

جَائِزَةُ الْحُسَيْنِ
بْنِ عَبْدِ اللَّهِ الثَّانِي
لِلْعَمَلِ التَّطَوُّعِيِّ

AL HUSSEIN BIN ABDULLAH II
AWARD FOR VOLUNTARY WORK



النادي الطبي
Medical Club



Radiology

Subject: Radiation principles (notes)

Group no: D11

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هَذَا خُلِقَ اللَّهُ فَأَرْوَنِي مَاذَا خُلِقَ الذِّينَ مِنْ دُونِهِ بَلِ الظَّالِمُونَ فِي ضَلَالٍ مُبِينٍ

* عبارة عن مكونات (الكرومات) متعلق من
ال Cathode لا Anode بتساري عالي جدًا .
(معدن) (معدن)

* source of x-ray → tube

الغلبة تتم بداخل Tube
من Pyrex → تتحمل درجات حرارة عالية جدًا
Vaccum
له "مفرغ من الهواء" صناعي
الإلكترونات ماضية من الكاثود
جهد عالي أو تساريف خاص
Source of X-Ray
من أنابيب ال X-Ray
إلى يتم فيه عملية إنتاج الأشعة

الأشعة السينية هي نوع من الإشعاع الكهرومغناطيسي ذو طاقة عالية وطول موجي قصير، قادر على اختراق أنسجة الجسم بدرجات متفاوتة حسب كثافتها، ويُستخدم بشكل أساسي في التصوير الطبي لتشخيص الأمراض.

الإشعاع - موجات مغناطيسية ذات تساريف عالي مصدرها من الإلكترونات .

ALARA Principle (As Low As Reasonably Achievable)

ALARA is a fundamental principle in radiology and radiation protection.

Definition
Radiation exposure should be kept as low as reasonably achievable, taking into account clinical benefit, cost, and practicality.

It applies to:

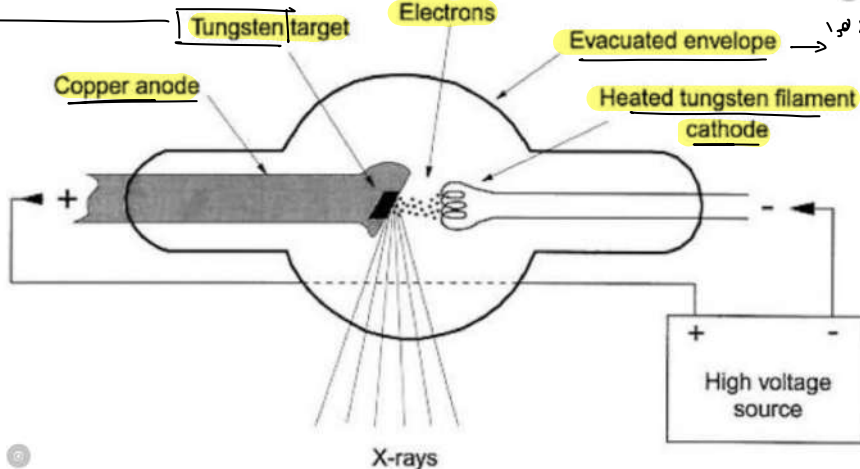
- Patients
- Radiology staff
- Public

ALARA (As Low As Reasonably Achievable) is a fundamental principle in radiology and radiation protection. It states that radiation exposure should be kept as low as reasonably achievable, taking into account clinical benefit, cost, and practicality. It applies to patients, radiology staff, and the public.

