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KBR PART ONE **PHYSICS SYLLABUS**

FLUOROSCOPY

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MONDAY **13 JAN 2025** **CHAPTER ONE** FLUOROSCOPY **SYSTEMS**

MONDAY **20 JAN 2025** **CHAPTER TWO** INTERVENTIONAL **ANGIOGRAPHY**

MONDAY **27 JAN 2025** **CHAPTER THREE** RADIATION **SAFETY**

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MONDAY **13 JAN 2025** **CHAPTER ONE** FLUOROSCOPY **SYSTEMS**

MONDAY **20 JAN 2025** **CHAPTER TWO** INTERVENTIONAL **ANGIOGRAPHY**

MONDAY **27 JAN 2025** **CHAPTER THREE** RADIATION **SAFETY**

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CHAPTER TWO

INTERVENTIONAL ANGIOGRAPHY

- OVERVIEW
- KEY PRINCIPLES
- CONTRAST MEDIA
- SUBTRACTION & DSA
- IMAGE QUALITY

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CHAPTER TWO

INTERVENTIONAL ANGIOGRAPHY

- OVERVIEW
- KEY PRINCIPLES
- CONTRAST MEDIA
- SUBTRACTION & DSA
- IMAGE QUALITY

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WHAT IS FLUOROSCOPY

CHAPTER TWO

FLUOROSCOPY

Fluoroscopy is an imaging technique that uses x-rays to create **moving images** of internal structures of the body in **real-time**.

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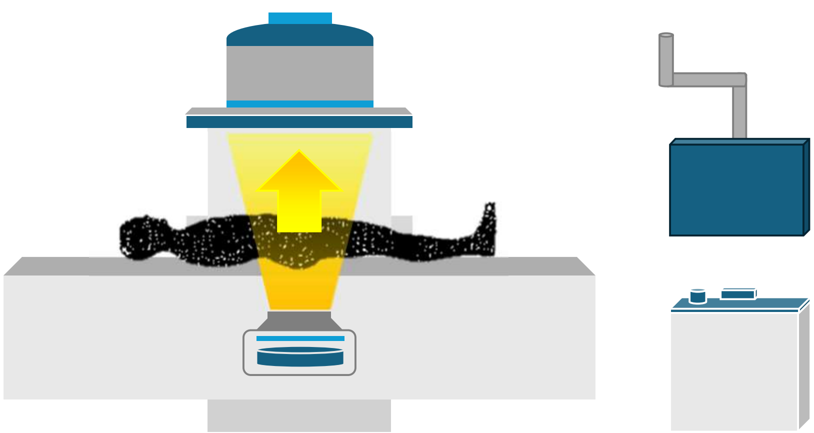
FLUOROSCOPY IMAGING CHAIN

CHAPTER TWO



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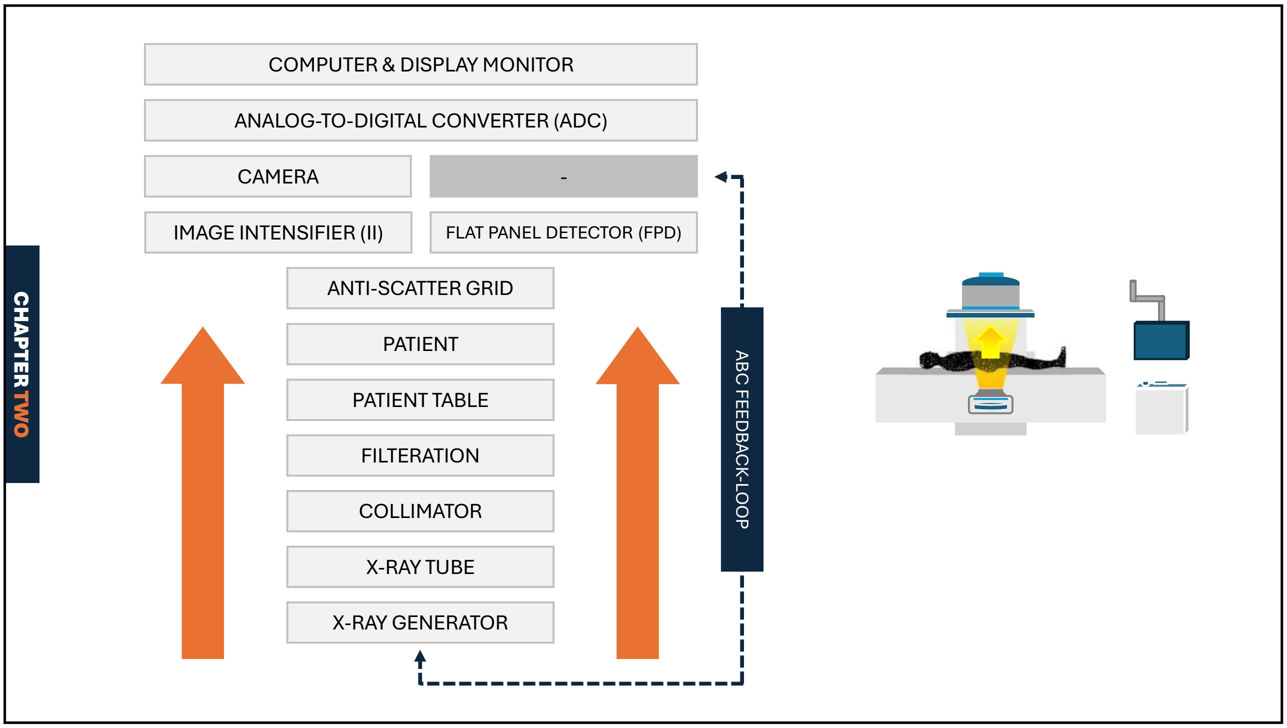
CHAPTER TWO
COMPUTER & DISPLAY MONITOR
ANALOG-TO-DIGITAL CONVERTER (ADC)
CAMERA
-
IMAGE INTENSIFIER (II)
FLAT PANEL DETECTOR (FPD)
ANTI-SCATTER GRID
PATIENT
PATIENT TABLE
FILTERATION
COLLIMATOR
X-RAY TUBE
X-RAY GENERATOR
ABC FEEDBACK-LOOP

