffin cells that secrete Epinephrine and norepinephrine**

❖ Hormonal functions:

Region/Zone	Hormone(s)	Primary Targets	Hormonal Effects	Regulatory Control
Zona glomerulosa	Mineralocorticoids (aldosterone)	Kidneys	Increase renal reabsorption of Na+ and water (especially in the presence of ADH and accelerate urinary loss of K+)	Stimulated by angiotensin II, elevated plasma K+, or a fall in plasma Na+؛ inhibited by AMP and BNP
Zona fasciculata	Glucocorticoids ؛ [cortisol (hydrocortisone), corticosterone]	Most cells	-Adipose tissue: (promote the breakdown of fat) -Bone: (reduces bone formation) -Liver: (Glucose generation) -Muscle: (decreasing amino acid uptake by muscle) -Pancreas: (cortisol counteracts insulin)	Stimulated by ACTH
Zona reticularis	Androgens	Most cells	Not important in adult man ؛ encourages bone growth, muscle growth, and blood formation in children and women	Stimulated by ACTH
Medulla	Epinephrine, norepinephrine	Most cells	Increases cardiac activity, blood pressure, glycogen breakdown, blood glucose level; releases lipids by adipose tissue	Stimulated during sympathetic activation by sympathetic preganglionic fibres

❖ Biochemistry:

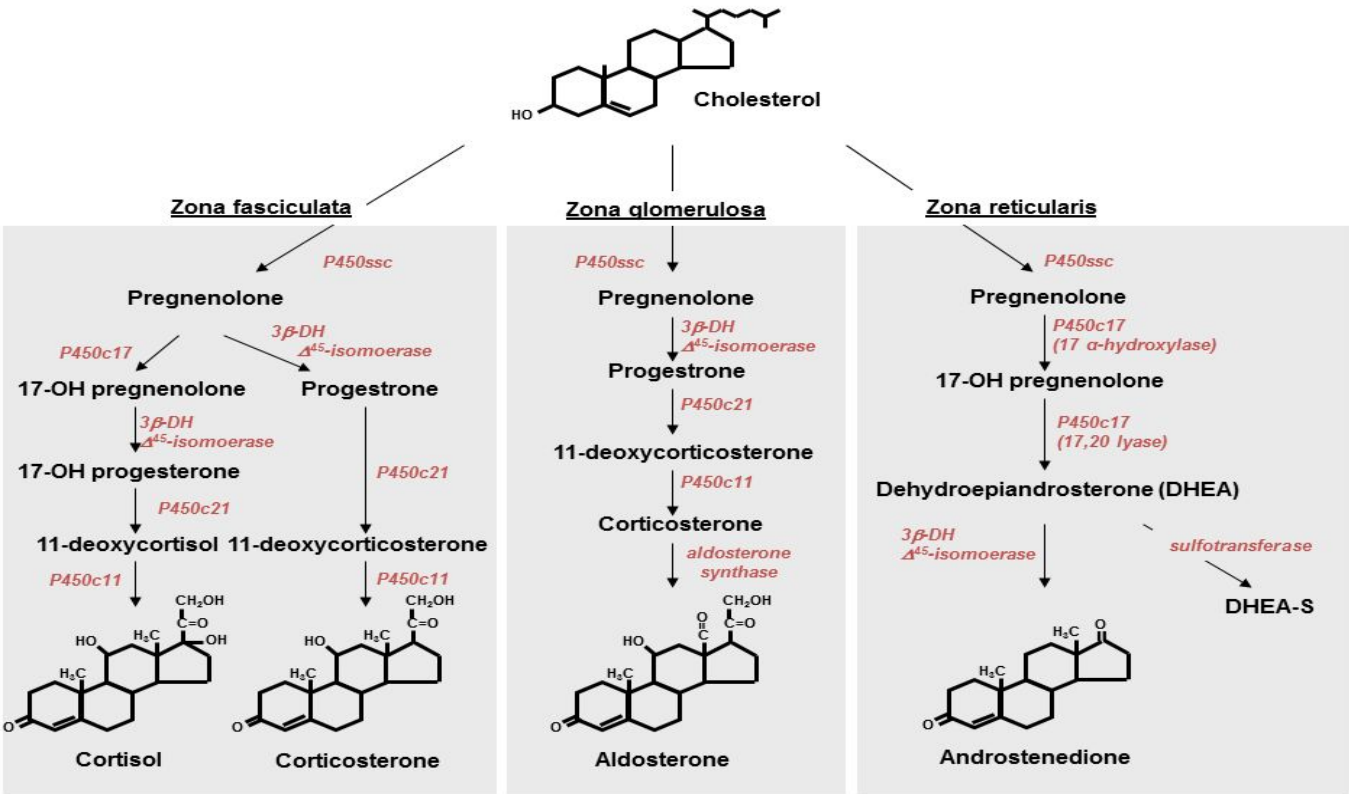
- **All adrenal hormones are originating from <u>Cholesterol</u>**
- **This pic below summarize the hormonal synthesis pathway**
- **Cortisol and the adrenal androgens circulate bound to plasma proteins**
- **90% Of circulating cortisol bound to protein [75% to CBG (cortisol binding globulin) or Transcortin & 15% to Albumen**
- **Only 10% of circulating cortisol is free and it is this biologically active cortisol which is regulated by ACTH**
- **Androgens except for testosterone bind weakly to albumin. However, testosterone is bound extensively to a specific globulin – sex hormone binding globulin (SHBG)**