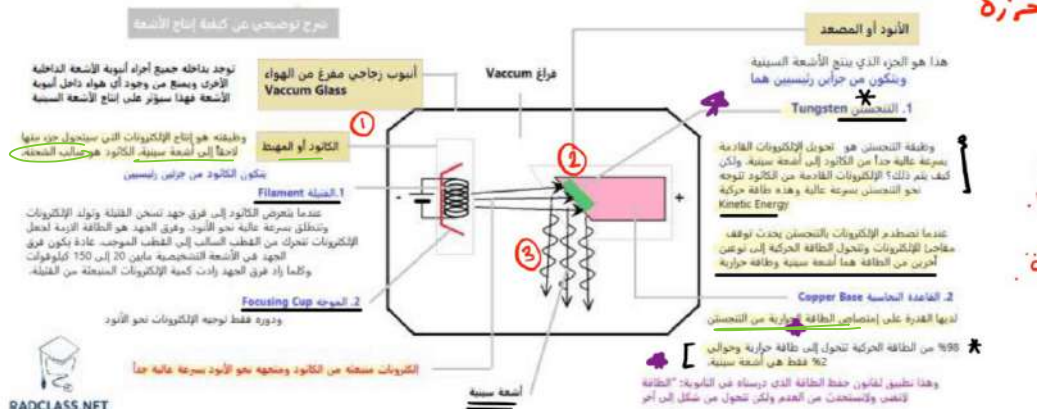
اعين د امر بتحمل الحرارة
بتحمل د 15 الأسم مئوية

Tungsten (W)

- عالي Atomic number ✓
- إلكتروناته ممسوكه بقوة BUT ✓
- تتحمل حرارة عالية جدًا ✓
- صعب يطلع إلكترونات بدون تسخين قوي ✓



عشان ارجع ما يتدمر بالهوا
و مصعد خلاصها



* هل الراجعة حرارة؟ طبعا

most Sensitise organs

=> ① thyroid ② gonads ③ LUs, ovaries / testes
④ bone marrow ⑤ breast ⑥ lenses → cataract

* كيف احمي حالي كطبيب ولكم يعني ، يعني كيف اخفضت ال dose -g تبعت ال احموة

(1) نهور ففهم الضرورة ← يعني في indication حقيقي ، مو اي صواي بعل brain CT مثلاً .

(2) distance ← كل ما بكون كل ما كان اصحت

$$\frac{m}{N} = \frac{\text{سرعة خاتية}}{\text{زمن اقل}} \uparrow \text{مساحة اقل}$$

(3) Time ← كل ما كان اقل كان اصحت

(4) لبس اللبس الواقعي للمريض والدكتور ← الواقعي الرماهي

وبغضلي الرماهي اي صايدي الهورما والالم مها findings

هو في الحياض بغضلي الرقيب علىان الغدة ، في عثمان ال gonds في مكنواو للعين وهيلك .

(5) مهم الذقة بالصور وطريقة التصوير + (6) اباجية تبعت الراكثرة اي بتصبمكم تفضوا للاحموة

* هلاك صحت نقدر نسج اليمين من ال احموة ، ومانهم لا Quality ، كثير هم انه نغاول ما نجد الهورة ، عثمان نقل ال تكرار التصوير .

ثانياً: حماية الدكتور / الطاقم

1 الوقت (Time)

• تقليل وقت التعرض للأشعة

2 المسافة (Distance)

• كل ما زادت المسافة → الجرعة تقل

3 التدريع (Shielding)

(Inverse square law)

• Lead apron

• Lead gloves

• Lead glasses

• الوقوف خلف حاجز رصاصي

✳️ الثلاثي الذهبي للحفظ:

Time - Distance - Shielding

3 المراقبة (Monitoring)

• استخدام Dosimeter badge

• لمراقبة الجرعة التراكمية



أولاً: حماية المريض

1 تقليل الجرعة (Dose reduction)

• اختيار أقل kVp و mAs مناسبين

• تجنب تكرار الصورة

• استخدام تقنيات رقمية بدل الفيلم

2 تحديد مجال التصوير (Collimation)

• تصوير المنطقة المطلوبة فقط

• يقلل الجرعة + يحسن جودة الصورة

3 الدروع الواقية (Shielding)

• Lead apron

• Gonadal & thyroid shields (إذا أمكن)

• مهم خصوصاً للأطفال والحوامل



4 الفحص عند الضرورة فقط

• ما نعمل أشعة إلا إذا إنها indication واضح

• تجنب الأشعة غير الضرورية

X-Ray → ↑ Penetration ⇒ ↑ radiation ⇒ more dark in color. (من كثرة الاشعة = اكثر)

Radiolucent → black, air high penetration

Radioopaque → white, bone absorption

- Fat → dark grey to black
- soft tissue → light grey

Bone →

dense, hyperdense, lucent

Lucent → more benign → likely cyst

Lytic → more aggressive → likely mets or multiple myeloma

↑ Penetration = ↑ black (lungs)
↓ Penetration = ↑ white (Bone)



Osteolytic lesion

1 Lucent vs Lytic — Are they the same?

- **Lucent lesion:** General term for any area in bone that appears darker on X-ray than normal bone (because it absorbs less X-ray).
- **Lytic lesion:** A type of lucent lesion where there is actual bone destruction. It's usually pathological.