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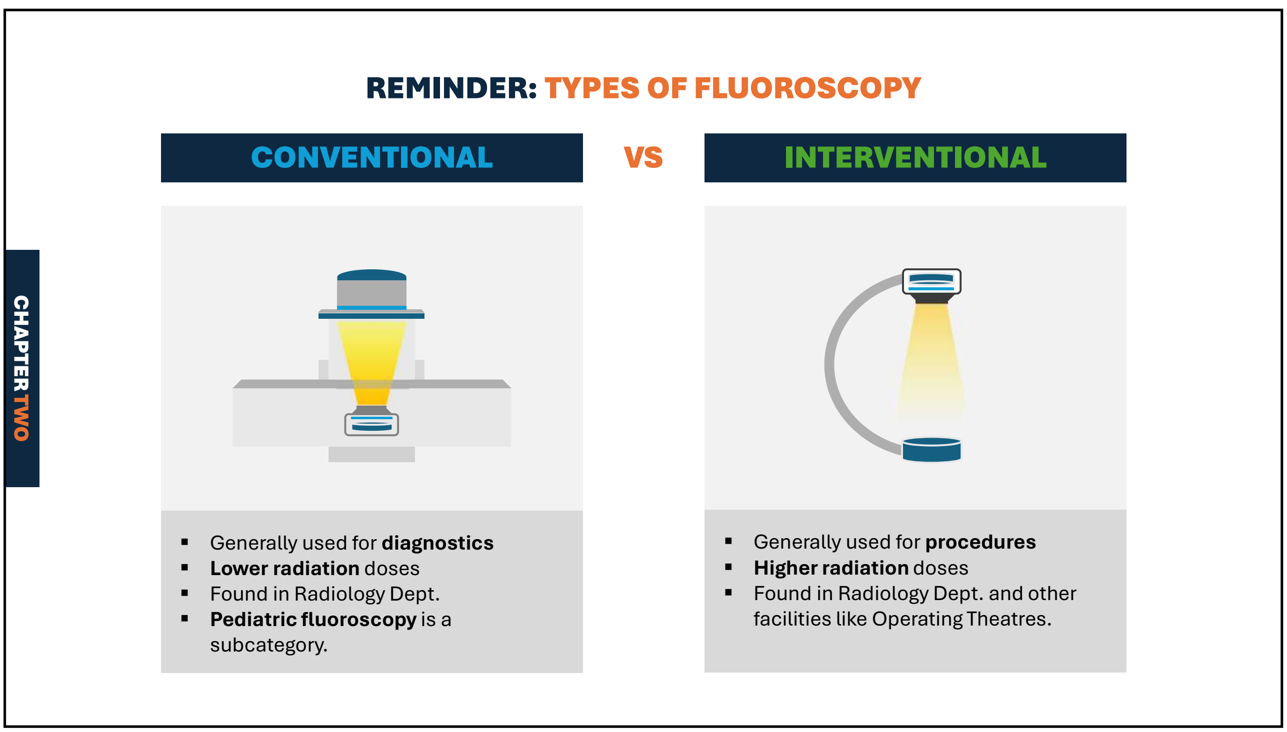
CHAPTER TWO
REMINDER: TYPES OF FLUOROSCOPY
CONVENTIONAL
VS
INTERVENTIONAL
Generally used for diagnostics
Lower radiation doses
Found in Radiology Dept.
Pediatric fluoroscopy is a subcategory.
Generally used for procedures
Higher radiation doses
Found in Radiology Dept. and other facilities like Operating Theatres.

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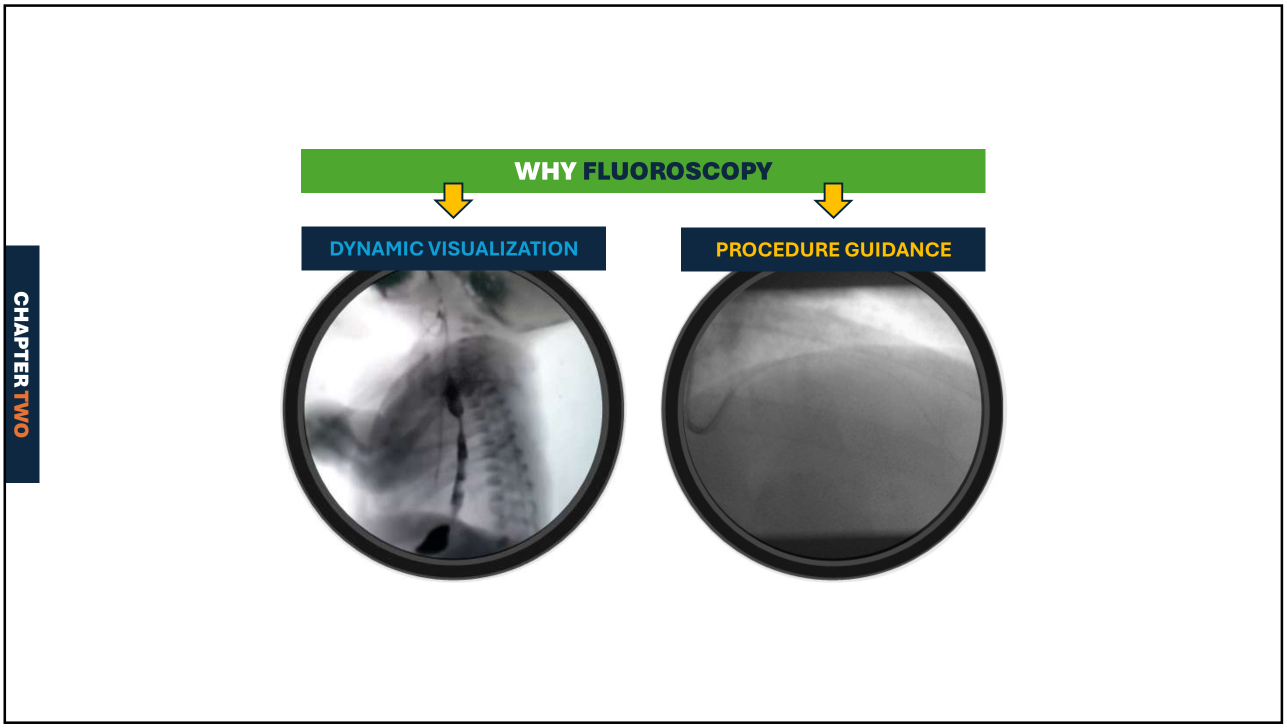
CHAPTER TWO
WHY FLUOROSCOPY
DYNAMIC VISUALIZATION
PROCEDURE GUIDANCE