Factors Increase CBG:

- Pregnancy
- OCP users
- Hyperthyroidism
- D.M.
- Certain hematological disorders
- Genetic familial condition

Factors Decrease CBG:

- Familial deficiency states
- Hypothyroidism
- Protein deficiency states
- Severe liver disease
- Nephrotic syndrome



❖ Regulation of Secretion:

- **Circadian Rhythm**
  - changed by:
    - Changes in Sleep pattern
    - Light-dark exposure
    - Feeding times
    - Psychological stress
    - CNS and pituitary disorders
    - Cushing syndrome
    - Liver disease
    - Chronic renal failure
    - Alcoholism
    - Certain Drugs e.g. cyproheptadine
- **Stress.** ACTH and cortisol is secreted within minutes of the onset of stress
- **Feedback inhibition.** glucocorticoids acts on both the pituitary and hypothalamus to inhibit CRH and ACTH production

❖ Introduction:

- **Adrenal gland** is a tiny structure. However, it has A lot of physiological and biological activities in our body that makes it **Essential for life.**
- After speaking briefly about Anatomy, physiology and biochemistry of the Adrenal gland
- We are going to discuss each component of adrenal gland and the common disorders happen with that and the way of diagnosis and management
- **Hyper**functioning and **Hypo**functioning , **Primary** and **Secondary**. these are the keywords for most Adrenal disorders

Hypoadrenalism (adrenal insufficiency)

❖ Primary adrenal insufficiency(Addison disease):

- **results from progressive destruction of adrenal cortex. At least 90% of gland is destroyed before signs of insufficiency appear.**
- **High ACTH**
- **Low cortisol and adrenal hormones.** (due to destruction)

❖ Causes:

- **"Idiopathic" atrophy (autoimmune). Most common**
- **Infection (TB., fungal, viral-esp. AIDS). 2nd Most common**
- **Iatrogenic (Surgical removal)**
- **Adrenal Hemorrhage**
- **Invasion: metastases, amyloidosis, sarcoidosis**
- **Others:**
  - **Congenital adrenal hyperplasia (CAH)**
  - **Enzyme inhibitors: (Metyrapone, Ketoconazole, Aminoglutethimide)**
  - **Cytotoxic agents: (Mitotane)**

Idiopathic Addison's disease is frequently accompanied by other glandular failure disorders and also with a higher incidence of other immunological and autoimmune endocrine disorders e.g. **hyperthyroidism, hypothyroidism, anemia and gonadal failure, DM1**

❖ Secondary adrenal insufficiency:

- **Results from either:**
  - **Long-term steroid therapy. Most common**
  - **hypopituitarism**
- **Low ACTH and cortisol**
- **Preserved aldosterone.** Remember aldosterone is regulated by renin & angiotensin and the only problem with Secondary adrenal insufficiency is low ACTH

Abdominal radiograph reveal adrenal calcification in half the patients with tuberculous adrenalitis and in some patients with other invasive or hemorrhagic causes of adrenal insufficiency

★ Clinical features of adrenal insufficiency

A. Cortisol deficiency

- **General symptoms: weakness, tiredness, fatigue**
- **GI symptoms: Nausea, Vomiting, Constipation, Abdominal pain, Diarrhea, weight loss**
- **Hyperpigmentation.** Only in Primary adrenal insufficiency (due to ACTH)
- **Hypoglycemia.** Cortisol is a gluconeogenic hormone
- **Mental symptoms: Lethargy, confusion, psychosis**

B. Aldosterone deficiency

- **Electrolyte disturbances: Hyponatremia & Hyperkalemia**
- **Hypotension.** due to decreased volume retention (Hypovolemia).

It also can be in orthostatic form

- **Salt craving**

C. Androgen deficiency

- **Decreased axillary and pubic hair (in women only)**

- ACTH is derived from a molecule called pro-opiomelanocortin (POMC). POMC is also a precursor for beta endorphin and melanocyte stimulating hormone (MSH)…so if you make more POMC (in order to make more ACTH), you'll make more beta endorphin and MSH.

- MSH stimulates melanocytes, giving the skin a bronze color

★ Laboratory findings of adrenal insufficiency

- **Electrolytes disturbances**
  - **Hyponatremia**
  - **Hyperkalemia**
  - **Hypercalcemia.** Unknown reason
- **Azotemia**
- **Anemia.** 2 hormones are important for BM (Bone marrow) function: T4, cortisol
- **Eosinophilia**

❖ Diagnostic Tests:

1. **Plasma cortisol level**
   - **Low: Adrenal problem. go to the next step**
   - **Normal: consider other diagnosis**
2. **ACTH level**
   - **It differentiates between primary and secondary states being high in the primary form and low normal or low in secondary forms.**
3. **ACTH stimulation test**
   - **A definitive test to diagnose primary adrenal insufficiency**
   - **After a baseline cortisol sample is obtained a synthetic ACTH called Tetracosactrin is given in a dose of 0.25mg IM. Or IV. and additional cortisol samples are obtained at 30 and 60 min following the injection**
   - **Failure to increase cortisol = Primary adrenal insufficiency**
   - **Increase in cortisol = Secondary adrenal insufficiency.** However, you may have to repeat test many times
4. **Imaging tests**

- **MRI of brain.** In case of suspecting secondary or tertiary adrenal insufficiency

❖ Management:

- **As simple, Replace those hormones who are deficient**
- **Primary adrenal insufficiency(Addison disease):**
  - **Hydrocortisone.**
  - **Fludrocortisone.**
- **Secondary adrenal insufficiency:**
  - **Hydrocortisone <u>only</u>**
  - **No need for Fludrocortisone as the mineralocorticoids are preserved**

Acute Adrenal Crisis

- **A state of acute and severe adrenocortical insufficiency occurring in patients with Addison's disease who are <u>exposed to the stress</u> of infection trauma surgery or dehydration. It's a life-threatening condition!**
- **So, adrenal crisis can occur in any stressful condition: Trauma, infection, surgery, dehydration, even pregnancy**
- **Characterized by: severe hypotension, cardiovascular collapse, abdominal pain, acute renal failure and death**
- **Treat it with:**
  - **IV Hydrocortisone**
  - **IV Fluids**
- **Then, look for the other condition that initiate the crisis and resolve it**

Hypercortisolism (cushing syndrome)

- Excessive cortisol level in the blood leading to differents clinical manifestation that are called cushingoid features
- Cushing syndrome is divided into:
  - ACTH dependant. (Cushing's disease + Ectopic ACTH)
  - ACTH independant.