So: All lytic lesions are lucent, but not all lucent areas are lytic.

2 Why do they appear dark?

- X-rays pass more easily through areas with less mineralized bone.
- Causes of lucency:
 - Bone loss (osteoporosis)
 - Bone replaced by tumor
 - Infection

3 Radiologic appearance

◆ Lytic lesion

- Focal well-defined or ill-defined dark area in the bone
- Can have cortical thinning or expansion
- May show "moth-eaten" or "geographic" patterns

Examples:

- ✓ Multiple myeloma → "punched-out" lytic lesions
- ✓ Metastatic cancer → variable lytic lesions
- ✓ Osteomyelitis → lytic area with irregular borders

◆ Lucent lesion (general)

- Could just be a simple radiolucent cyst or area of bone thinning
- ✳ Not necessarily aggressive
- Example: Bone cyst, fibrous dysplasia

4 Key features to describe in radiology

1. **Size & shape** – round, oval, irregular
2. **Borders** – well-defined (benign) vs ill-defined (aggressive)
3. **Effect on cortex** – intact, thinned, expanded, broken
4. **Matrix** – calcified or not
5. **Number & location** – single vs multiple, metaphysis vs diaphysis

Quick tip for exams:

- Lucent = dark on X-ray
- Lytic = destructive dark lesion, usually pathological

* Density of colors on X-ray.

1 Black (Radiolucent)

What it means:

- The area appears black because X-rays pass through it easily
- Very low density
- Low atomic number

Why black?

- Almost no absorption of X-rays
- Most photons reach the detector

Examples:

- Air (lungs, bowel gas)
- Pneumothorax
- Emphysema

✳ Air is the most radiolucent structure on X-ray.

2 White (Radiopaque)

What it means:

- The area appears white because it absorbs or blocks X-rays
- Very high density
- High atomic number

Why white?

- X-rays are absorbed → few photons reach the detector

Examples:

- Bone (calcium)
- Metal (prosthesis, bullets)
- Contrast media (barium, iodine)
- Calcifications

✳ Bone is white because calcium strongly attenuates X-rays.

3 Gray (Soft tissue density)

What it means:

- Partial absorption of X-rays
- Intermediate density

Why gray?

- Some X-rays are absorbed
- Some pass through

Examples:

- Muscles
- Liver, spleen, kidneys
- Blood and fluids
- Soft tissue masses

✳ Most abdominal organs appear gray and overlap in density.

Fat vs Soft tissue (important nuance)

- Fat → darker gray
- Soft tissue / fluid → lighter gray

That's why:

- Fat planes help us outline organs
- Loss of fat planes suggests inflammation or mass

The Density Rule (High-yield for exams)

From darkest to brightest:

Air → Fat → Soft tissue → Bone → Metal

CT

الفكرة الأساسية

الـ CT ما بنش "صورة رمادية".

هو قياس رقمي للكثافة اسمه Hounsfield Units (HU).

كل تسجيح إله رقم $\rightarrow$ يتحول لدرجة رمادي.

Hounsfield Units (High-yield)

Tissue	HU (approx.)	Appearance
Air	~ 1000	Black
Fat	~ 100 to ~ 50	Dark gray
Water	0	Gray
Soft tissue	+30 to +60	Light gray
Bone	+700 to +1000	White
Metal	$> +1000$	Very white

1 Black – Hypodense

Meaning:

- Very low density
- Low attenuation of X-rays

Why black?

- X-rays pass easily $\rightarrow$ minimal absorption

Examples:

- Air (lungs, bowel gas)
- Pneumothorax

✶ Air is the most hypodense structure.

2 Dark Gray – Fat density

Meaning:

- Low density, but not as low as air

Why dark gray?

- Fat attenuates X-rays more than air, less than water

Examples:

- Subcutaneous fat
- Retroperitoneal fat

✶ Fat planes help define organ borders.