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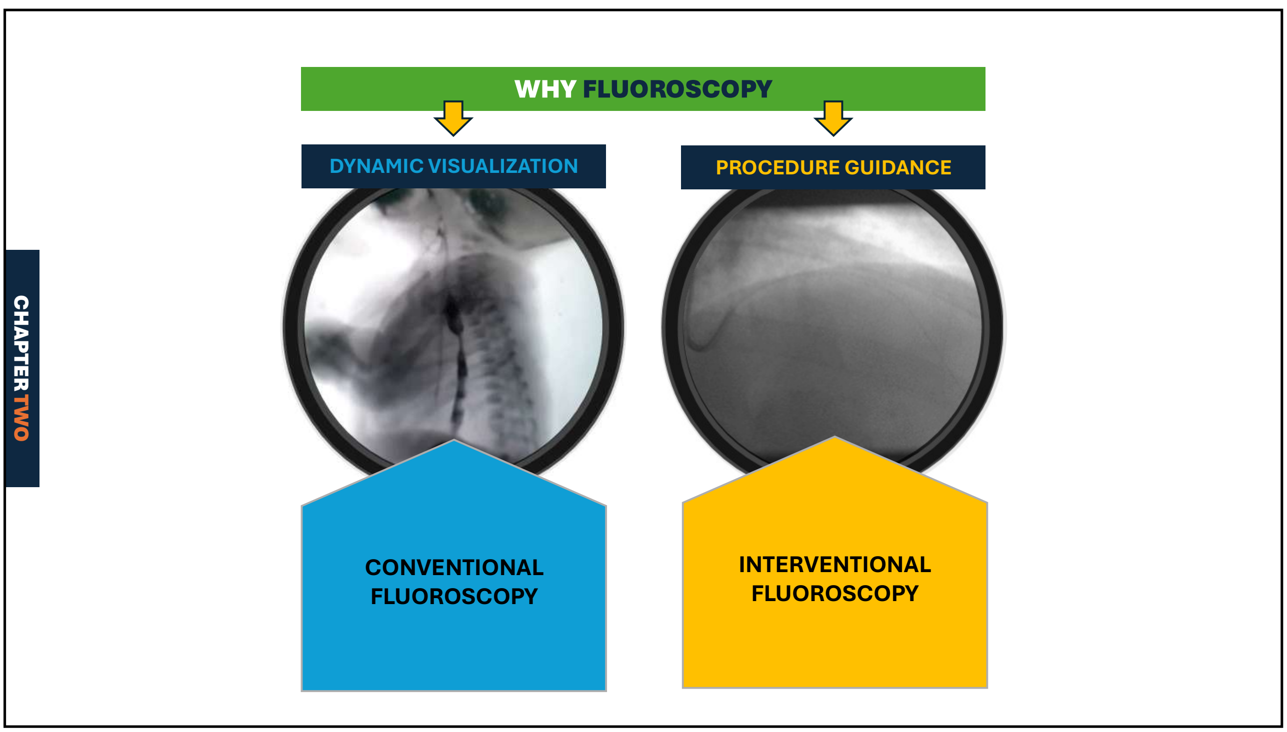
CHAPTER TWO
WHY FLUOROSCOPY
DYNAMIC VISUALIZATION
PROCEDURE GUIDANCE
CONVENTIONAL FLUOROSCOPY
INTERVENTIONAL FLUOROSCOPY

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CHAPTER TWO

PROCEDURE GUIDANCE

INTERVENTIONAL RADIOLOGY (IR)

IR is a radiology subspecialty that uses **minimally invasive image-guided procedures** to diagnose and treat diseases

- NEEDLES
- CATHETERS
- GUIDE-WIRES
- OTHER DEVICES

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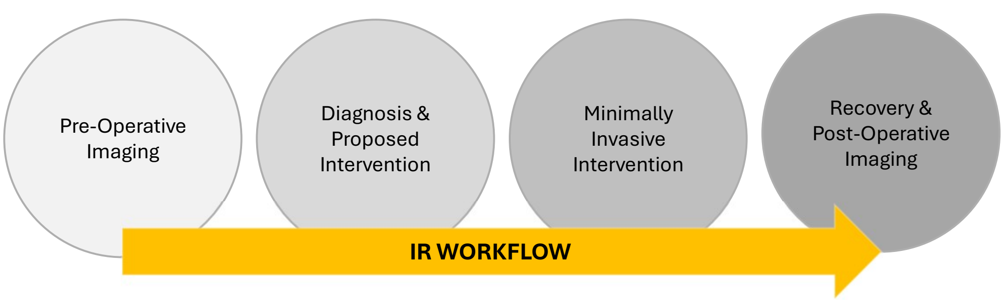
CHAPTER TWO

INTERVENTIONAL RADIOLOGY (IR)



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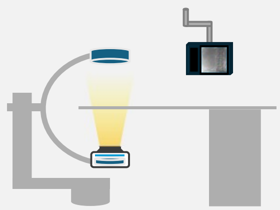
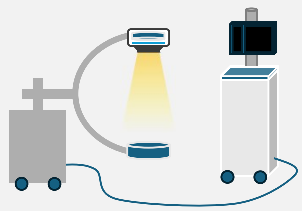
CHAPTER TWO

C-ARM CONFIGURATIONS

INTERVENTIONAL SUITE	VS	MOBILE C-ARM UNIT
		
Can be found in Radiology & Cardiology		Generally used in operating rooms

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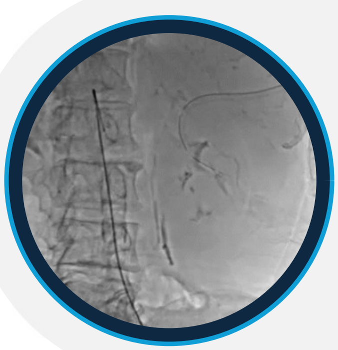
CHAPTER TWO



ANGIOGRAPHY

a technique used to **visualize the inside (lumen) of blood vessels and organs**, particularly arteries, veins, and the heart chambers. This is **achieved by injecting a contrast agent** into the bloodstream and then acquiring a series of X-ray images.