❖ ACTH dependent Cushing syndrome:

◇ Pituitary adenoma (Cushing disease):-

- **Is a specific type of cushing's syndrome due to excessive pituitary ACTH secretion (commonly secondary to an adenoma). Most are Microadenoma**
- **The commonest one in endogenous causes of cushing syndrome**
- **Tend to be more in Female. Women to men ratio is 8:1**
- **It has a long term, so there will be enough time for typical features of cushing syndrome to be developed**
- **Leads to Bilateral adrenal hyperplasia. due to the long term ACTH effect**

◇ Non-pituitary neoplasm (ectopic ACTH):-

- **A Tumors secrete explosive amount of ACTH**
- **Most common cause is lung cancer (small cell carcinoma)**
- **Others:**
  - **pancreatic islet cell tumors.**
  - **carcinoid tumors (lung, thymus, gut, pancreas, ovary).**
  - **medullary carcinoma of the thyroid.**
  - **pheochromocytoma and related tumors.**
- **More common in men**
- **As it has a rapid and short term, lack of classical features of Cushing's syndrome might happen**

❖ ACTH independent Cushing syndrome:

◇ Iatrogenic (long term exogenous steroid):-

- **The most common cause of cause of cushing syndrome among all causes**
- **Patients tend to have this due to their long-term use of steroids for chronic disease**
- **There is No androgen excess. Exogenous steroids suppresses androgen production by the adrenal**

◇ Adrenal adenoma:-

- **Adrenal adenoma is more common than carcinoma**
- **clinical picture of glucocorticoid excess alone. SO, no elevation of androgen or aldosterone and their symptoms shouldn't be there**
- **Gradual onset**
- **Mild to moderate hypercortisolism**

◇ Adrenal Carcinoma:-

- **Clinical picture of excessive glucocorticoids, androgens & mineralocorticoids secretion.**
- **Marked elevation of cortisol & androgens**
- **Abdominal pain, palpable masses & metasteses in liver & lungs.**
- **Atrophy of the uninvolved gland. Meaning that in CT for example you would see one gland enlarged "the one with cancer" and the other is atrophied**

★ Clinical features of Cushing syndrome each one is Important

- **Central Obesity. [face (moonfaced), neck, trunk(buffalo hump), and abdomen are affected with relative sparing of the extremities].** It's thought that due to high cortisol level, insulin will be secreted in high amount as a counteract regulation which will increase fat storage in those area we discussed
- **Abdominal striae. [A purple pinkish lines appear in the abdominal area].** Cortisol affect collagen synthesis and causing thinning of the skin
- **Hyperpigmentation.** happen with Ectopic ACTH
- **Hirsutism. [Facial hirsutism is the most common, but can happen anywhere].** A sign of excess Androgens and it happen with ACTH dependant cushing
- **Hypertension.** Cortisol in excess has aldosterone property and can act on kidney
- **Gonadal Dysfunction.** Excess of androgens interfere with Hypothalamic–pituitary–gonadal axis
- **Psychological Disturbances**
- **Muscle Weakness. [commonly in Proximal muscle and lower limbs].** Cortisol breaks down muscle producing amino acids for gluconeogenesis
- **Osteoporosis**
- **Renal Calculi.** secondary to hypercalciuria
- **Thirst and Polyuria.** In case of developing DM secondary to cushing syndrome

★ Laboratory findings of Cushing syndrome

- **High Cortisol level**
- **High normal hemoglobin.** Remember what we said about role of cortisol in BM function
- **Hypokalemic alkalosis.** As we said above. cortisol in excess amount can do like A mineralocorticoids function
- **Hyper- insulinism and abnormal glucose tolerance tests.** As a result of high glucose level in the blood
- **lymphocytopenia.** Steroids effect

The 1st thing that patient loss in hypercortisolism is the loss of circadian rhythm