3 Gray – Water / Fluid density

Meaning:

- Density around 0 HU

Why gray?

- Balanced absorption and transmission

Examples:

- CSF
- Urine
- Simple cysts
- Edema

✶ Simple fluid = water density.

4 Light Gray – Soft tissue (Isodense)

Meaning:

- Moderate density

Why light gray?

- Partial attenuation

Examples:

- Liver, spleen
- Muscle
- Blood (non-contrast)

✶ Many organs look similar $\rightarrow$ called isodense.

5 White – Hyperdense

Meaning:

- High density
- Strong attenuation

Why white?

- X-rays absorbed strongly

Examples:

- Bone
- Acute hemorrhage
- Calcifications
- Contrast (iodine)

✶ Fresh blood is hyperdense on non-contrast CT.

Important CT terms (Exam gold 🌟)

- Hypodense $\rightarrow$ darker than surrounding tissue
- Hyperdense $\rightarrow$ brighter than surrounding tissue
- Isodense $\rightarrow$ same density as surrounding tissue

✶ These terms are CT terms, not X-ray terms.

CT vs X-ray (quick compare)

Feature	X-ray	CT
Density description	Opaque / Lucent	Hyper / Hypo / Iso
Measurement	Qualitative	Quantitative (HU)
Image	2D	Cross-sectional

One-Dose

Multiple doses
(مقاطع)
(high radiation dose)

MRI

What is MRI?

Magnetic Resonance Imaging (MRI) is an imaging modality that:

- Does not use ionizing radiation
- Uses a strong magnetic field and radiofrequency (RF) pulses
- Is based on the behavior of hydrogen protons (H^+) in the body

MRI is excellent for soft tissue imaging.

Why hydrogen (H^+)?

- Hydrogen is abundant in the body (water and fat)
- Each hydrogen atom has one proton
- Protons have a magnetic moment, so they respond well to magnetic fields

What happens inside the MRI scanner?

1 Main magnetic field (B_0)

- The strong magnetic field causes hydrogen protons to align:
 - Parallel
 - Anti-parallel
- This creates a net magnetization vector

2 RF pulse (Excitation)

- An RF pulse is applied
- Protons absorb energy and change their alignment
- They move into an excited state

3 Relaxation (Signal generation)

- When the RF pulse stops:
 - Protons return to their original state
 - They release energy as a signal
- The MRI system detects this signal and creates the image

There are two main types of relaxation: T1 and T2

T1 Relaxation (Longitudinal relaxation)

- Refers to recovery of magnetization along the direction of the magnetic field (B_0)
- Tissues that recover faster appear bright

T1-weighted images:

- Fat $\rightarrow$ bright
- Water / CSF $\rightarrow$ dark

Uses:

- Anatomical detail
- Post-contrast imaging (gadolinium)

Mnemonic: T1 = Fat is bright

T2 Relaxation (Transverse relaxation)

- Refers to loss of phase coherence between protons
- Tissues that retain signal longer appear bright

T2-weighted images:

- Water / edema $\rightarrow$ bright
- Fat $\rightarrow$ less bright

Uses:

- Pathology detection
- Edema, inflammation, tumors

Mnemonic: T2 = Water is bright

T1 vs T2 (Quick comparison)

Feature	T1	T2
Water	Dark	Bright
Fat	Bright	Gray / mildly bright
Best for	Anatomy	Pathology

How does H^+ affect image intensity?

Signal intensity depends on:

- Hydrogen proton density
- T1 and T2 relaxation times
- The molecular environment (water, fat, proteins)

Important note

MRI image brightness represents signal intensity, not tissue density (unlike CT).

That's why we describe MRI findings as:

- Hyperintense
- Hypointense
- Isointense

What is Ultrasound (US)?

Ultrasound is an imaging modality that:

- Uses **high-frequency sound waves**
- Does **not** use ionizing radiation
- Produces **real-time images**

Because it is **very safe**, it is widely used in:

- **Pregnancy**
- **Pediatrics**
- Bedside and emergency settings

How does Ultrasound work?

1 The transducer (probe)

- Contains **piezoelectric crystals**
- When electrical energy is applied:
 - The crystals **emit ultrasound waves**
- When reflected waves return:
 - The crystals **convert them back into electrical signals**

These signals are processed to form an image.