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CHAPTER TWO

INTERVENTIONAL **ANGIOGRAPHY**

- OVERVIEW
- KEY PRINCIPLES
- CONTRAST MEDIA
- SUBTRACTION & DSA
- IMAGE QUALITY

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CHAPTER TWO

INTERVENTIONAL **ANGIOGRAPHY**

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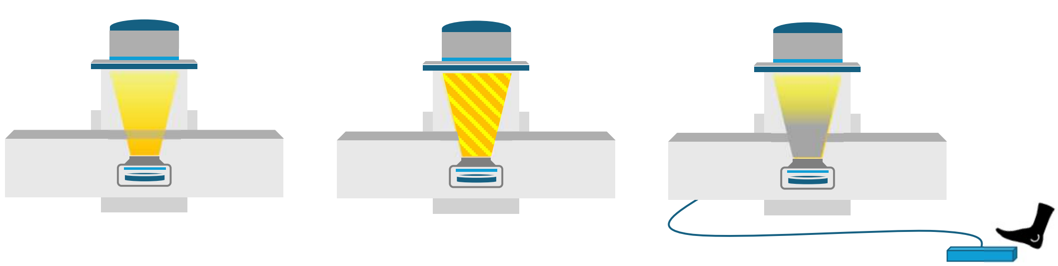
CHAPTER TWO

CONTINUOUS FLUOROSCOPY | **PULSED FLUOROSCOPY** | **INTERMITTENT FLUOROSCOPY**



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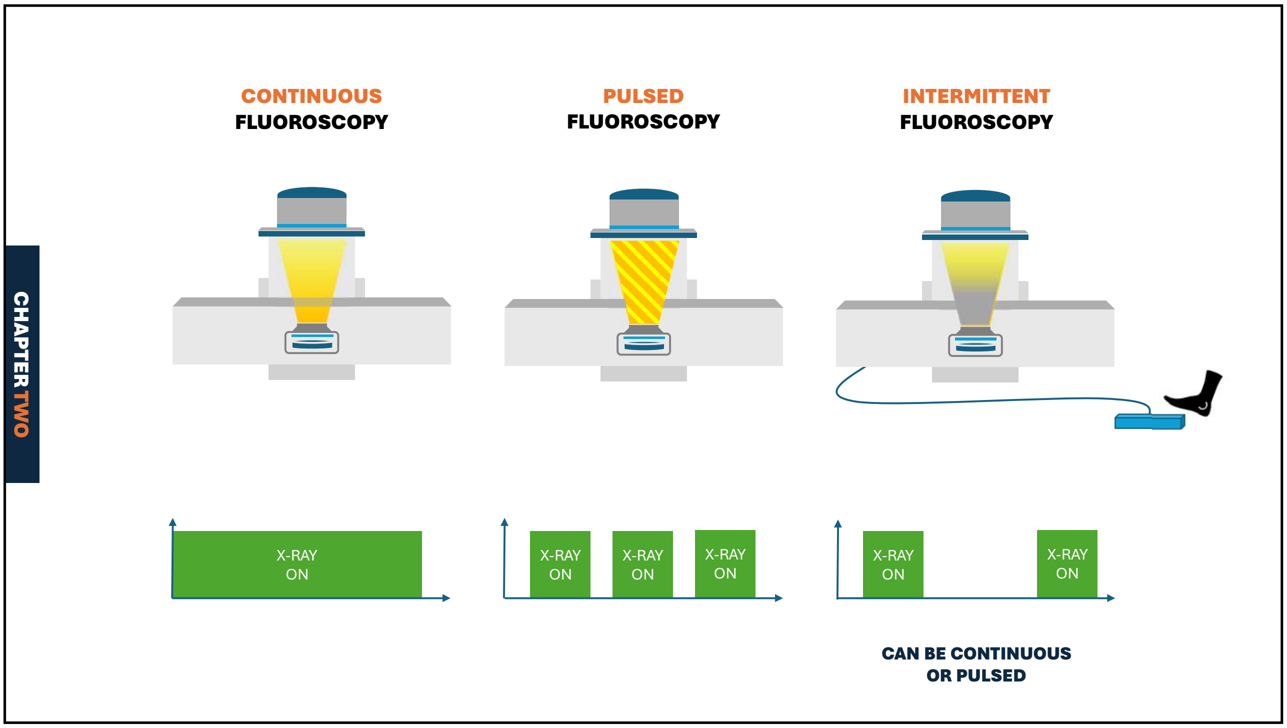

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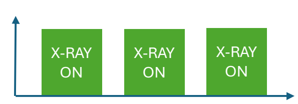
CHAPTER TWO

CONTINUOUS FLUOROSCOPY

- **X-Ray exposure is on continuously when exposure switch is pressed.** (30 pulses / second)
- Extremely high radiation doses to patients and medical staff
- High tube heat
- Smooth, uninterrupted visualization of moving structures like catheters and guidewires.

PULSED FLUOROSCOPY



- **X-Ray exposure is rapidly switched on and off at set intervals when exposure switch is pressed.** (1, 3, 5, … , 15 pulses / second) pulse rate (frame rate or frames per second)
- Significantly reduces radiation dose
- Low tube heat
- Real-time imaging but slightly less smooth appearance – depending on pulse rate.

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CHAPTER TWO

PULSED FLUOROSCOPY

FRAME RATE

The number of images acquired and displayed per second (fps). **Higher frame rates** provide **smoother motion** but cost of **higher radiation dose**.

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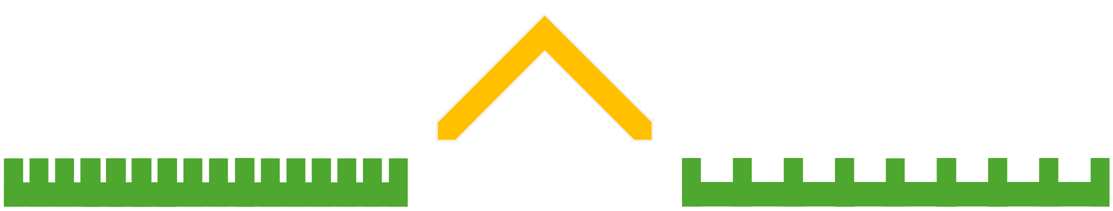
CHAPTER TWO

PULSED FLUOROSCOPY

FRAME RATE

The number of images acquired and displayed per second (fps). **Higher frame rates** provide **smoother motion** but cost of **higher radiation dose**.



