atomic model

① in which departments is radiation used?

medical imaging, X-Ray imaging, Tomograph, and Radiotherapy.

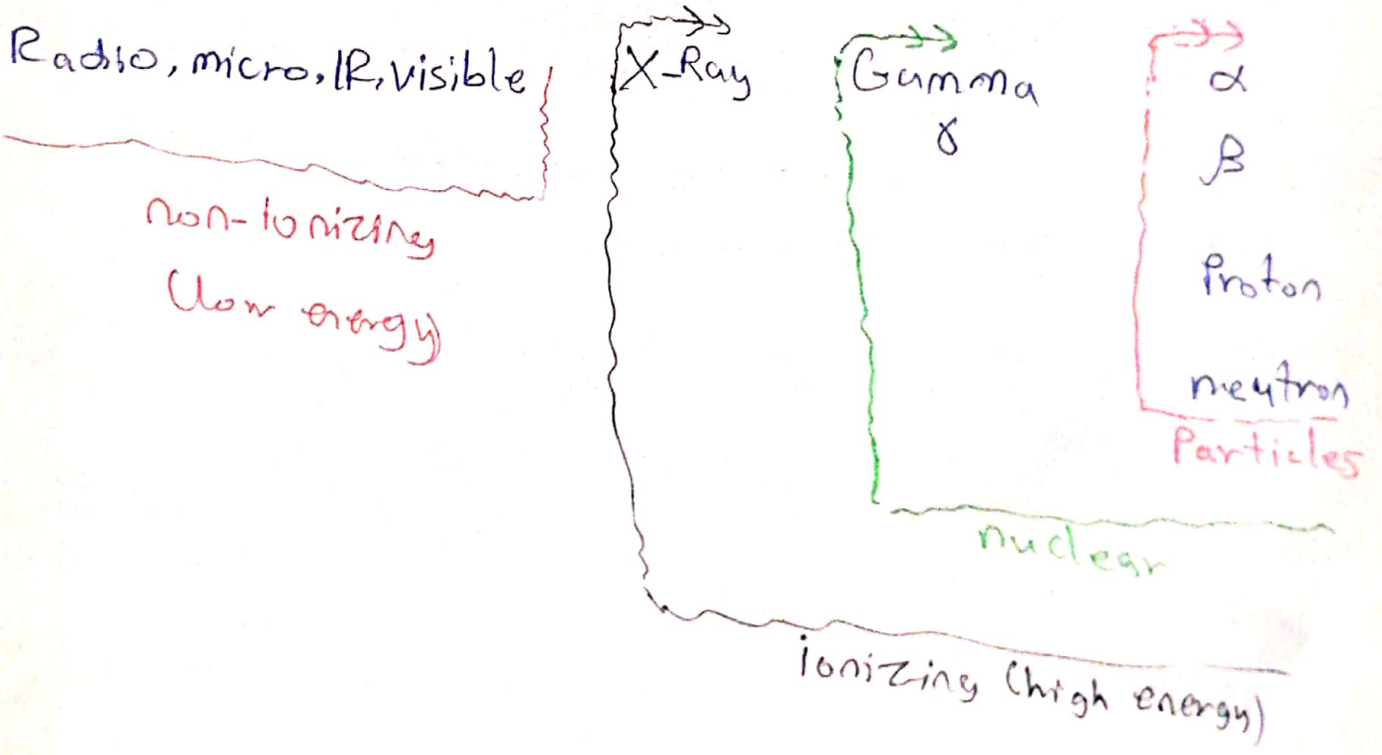
② what instruments are used in the radiology department?

emr, mamography, X-Ray, and more...

③ what is the radiation?

emission of energy from nuclear or orbit

④ types of radiation

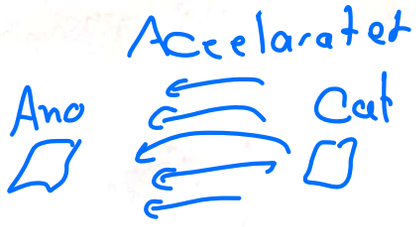


⑤ what are the differences between Gamma and X-Ray?