2 Interaction of sound waves with tissues

Ultrasound waves may:

- Reflect ✓
- Refract ✓
- Scatter ✓
- Be absorbed ✓

The image depends on:

- **Time of return** of the echoes
- **Strength of the reflected signal**

Why do tissues look different on ultrasound?

This depends on **acoustic impedance**, which is related to:

- **Tissue density**
- **Speed of sound within the tissue**

A greater difference in acoustic impedance between tissues results in **stronger reflection**.

Echogenicity (Key concept)

Term	Appearance	Example
Anechoic	Black	Fluid cyst
Hypoechoic	Dark gray	Muscle
Isoechoic	Same as surrounding tissue	Normal organs
Hyperechoic	White	Bone, stones, fat

★ **Fluid produces no echoes and therefore appears black.**

Ultrasound artifacts (High-yield)

◆ Posterior acoustic enhancement

- Seen **behind fluid-filled structures**
- Due to **minimal attenuation** of sound

◆ Acoustic shadowing

- Seen **behind bone or calculi**
- Due to **strong absorption or reflection** of sound

Clinical uses of Ultrasound

- **Abdominal imaging:** liver, gallbladder (stones), kidneys
- **Pelvic imaging:** uterus, ovaries, pregnancy
- **Pediatrics:** pyloric stenosis, intussusception
- **Vascular imaging:** Doppler studies
- **Procedures:** biopsies, central line insertion

Doppler Ultrasound

- Used to **assess blood flow**
- Measures:
 - Direction
 - Velocity
- Commonly used in:
 - Deep vein thrombosis (DVT)
 - **Carotid artery disease**

Advantages of Ultrasound

- No radiation
- Low cost
- Portable
- Real-time imaging
- Safe in pregnancy and children

Limitations

- **Operator dependent**
- Poor penetration through:
 - Bone
 - Air (lungs, bowel gas)
- **Reduced image quality in obese patients**

1 Bone appears hyperechoic (very bright / white)

Why?

- أغلب الموجة الصوتية **تتبعكس مباشرة**
- يرجع Echo قوي للـ probe

لذلك: ★

سطح العظم = أبيض جداً على US

2 Posterior acoustic shadow

Why?

- الموجات ما بتقدر تخترق العظم
- ما في echoes خلفه

المنطقة خلف العظم تطلع سوداء

هذا اسمه: ★

Acoustic shadowing

• Hazy / dirty shadow

- أو تشويش بالصورة

• Strong reflection

• Scattering

• Shadow

غالباً المقصود:

وهذا بسبب:

• تشتت الموجات

• انعكاس غير منتظم من سطح صلب مثل العظم

★ العظم يعمل:

★ هناك نوع probe خاص بال bone.

Projection

* لوعنديه projection على Side شروح احباري؟ PO (ت عسات يعوت احبار اسلي)

* الوجه المراد تصويرها ← اقرب للفيلم

● **Projection:** the direction of the beam through the body

PA: from posterior to anterior *More routinely Done.* من وراء القدم ← heart بعيد عن فيلم بتاليه مجمه جالبي/لو كان قريت رج يخبي lung سين كبير

AP: from anterior to posterior

APO: anterior part of the body is closer to the tube in oblique position

PAO: posterior part of the body is closer to the tube in oblique position

Mediolateral: from the medial part to the lateral part

Lateromedial: from the lateral part to the medial part

* معتمد AP بال chest؟ لما ما احتر اعلم PA ← كيس مش قادر يتحرك

← حفيف
← بعد عمليه

Ap → Arm
→ Abdominal

مثال الذراع
من الجنب ال
Medial
to
lateral
أو العكس

CXR

* best PA → due to heart may appear large than normal in AP

* Check that clavicle not cover the apex of the lung

* During full inspiration → The 6th rib cut diaphragm in half

* full expiration in → Small PTX and foreign body air trapping (distal)

* Pneumothorax
 زي مثال
 لما تنفخ
 بالون في
 المياه
 وتنفخ
 بعض
 مع الضغط القوي تنفخ
 مع الزفير الهواء المتشرب يتصعد

لما توفد نفس خالص الهواء
 صافا ال foreign body ولكن
 مع التبر بعلق الهواء جوا

PA chest radiography is preferred to AP, why?