HIGH FRAME RATE **LOW FRAME RATE**

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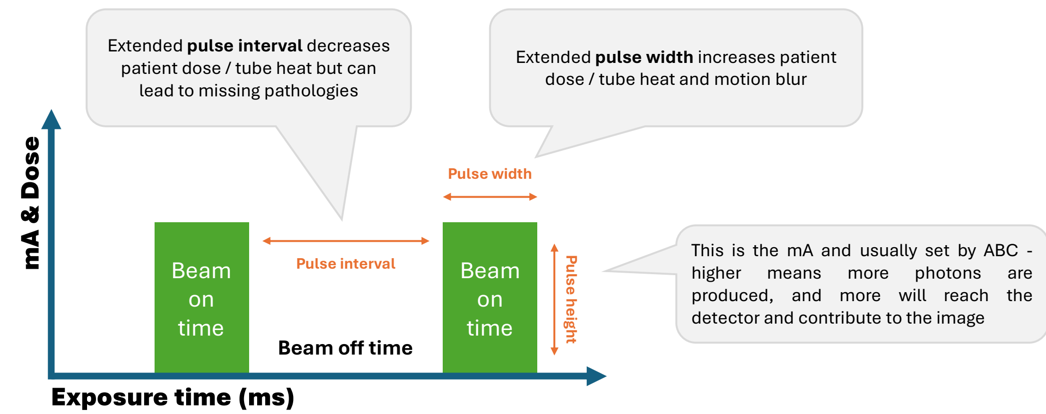
CHAPTER THREE



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CHAPTER TWO

EFFECTS OF FRAME RATE ON IMAGE QUALITY

SPATIAL RESOLUTION

The ability of an imaging system to accurately depict two distinct objects as separate and distinguishable entities in the image. It essentially defines the **smallest detail** that can be visualized.

CONTRAST RESOLUTION

The ability of an imaging system to differentiate between objects with subtle differences in X-ray attenuation. It represents the system's capacity to depict **subtle variations in grayscale**.

TEMPORAL RESOLUTION

The ability of an imaging system to capture and display events or **changes that occur over time**. It refers to how quickly the system can acquire and refresh images.

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CHAPTER TWO

	HIGH FRAME RATE	LOW FRAME RATE
SPATIAL RESOLUTION	Reduced motion blur improves image sharpness (short pulse width or exposure time may lead to low SNR!)	higher motion blur reduces image sharpness (long pulse width or exposure time may lead to high SNR!)
CONTRAST RESOLUTION	short pulse width or exposure time may lead to low SNR, which increases noise. Higher image noise levels reduce contrast resolution	long pulse width or exposure time may lead to high SNR, which reduces noise. Lower image noise levels improve contrast resolution
TEMPORAL RESOLUTION	short pulse width or exposure time reduces motion blur and improves temporal resolution.	long pulse width or exposure time increases motion blur and reduce temporal resolution
	HIGH RADIATION DOSE	**LOW** RADIATION DOSE

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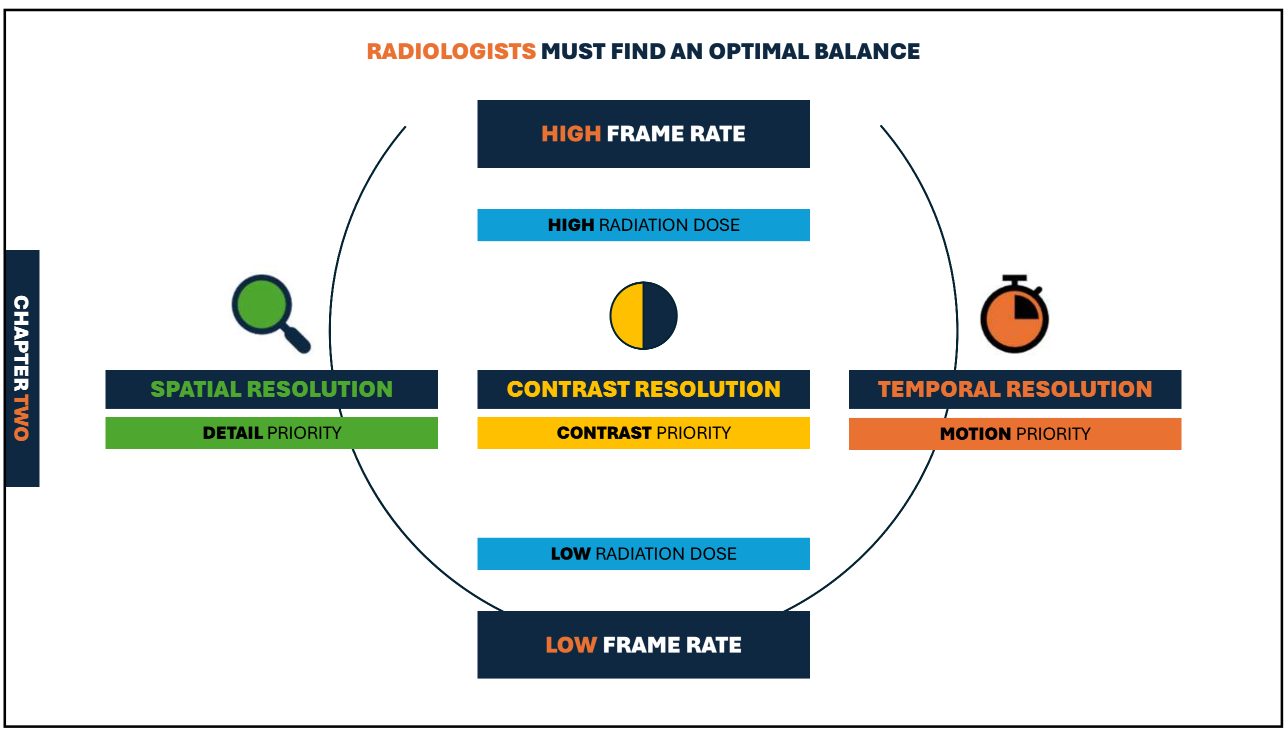

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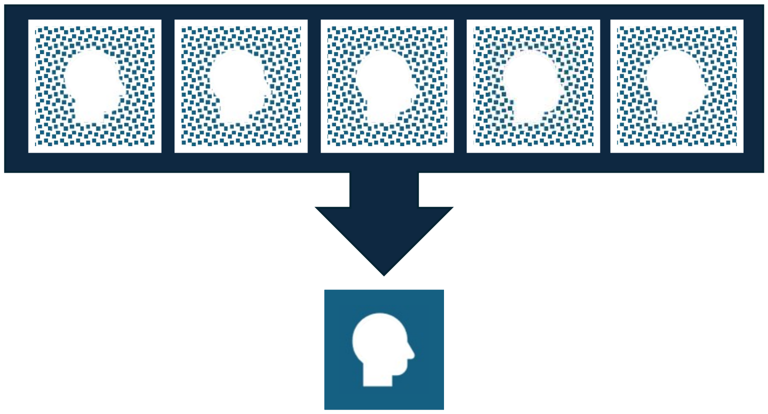
CHAPTER THREE

FRAME AVERAGING



Frame averaging is a technique used in pulsed fluoroscopy to **reduce image noise** and **improve image quality** without increasing radiation dose. It works by averaging the pixel values from several consecutive frames to create a composite image.