★ Approach to the diagnostic tests of Cushing syndrome

- **1st You should follow the three steps of diagnosis below carefully**
  - **Clinical suspicion.**
  - **Biochemical diagnosis of hypercortisolism status.**
  - **Differential diagnosis for etiology of hypercortisolism (Biochemical & Imaging Tests).**
- **Ok, before we go to the diagnostic tests we can divide the tests into: screening & specific tests**
- **Screening test: the goal of it is to tell you that patient has a cushing syndrome**
  - Overnight low-dose dexamethasone suppression test
  - 24 h urine free cortisol level. [Most sensitive]
  - Diurnal rhythm of cortisol secretion
- **Specific test: the goal is to tell you the site of the lesion where**
  - Plasma ACTH level
  - High-dose dexamethasone suppression test
  - CRH stimulation test
  - Imaging studies

Two out of the three screening test is enough to establish a cushing syndrome

❖ Diagnostic Tests:

❑ Screening tests:

1. **Overnight low-dose dexamethasone suppression test.** A normal response should be suppression of the ACTH level. However, If the test is positive (ACTH level remains high and unsuppressed) in the absence of conditions causing false positive results. e.g. alcoholism, depression, and drugs, then the diagnosis should be confirmed by other tests
2. **24- hour urinary free cortisol.** an excellent method for diagnosis of Cushing's syndrome and in differentiating it from other forms of hypercortisolism, e.g. obesity.
3. Diurnal rhythm of cortisol secretion.

- **Now after establishing the diagnosis of cushing syndrome, we want to know the site of lesion. Here specific tests come**

❑ Specific tests:

1. **ACTH plasma level.**
   - **If High → ACTH dependant causes. [eg: pituitary adenoma, ectopic ACTH].**
   - **If Low → ACTH Independent causes. [eg: adrenal tumor or hyperplasia]**
2. **High-dose dexamethasone suppression test**
   - **Cushing disease: Suppression is occur with >50% reduced in cortisol level**
   - **Ectopic ACTH: Suppression does NOT occur, ACTH level remains high**
   - **Adrenal tumor: No detectable ACTH**
3. **CRH stimulation test**

- **CRH is administered intravenously**
  - **↑ ACTH level. meaning that it increases on demand as the normal physiology and this confirm that the origin is in Pituitary**
  - **No increase ACTH. that's mean there is ACTH secreting tumour "Ectopic ACTH" which doesn't respond to the normal stimuli**

4. **Imaging studies**
   - **After the above hormonal tests is done. now we want to establish the site of the disease either by: CT scan OR MRI**

❖ Management:

★ Surgical therapy:

- **Cushing disease:**
  - **Microsurgery**
  - **Radiotherapy**
  - **Pharmacological inhibition of ACTH secretion**
- **Ectopic ACTH:**
  - **Surgical removal of the tumour which is only successful in the benign tumours**
  - **If not accessible "malignant", Blocking the synthesis of cortisol with Metyrapone and mitotane with steroid replacement if necessary.**
- **Adrenal Tumors:**
  - **Surgical removal (Adrenalectomy)**

★ Medical therapy:

- **All medical therapy below is synthesized to block or interfere with the synthesis of steroids.**
- **Mitotane.** acts by inhibiting cortisol synthesis through inhibiting the P450 enzyme responsible for 11B hydroxylation.
- **Metyrapone.** also blocks cortisol synthesis by inhibiting 11B hydroxylase action
- **Ketocenazole "anti-fungal".** a potent inhibition of the P450 enzymes with a principle effect on the 17-20 lyase enzymes but it also inhibits 11B hydroxylase, 18 hydroxylase and cholesterol side-chain cleavage
- **Aminoglutethimide**
- **RU486 (Mifepristone)**

Hyperaldosteronism

- Excessive aldosterone level in the blood leading to classical findings of: **Hypertension, Hypokalemia, and Metabolic alkalosis**

aldosterone biosynthesis is intensified, the entire biosynthetic pathway becomes activated and precursors like DOC corticosterone and 18-hydroxycorticosterone are present in increased amount in person with an aldosterone producing tumour.