- Less magnification of the heart.
- More lung fields are visualized.
- The PA projects the scapula away from the lung fields. → ينشأ الأضلاع خلف الصدر بعيدا عن الرئة
- The apices of the lungs are closer to the film in the PA and appear more clear. → ينشأ القمة في

Radiologic appearance (CXR):

On expiration film:

- Affected lung → more lucent (darker)
- Hyperinflation
- Possible mediastinal shift to the opposite side



the lateral view for localisation

Before reading the x-ray film, the following should be checked:

1. Request form

- name, age, sex and date.
- clinical information.

2. Technical factors:

- markers.
- centering (patient position).
- degree of inspiration.
- exposure (penetration).

الدرجة
 كبر
 صغير

كثير مع يكون
 قليل مع يكون

markers on Rt or Lt
 pt. with dextro-cardia
 their apex of Rt. not on Lt.

the amount of radiation differs from person to person depend on weight

* try to give the pt, least amount of radiation. to avoid cancer, mutations

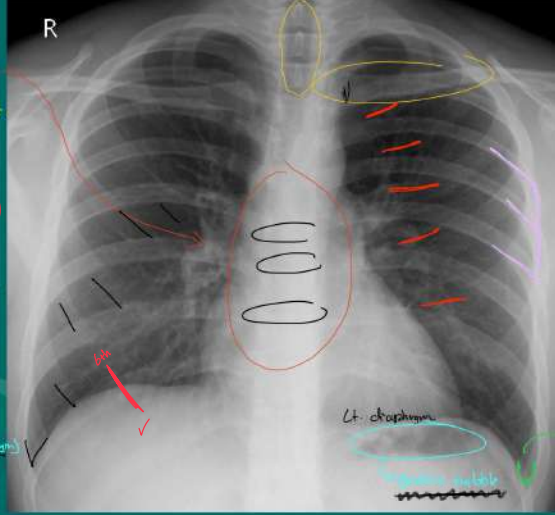
Normal CXR

* Retro cardiac vertebral body → just visible

* depend on them → we know if the exposure is suitable to pt. or not

* Imp to know the difference between gastric bubble and pneumoperitoneum (air under diaphragm)

Air under diaphragm → Crescent in shape



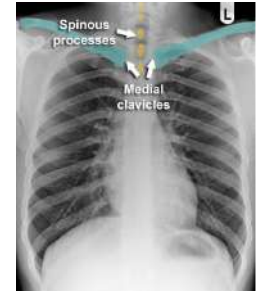
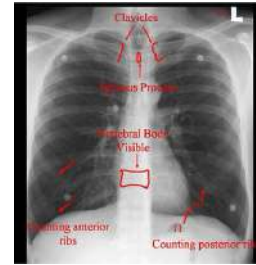
Spinous process medial end to clavicle → Bilaterally

* 6-7 Ribs Anteriorly
 6 → in middle of diaphragm

* 9-10 Ribs Posteriorly

→ Sharp
 first sign to pleural effusion

* Position → C7 to check for apex of the lungs, if difficulty to see → apical lung tumor, abscess
 Spinous process and Clavicle Bilaterally same (distance)
 Costophrenic angle ✓



* Exposure → retro cardiac vertebral body → Just visible (disc space)

↔ if ↑ → 1
 ↔ if ↓ → 1

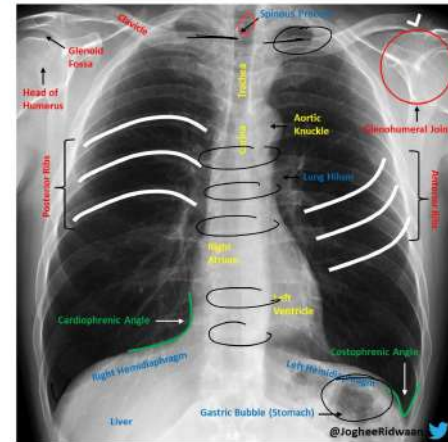
* Inspiration → Ant Rib 6 → 10th rib to diaphragm (full)
 Post. Rib 10

↪ { distance between
 full inspiration — full expiration.