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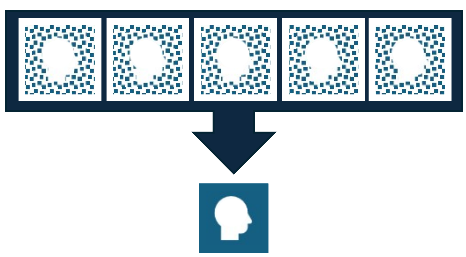
CHAPTER THREE



BENEFITS OF FRAME AVERAGING

Reduced noise: Improves image quality by smoothing out random fluctuations.
Enhanced contrast: Subtle contrast differences may become more apparent in the averaged image.
No increase in dose: Achieves image quality improvement without increasing the radiation dose.

DRAWBACKS OF FRAME AVERAGING

Reduced temporal resolution: Averaging frames can introduce a slight lag or blur.
Not ideal for all procedures: When visualization of fast movements, frame averaging might not be suitable.

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CHAPTER TWO

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CHAPTER TWO

LARGE FIELD OF VIEW

SMALL FIELD OF VIEW

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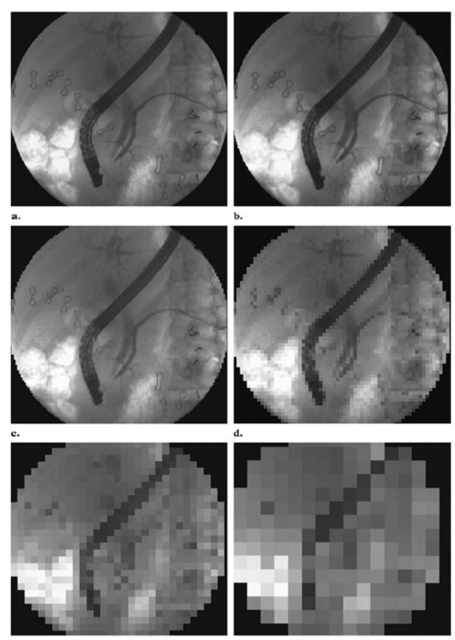
CHAPTER TWO

FOV & MATRIX
IN FLUOROSCOPY

512 X 512 OR 1024 X 1024 PIXELS

Just remembers that changing the Field-of-View (FOV) is **not free** in fluoroscopy.

Reducing the FOV (Zooming-In) **increases the patient dose**. Zoom causes a decrease in Signal-to-Noise Ratio (SNR); As a result, the Automatic-Brightness-Control (ABC) system increases the exposure factors to maintain image quality (brightness) and compensate for the decrease in SNR. **This effect is more prominent in Image-Intensifiers.**



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CHAPTER TWO

BIT DEPTH

the number of colors (or shades of grey) used to represent each pixel in a digital image. A higher bit depth means more shades of gray can be represented, leading to smoother transitions and finer detail.

DYNAMIC RANGE

the ratio between the maximum and minimum signal intensities that an imaging system can detect and record. A wider dynamic range means the system can capture a broader range of intensities.

WINDOW-LEVEL (WL)

controls the brightness of the image. It determines which pixel value is displayed as the middle gray level on the monitor.

WINDOW-WIDTH (WW)

controls the contrast of the image. It determines the range of pixel values that are displayed as shades of gray. A narrow window width increases contrast, while a wider window width decreases contrast.

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CHAPTER TWO

How many colors can I use to paint my scene	BIT DEPTH
How many colors can my camera capture	DYNAMIC RANGE
How bright or dark will I make my painting	WINDOW-LEVEL (WL)
Will I make my painting strong contrasting colors or subtle gradients	WINDOW-WIDTH (WW)

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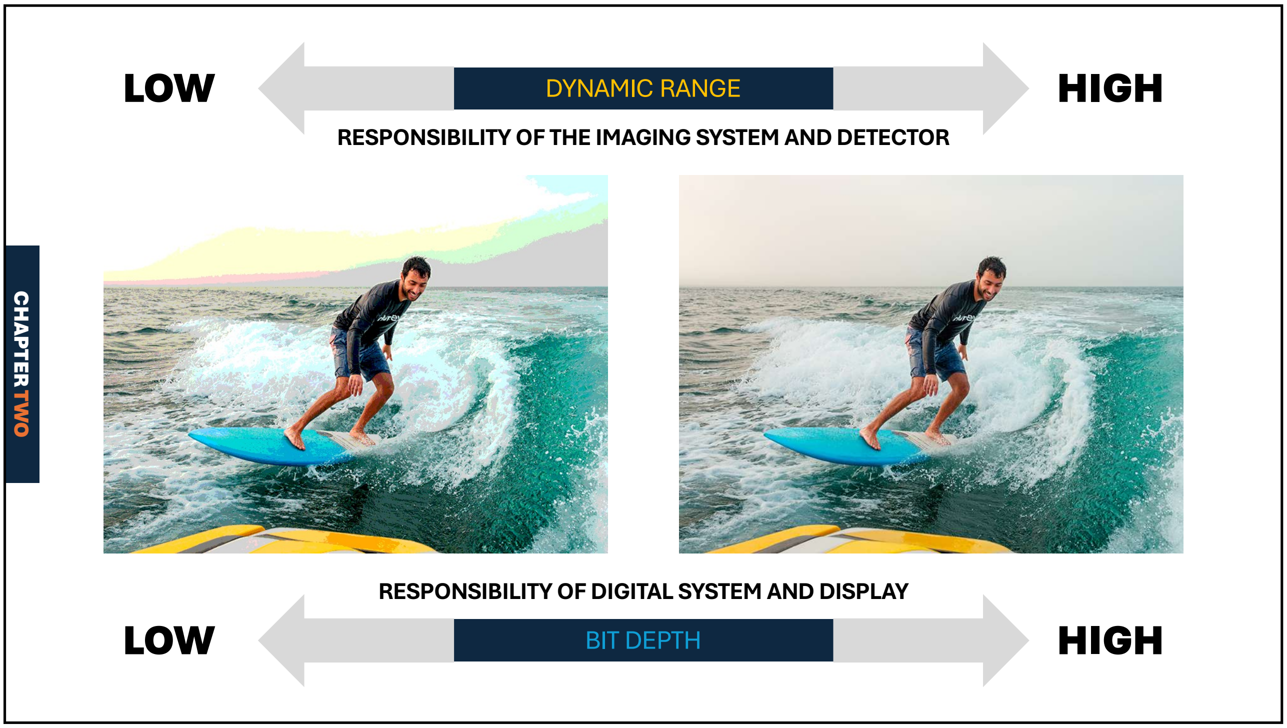
LOW
DYNAMIC RANGE
HIGH
RESPONSIBILITY OF THE IMAGING SYSTEM AND DETECTOR
CHAPTER TWO
RESPONSIBILITY OF DIGITAL SYSTEM AND DISPLAY
LOW
BIT DEPTH
HIGH