❖ Primary Hyperaldosteronism: In more than ⅔ of cases

- **The abnormality is in the adrenal gland itself**

❖ Causes:

- **Adrenal adenoma (Conn syndrome).** The Most common
- **Adrenal hyperplasia.** patients have **bilateral** enlargement of adrenal glands
- **Adrenal carcinoma.** Rare

❖ Secondary Hyperaldosteronism: Not common

- **The abnormality is NOT in adrenal glands. There is something that <u>increase Renin production</u> (activating of RAAS) which will increase the production of aldosterone**

❖ Causes:

- **Renal artery stenosis.** I think it's clear :)
- **CHF.** decrease heart pumping → ↓ perfusion to the kidney → initiate RAAS

★ Clinical features of Hyperaldosteronism

- **Hypertension**
  - **Usually they present with hypertension in young age**
- **Symptoms of hypokalaemia**
  - **Arrhythmias**
  - **Polyuria and Polydipsia**
  - **Muscular weakness, fatigue, paralysis.**
- **A positive trousseau or chevostek.** pseudohypocalcemia Due to metabolic alkalosis
- Accelerated/malignant hypertension is rare

★ Laboratory findings of Hyperaldosteronism

- **High serum sodium**
- **Potassium depletion**
- **Metabolic alkalosis**
- **Abnormal glucose tolerance.** Not to the way that can get DM, but they have glucose level abnormality

❖ Diagnostic Tests:

- **Ratio of plasma aldosterone to plasma renin (ARR)*.** Sensitive test that tells you whether patient has a Primary OR Secondary hyperaldosteronism
  - **We measure plasma Aldosterone level AND plasma renin level, IF:**
    - **The Ratio is high (Low renin & High aldosterone) = Primary**
    - **The Ratio is Low (High renin & High aldosterone) = Secondary**
- **24-hour urinary aldosterone excretion test.** it is superior to plasma aldosterone measurement in detecting abnormal production of aldosterone
- Saline infusion
- Oral sodium loading
- **Now, if we want to make sure that the cause is <u>primary hyperaldosteronism</u> we will use the following test:(Biochemical / Imaging)**
  - **Adrenal venous sampling.** A sample is taken from adrenal veins
    - **High level of aldosterone on <u>one side</u> = Adrenal adenoma**
    - **High level of aldosterone on <u>both sides</u> = Adrenal hyperplasia**
- **Imaging tests**
  - **CT scan/MRI of adrenals.** Demonstrate adenoma OR hyperplasia anatomically
  - **Iodocholesterol scanning.** Functional approach to differentiate between adenoma and hyperplasia

*ARR = aldosterone : renin ratio

❖ Management:

- **Adenoma → Surgical resection (Adrenalectomy)**
- **Adrenal hyperplasia**
  - **Spironolactone.** (potassium sparing). It helps in correcting both HTN & Potassium
  - **NO surgery.** remember there is bilateral enlargement, you can not take them out

Pheochromocytoma

- **Pheochromocytomas are tumours arising from the chromaffin cells in the sympathetic nervous system.** It could be from adrenal medulla (most common) or extra adrenal
- **They release epinephrine or norepinephrine (or both) and in some cases, dopamine into the circulation causing hypertension as well as other signs and symptoms.**
- **Might be fatal if not diagnosed.** **Especially in case of delivery or surgery**
- **Pheochromocytoma may occur as a heritable disorder either alone or in combination with other endocrine tumours (eg: MEN type II A or MEN type II B)**
- **Most patients have symptoms that is mainly episodic or paroxysmal**

★ Clinical features of Pheochromocytoma

- **Hypertension.** Blood pressure is high always. On top of that, they can develop episodes of severe HTN (Paroxysmal). Remember: among causes of HTN, Pheochromocytoma is only 0.1%
- **Headache**
- **Sweating**
- **Forceful heart beat with or without tachycardia**
- **Anxiety or fear of impending death**
- **Tremor**
- **Fatigue or exhaustion**
- **Nausea and vomiting**
- **Abdominal or chest pain**
- **Visual disturbances**
- **Laboratory findings: Hyperglycemia, hyperlipidemia, hypokalemia**

In the attack, the symptoms resemble those produced by injection of epinephrine or norepinephrine