* diaphragm during respiration →
 move 3-5 cm (2.5 vertebrae) normally

but if in each insp and exp move only
 1 vertebra → indicate phrenic nerve palsy

Extra →



- **Unilateral:** may be asymptomatic, mild dyspnea
- **Bilateral:** severe dyspnea, orthopnea
- **Paradoxical movement:** diaphragm moves **upwards** during inspiration (instead of down)

detect
air - fluid
level

air
fluid

Decubitus position

Lying down,
specifically according
to the part of the body
resting on a flat

Surface, as in left or
right lateral decubitus,

location ← مهمه بتحدد

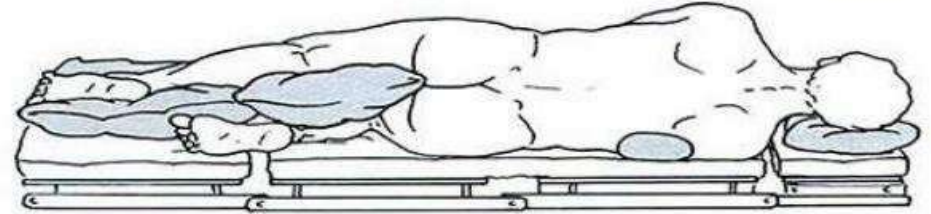
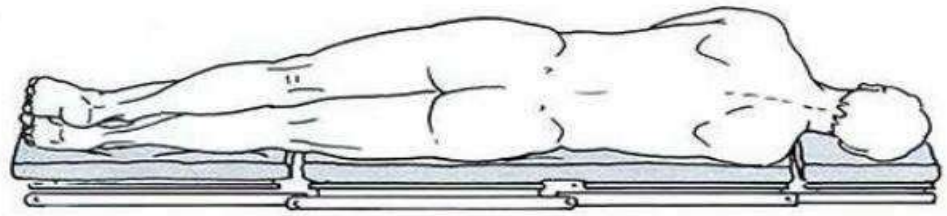
or dorsal or ventral
decubitus

DD → Free gas in abdomen
شوف فرق spine عن dorsal
decubitus

التي ناي على ظهره
بس بال DD بتكون اشبه

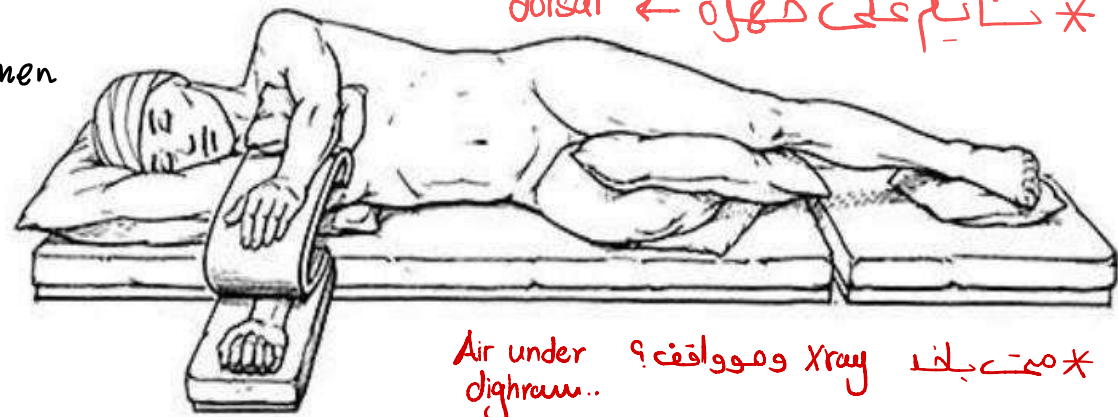
Cross section
لا spine من فوق +

موقع ال Film في DD
على جنبنا مثل كته



* ناي على جنبه ←
+ لونايم شمال
+ لونايم يمين R

* ناي على ظهره ← dorsal



* مت جلد Xray ومواقف؟
Air under diaphragm...
اختناام حاضره مانقيه

Decubitus Positions

- ◆ **Ventral decubitus**

- patient is prone & a horizontal beam is used



- ◆ **Dorsal decubitus**

- patient is supine & a horizontal beam is used



- ◆ **Left lateral decubitus**

- patient lying on the left lateral side & a horizontal beam is used