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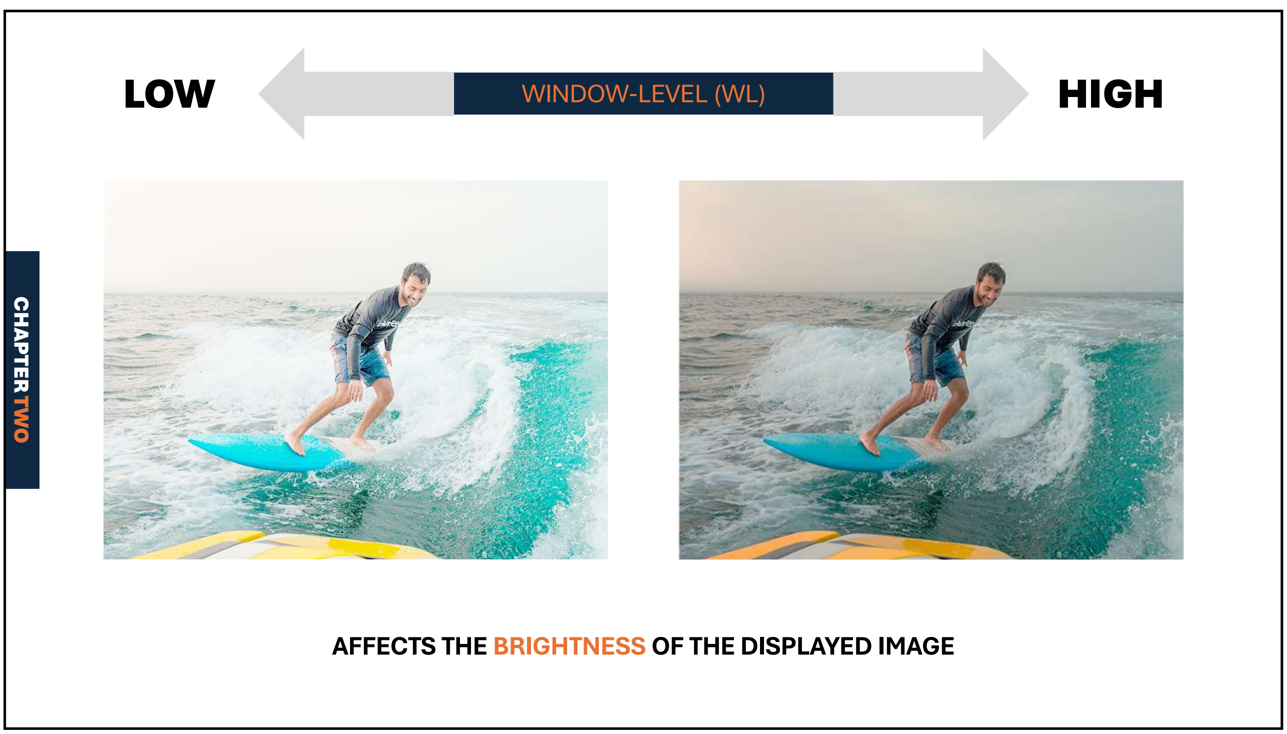
LOW
WINDOW-LEVEL (WL)
HIGH
CHAPTER TWO
AFFECTS THE BRIGHTNESS OF THE DISPLAYED IMAGE

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CHAPTER TWO

LOW — WINDOW-WIDTH (WW) — **HIGH**

AFFECTS THE CONTRAST OF THE DISPLAYED IMAGE

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CHAPTER TWO

W/L & W/W IN FLUOROSCOPY

W/W

W/L

Window-level and window-width are tools used to **optimize the display of this information.** Radiologists can fine-tune the brightness (W/L) and contrast (W/W) of the image to highlight specific features, emphasize certain types of tissue and enhance visualization. Adjusting the windowing does not affect radiation dose. It can be done even after the exposure is terminated.

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CHAPTER TWO

INTERVENTIONAL ANGIOGRAPHY

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- IMAGE QUALITY

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CHAPTER TWO

INTERVENTIONAL ANGIOGRAPHY

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- CONTRAST MEDIA
- SUBTRACTION & DSA
- IMAGE QUALITY

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IMAGE **CONTRAST**

CHAPTER TWO

BEAM ENERGY

Higher kVp settings produce X-rays with greater energy and penetrating power.

ABSORPTION
PHOTOELECTRIC EFFECT

An X-ray photon is completely absorbed by an inner-shell electron in an atom, ejecting the electron. This effect is more pronounced in materials with higher atomic numbers (like bone) and at lower X-ray energies.

SCATTER
COMPTON EFFECT

An X-ray photon interacts with an outer-shell electron, losing some energy and changing direction. This scattered radiation can reach the detector but doesn't contribute to useful image formation.

ADDED CONTRAST

Substances like iodine or barium are introduced into the body to enhance the contrast of specific organs or vessels. These materials have high atomic numbers and absorb more X-rays.

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CHAPTER TWO

BEAM ENERGY

PENETRATION QUALITY (kVp)

Decreasing kVp reduces penetration and improve image contrast but is not a desirable option to maintain adequate image quality and acceptable patient doses.

ABSORPTION

SCATTER

SUBJECT CONTRAST

Subject contrast is inherently poor or insufficient in fluoroscopic imaging, especially at the high kVp values generally used.

ADDED CONTRAST

RADIO-OPAQUE MARKERS & CATHETERS
CONTRAST MEDIA

Essential to produce desirable image contrast levels for diagnostic and procedure guidance

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CHAPTER TWO

ADDED CONTRAST

IODINE	POSITIVE CONTRAST AGENT
BARIUM	POSITIVE CONTRAST AGENT
CO_2	NEGATIVE CONTRAST AGENT

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CHAPTER TWO

ADDED CONTRAST

We will focus on positive contrast agents as they are the most common in clinical practice.