Gamma	X-Ray
From nuclear	From orbit or electrons
high energy than X-Ray	Low energy than Gamma

X-Ray Production

- Bremsstrahlung X-Ray production
- Characteristic X-Ray production
- X-Ray spectrum
- Quality & Quantity



① How are X-rays produced?

electrons are accelerated by the high voltage from cathode to anode.

② How many types for X-Ray production?

two type:
1. bremsstrahlung → produce 90% of X-Ray
2. characteristic → produce 10% of X-Ray

③ How many % electron energy convert into X-Ray?

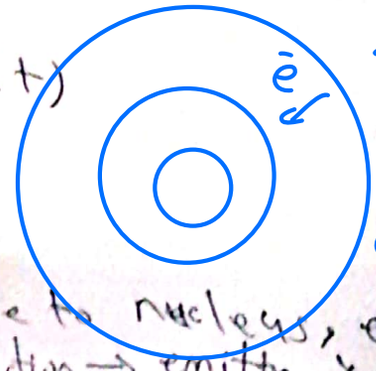
1% is converted into electromagnetic energy or X-Ray

// 99% is converted into heat energy.

④ explain Bremsstrahlung interaction

- radiation produced when projectile electrons are slowed down in the anode.

- electrons (-) → ← nucleus (+)



↓

have high energy

⇒ when electron gets close to nucleus, electron slow down and change direction ⇒ emitte X-ray

(5) which electron produce or emmit high energy?

electrons that pass very close to the nucleus.

high energy ⟹ e pass to the nucleus closer

(6) what is peak kilovoltage (kVp)?

max X-Ray energy = which is equal to the energy of projectile electrons.

(7) X-Ray dosen't change, we can just control V (voltage applied to the x-Ray tube)

↑ V ⇒ ↑ x-ray on ↑ quality & ↑ quantity

(8) in the x-Ray we use 10K electron volt in hospital

False

we use 80K, 90K, and 100K

Hospital: 80K electron V
90K electron V
100K

For mammography we use 25K, 30K, and 40K

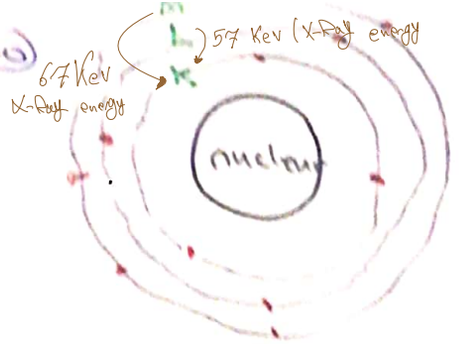
(9) What is the characteristic X-ray production?

electron has high energy

(1) the electron which has high energy remove another electron from orbit

(2) ⇒ another electron in the atom go to fill the place of the electron which removed

(3) ⇒ this transition produce many X-Ray photons.

(10) 

- most common transition of electron from L shell to K shell (From L to K ⇒ X-Ray have 57 Kev energy)
- From M to K : less probability (M to K ⇒ 67 Kev X-Ray energy)

L → K : 57 Kev

M → K : 67 Kev X-Ray ener

(11) What is Quality and Quantity

Quality ↓ energy level ↓ related to kVp setting

Quantity ↓ amount of energy ↓ related to x-Ray intensity ↓ depends on the number and energy of x-Ray photons (mA setting)

(12) kVp and mA, How do the effect on the Quantity and Quality

↑ V ⇒ ↑ Quantity , ↑ Quality

Time = ↑ mA ⇒ ↑ Quantity , Same → Quality

↳ that's mean time has the same effect on X-Ray production as mA

	Voltage	mA = time
high	↑ Quality , ↑ Quanti	Same → Quality , Quantity ↑

X-Ray Tubes

① What does X-Ray Tube consist of?