- **The Role of 10**
  - **10% bilateral**
  - **10% Familial**
  - **10% Malignant**
  - **10% Extra adrenal**

Common extra adrenal sites and near the kidneys and the organ of Zuckerkandl. can also occur in the posterior mediastinal region

Pheochromocytoma may occur as a heritable disorder either alone or in combination with other endocrine tumours, e.g:

- **MEN type II A – hyperparathyroidism, pituitary adenoma and medullary thyroid carcinoma or**
- **MEN Type II B – pheochromocytoma with mucosal neuroma**

★ Histories help in suspecting Pheochromocytoma

- **Patients with paroxysmal symptoms**
- **Children with hypertension**
- **Adults with severe hypertension not responding to therapy.**
- **Hypertensive patients with diabetes or hyper metabolism**
- **Hypertensive patients with symptoms resembling the symptom complex.** **mentioned above**
- **Patients who become severely hypertensive or go into shock during anesthesia.** **Scenario:patient has had appendicitis and he said that the doctors say he was shocked during anesthesia**
- **Patients who have disorders sometimes associated with pheochromocytoma** (i.e: MEN syndrome)

❖ Diagnostic Tests:

- **Plasma catecholamines (Metanephrines)**
- **Urine screen.** to detect the presence of the breakdown metabolite of epinephrine or norepinephrine
  - Metanephrine
  - Normetanephrin
  - Vanilly Mandelic Acid (VMA)
- **Imaging test:**
  - **MRI**
  - **CT scan**

❖ Management:

- **Surgical removal of the tumour**
  - Patients should take **α-blocker (Phenoxybenzamine)** 14 days before surgical removal as well as β-blocker (eg:propranolol) to control both BP and tachycardia
- **Once the tumor is removed, the blood pressure usually falls. So, IV fluids and / or blood might be needed to restore circulatory volume**

MCQ's

Q1:A 55-year-old patient presents with chronic cough. In addition to the cough, the patient has gained weight recently with development of a "buffalo hump" and Cushingoid features. A chest x-ray film demonstrates a mass involving the central area of the chest. Bronchoscopy is performed, and it proves possible to biopsy the tumor during the procedure, .ich of the following is the most likely diagnosis?

(A) Adenocarcinoma
(B) Bronchoalveolar carcinoma
(C) Large cell carcinoma
(D) Small cell carcinoma
(E) Squamous cell carcinoma

Q2:A 27-year-old woman comes to her physician because of weakness, weight loss, and amenorrhea for 6 months. Her blood pressure is 100/65 mm Hg. On examination, increased skin pigmentation is seen, especially around the nipples and over the knees, elbows, and knuckles. Laboratory analysis shows:

- **Sodium 125 mEq/L**
- **Potassium 6.3 mEq/L**
- **Chloride 100 mEq/L**
- **Calcium 10 mEq/L**

Complete blood count shows mild lymphocytosis with eosinophilia. Low plasma levels of cortisol and high levels of ACTH are detected on a blood sample drawn at 8 am. Which of the following is the most common cause of this disease?

(A) Adrenoleukodystrophy
(B) Autoimmune destruction
(C) Bilateral adrenal hemorrhage
(D) Fungal infection
(E) Metastatic disease

Q3:64-year-old man presents to the emergency department after a motor vehicle crash and receives a CT of the abdomen that shows a finding of a unilateral mass in the left adrenal gland. He is unharmed from the accident, feels well, and has never smoked. His blood pressure is 155/90 mm Hg, deep tendon reflexes are 3/4, and muscle strength is 4/5. Laboratory studies show:

- **Na+: 150 mEq/L**
- **K+: 3.0 mEq/L**
- **Cl−: 105 mEq/L**
- **HCO3-: 36 mEq/L**

Plasma renin activity is also decreased. Which of the following is most likely to be increased?

(A) Aldosterone
(B) Anion gap
(C) Carcinoembryonic antigen
(D) Prostate-specific antigen

Answers: 1.D, 2.B, 3.A

Thank you

If you have any question please contact with us at:
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