Cathode (①) and anode (②), electrons go from ① to ②

negatively charged

① **Cathode**: contains the filament, which is heated to boil off the projectile electrons

anode: contains a focal spot, it's area few square millimeter

positively charged

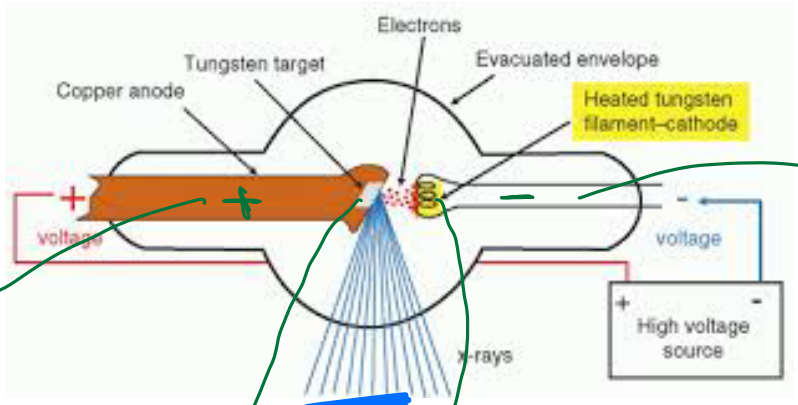
③ **Tube housing**: protective housing surrounds the X-Ray, it contains and shield the emitted X-Rays, include cooling mechanisms
- The house protect against electric shock.

metal house

② what is the thermionic emission?
release of electrons in response to heat, which are heated by filament of cathode.

③ large filaments: produce large focal spots for higher X-Ray production
smaller filaments: produce smaller focal spots for lower X-Ray production

④ smaller filament produces a small focal spots when sharper images or better spatial resolution is required.



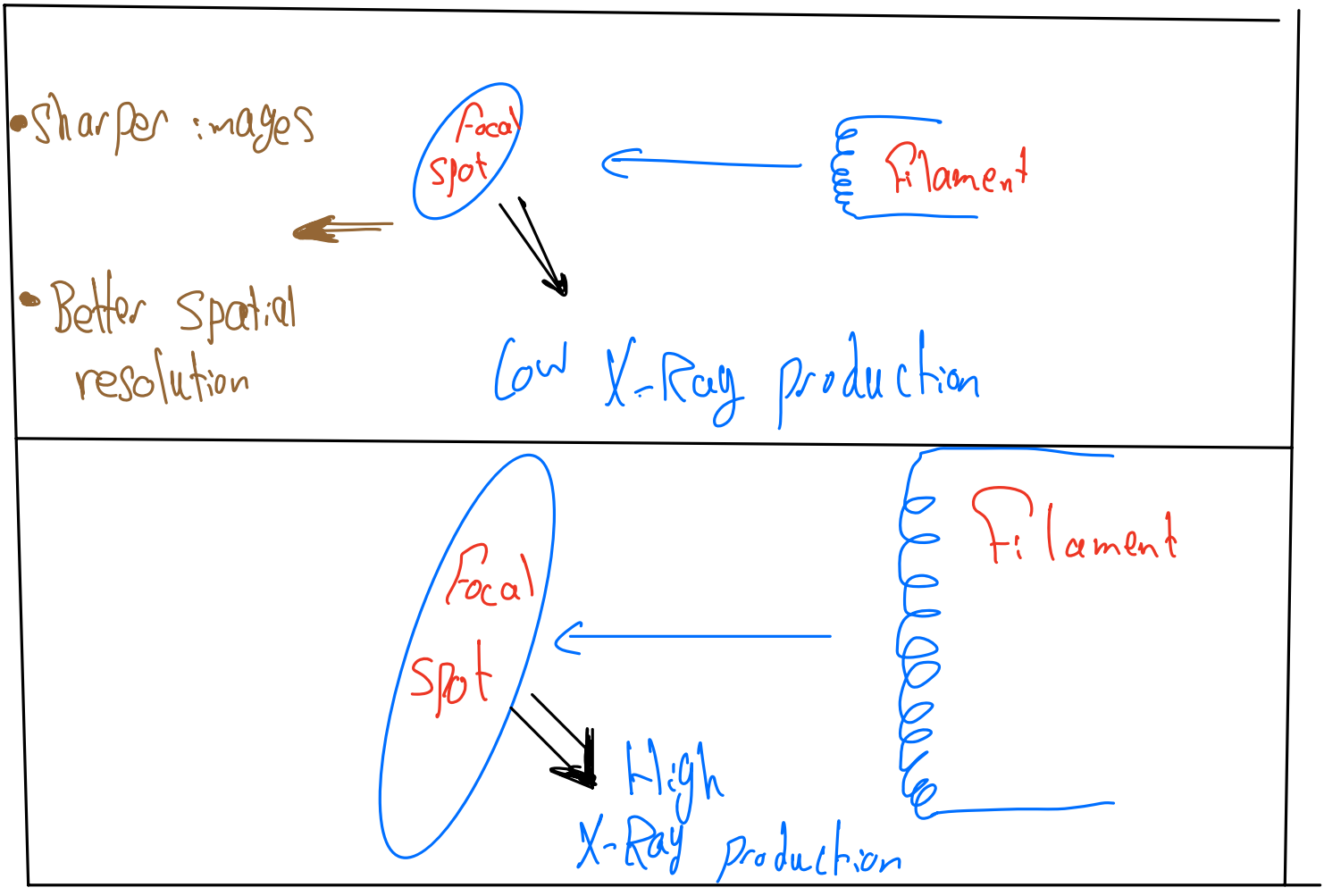
Anode (+)

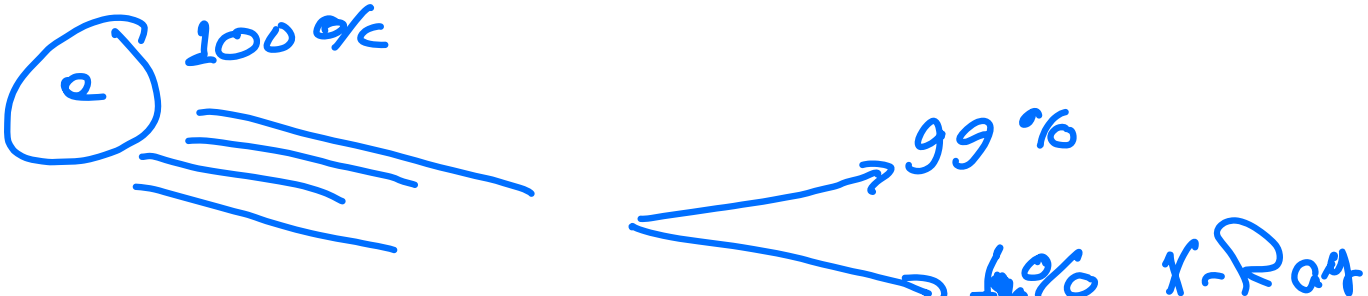
Cathon (-)

Focal Spot

Filament to heat the projectile electrons

- Sharper images
- Better Spatial resolution



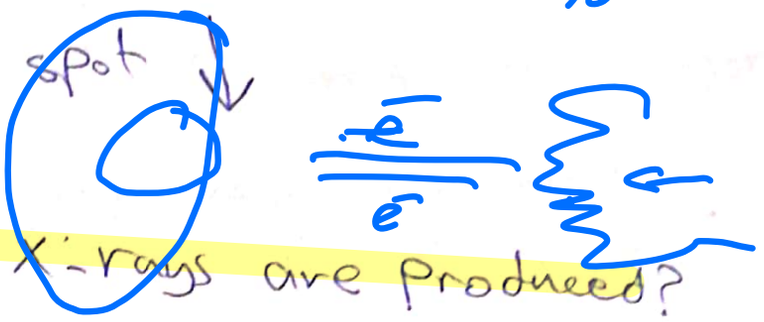


(5) mA ↑ => Focal spot ↑

mA ↓ => Focal spot ↓

99% turn

1%



(6) explain how X-rays are produced?

(-) Cathode

↓

Filament release electrons

↓

applying high V to pass electrons with acceleration

↓

Focusing cup make the electrons go in a narrow beam to anode

(+) anode

↓

Focal spot forces electrons to stop

↓

Projectile electrons hit anode => releasing energy

↓

99% of the electron energy converts into heat

1% converts into X-Ray photons.

(7) The Focal spot on the anode reach temperature > 3000°C during an X-Ray exposure True

!! 3000°C To Produce X-Ray!

(8) Why Tungsten is the metal of choice to make an anode ?

① high atomic number

② high melting point

③ heat conduction ability

(9) Rotating anodes in X-Ray tubes are better than non-rotating anodes

True ✓ Rotatable Anode ✓✓

(10) Why do they better ?

because of their role in spreading heat over a circular track as the anode rotates.

(11) explains the line focus principle

tilting the anode surface at an angle to the X-Ray beam spreads heat over a large area

(12) maintaining a smaller effective focal spot results in sharper images

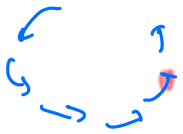
True ✓

(13) Two properties make the anode more effective

① Rotating anode ✓

② tilting anode at an angle to X-Ray beam ✓

This properties make the anode more heat dissipative تبدد



(14) What is the heel effect ?

it is the difference in X-Ray intensity at the cathode and anode ends of the tube that limits the useful field size

X-Ray intensity cathod — X-Ray intensity Anode = heel effect

(15) What causes the heel effect ?!

because some of the X-Rays are produced below the anode surface

(16) When X-Rays produced at locations other than focal spot, this Radiation is called off-focus radiation True ✓

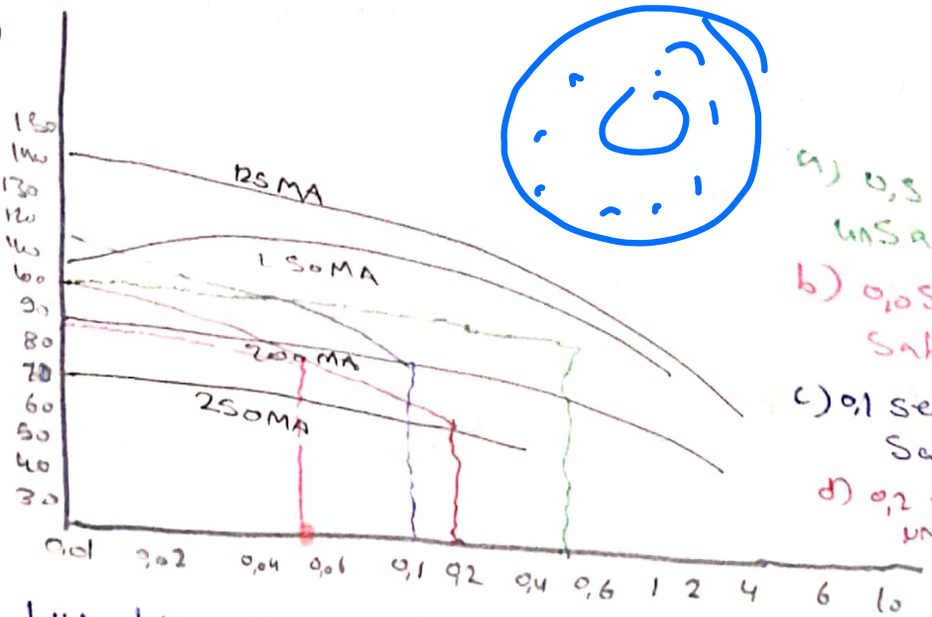
(17) what dose off-focus cause?

it causes radiographic images with appear unsharp, decreases overall image quality

(18) kv ↑ ⇒ off-focus ↓

mA ↑ ⇒ off-focus ↑

19



?!

a) 0,5 second, 125mA, 100kVp unsafe

b) 0,05 second, 200mA, 85kVp Safe

c) 0,1 second, 200mA, 115 kVp Safe

d) 0,2 second, 250mA, 100kVp unsafe

(20) HU = kVp x MA x time → For single phase

= kvp x mA x time x 1,35 → For 3 phase, six pulse

= kVp x MA x time x 1,41 → For 3 phase, 12-pulse (high freq)

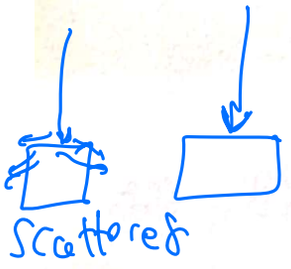
	Voltage	mA / time
high	Quality ↑	Quality → Same
	Quantity ↑	Quantity ↑
	off-locus ↓	off-locus ↑

X-Ray interactions

① What is the conditions of X-Ray photons when they enter the patient?

They can be absorbed, scattered, transmitted

Attenuation



Probabilities 99%

probability 1%

② Attenuation is the combination of absorption and scattering
↳ Reduction of X-Ray photon intensity

③ What does the amount of attenuation depend on?

↑ photon energy ⇒ ↓ Attenuation
↑ tissue thickness ⇒ ↑ Attenuation
↑ tissue density ⇒ ↑ Attenuation
↑ tissue material (atomic Number) ⇒ ↑ Attenuation

④ What is photoelectron?

electron was ejected from the atom when it ionized

⑤ What is the kinetic energy of photoelectron?

$$E_{ke} = E_i - E_b$$

- E_{ke}: photoelectron
- E_i: incident photon
- E_b: binding energy of electron

⑥ $E_i > E_b \Rightarrow$ then interaction occur True ✓

(7) Bone absorbs more photons than muscle True ✓

Because bone has a higher atomic number

(8) The attenuation of bone is [redacted] greater than The attenuation of muscle True ✓

(16) What is compton scattering?

Compton scattering changes the direction and energy of the X-Ray photon

(4) what are the differences between photoelectric interactions and compton scattering?

Photoelectric interaction	compton scattering
- Low X-Ray photon energy - all energy of photon absorbed by the atom - $E_b > E_{ke}$ - No enough energy to continue.	- High X-Ray photon energy - Some of photon energy transferd to the electron - $E_b >>> E_{ke}$ - because of photon [redacted] still has energy it continue to second stage ↓ to produce more X-Ray with another atoms

Questions:

1. Infrared used in MRI ?! X

MRI uses Radio Frequency waves to Generate the image.

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2. List the Electromagnetic spectrum

Radio, Gamma, Microwaves, Infrared, UV, ...

→ Radio waves "less powerful"

↓

Microwaves

↓

Infrared radiation

↓

Visible light

↓

UV radiation → X-Rays

↓

"Most powerful" Gamma Rays

2 ↓ 3 ↓ 2

3) which part of the electromagnetic spectrum is used in MRI ?! → Radio Frequency (RF) waves

Since the RF waves used by MRI "low energy end of the electromagnetic spectrum" and they used to excite the hydrogen protons in the body during the imaging process.

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4) what does the MRI visulize in the body ?!

↳ visualizes the hydrogen protons found in the water molecules within the body's cell.

The MRI machine detects the energy released by these protons as realign with the magnetic field after being distrubuted by the radiofrequency waves pulses

Medical Device	Used Radiation	Mechanism	Uses	Safety and Exposure	Real Time	Diagnostic Purposes
	X-rays	Uses X-rays to create cross-sectional images of the body.	Diagnosing diseases such as cancer, cardiovascular disease, infectious disease, trauma, and musculoskeletal disorders.	Involves exposure to ionizing radiation, with associated small risk of cancer.	No, images are not typically viewed in real-time.	Preferred for quickly visualizing bone fractures, chest imaging, and detecting tumors.
	Radiofrequency waves	Uses magnetic fields and radiofrequency waves to generate images of the organs.	Imaging of soft tissues like the brain, muscles, and tumors without exposure to ionizing radiation.	No ionizing radiation, considered safer for repeated use.	No, images are not typically viewed in real-time.	Preferred for detailed soft tissue contrast, neurological exams, and functional brain imaging.
	None (uses light)	Uses a lighted, flexible instrument to view the digestive tract or other hollow organs.	Visualizing and operating on the internal aspects of hollow organs, often for diagnostic and therapeutic purposes.	Invasive with potential discomfort, but no radiation exposure.	Yes, allows for real-time viewing of the internal organs.	Used for direct visual examination of organs, biopsy procedures, and surgical interventions.
	Sound waves	Uses high-frequency sound waves to create images of structures within the body.	Examining internal organs and tissues, used in prenatal, cardiac, and organ-specific imaging.	No ionizing radiation and non-invasive, safe for repeated use even during pregnancy.	Yes, provides real-time imaging which is useful for guiding procedures.	Commonly used for abdominal issues, pregnancy check-ups, cardiac exams, and guiding biopsies.