IODINE	**POSITIVE CONTRAST AGENT**
BARIUM	**POSITIVE CONTRAST AGENT**
CO_2	NEGATIVE CONTRAST AGENT

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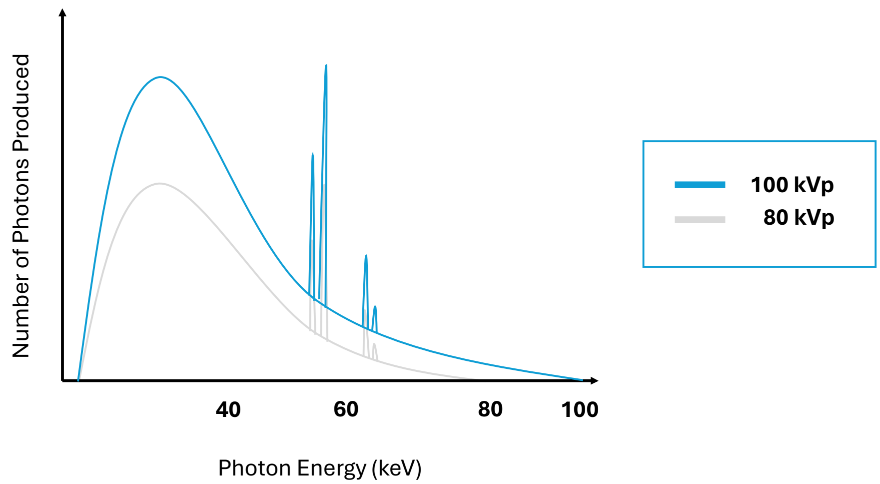
CHAPTER TWO

X-RAY **PRODUCTION**

X-RAY SPECTRUM OF **TUNGSTEN ANODE**



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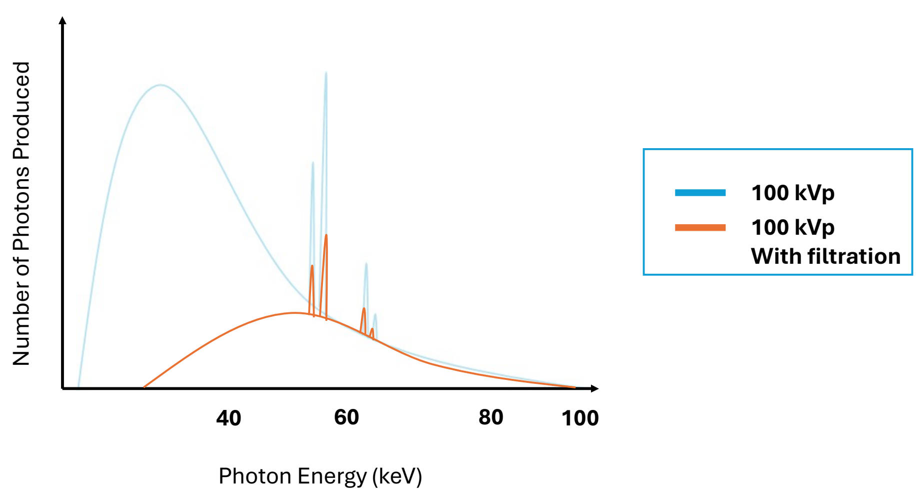
CHAPTER TWO

X-RAY **PRODUCTION**

X-RAY SPECTRUM OF **TUNGSTEN ANODE + FILTRATION**

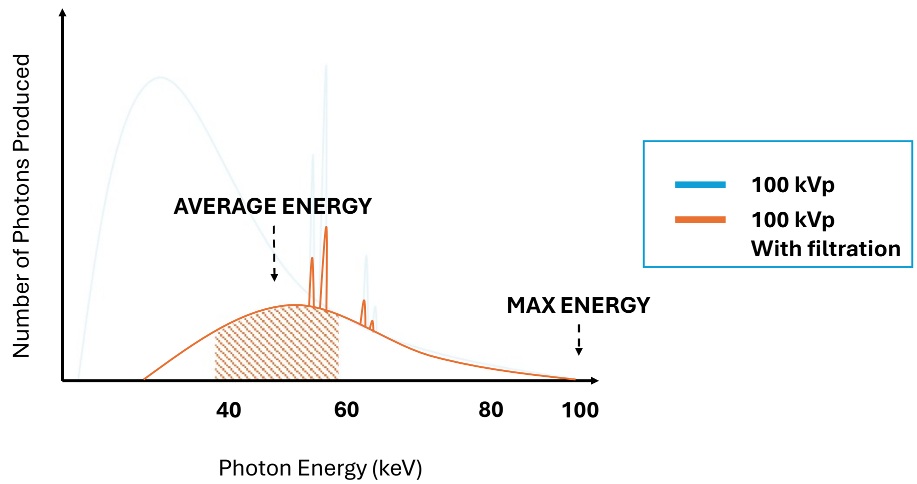


150

CHAPTER TWO

X-RAY PRODUCTION

X-RAY SPECTRUM OF TUNGSTEN ANODE + FILTRATION



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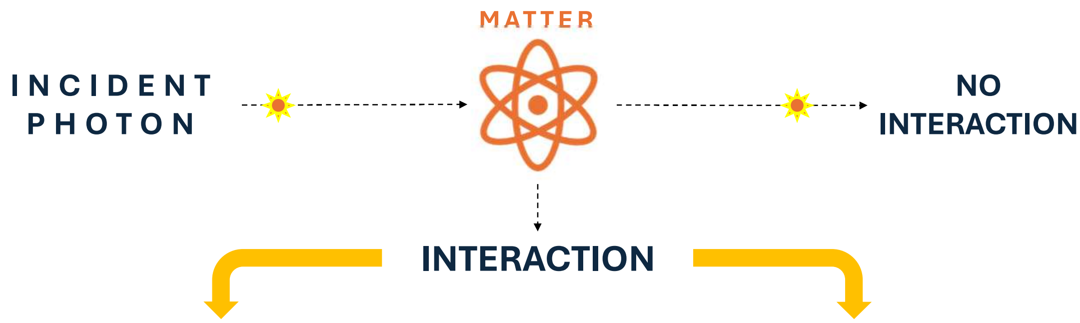
CHAPTER TWO

X-RAY INTERACTION



Photoelectric Effect (absorption)

- **Energy dependent:**

  probability of interaction increases as photon energy approximates K-shell binding energy of the substance.

- **Proportional to atomic number (Z)**

Compton Effect (deflection)

- **Energy independent:**

  probability of interaction can occur at entire diagnostic energy range.

- **Independent of atomic number (Z)**

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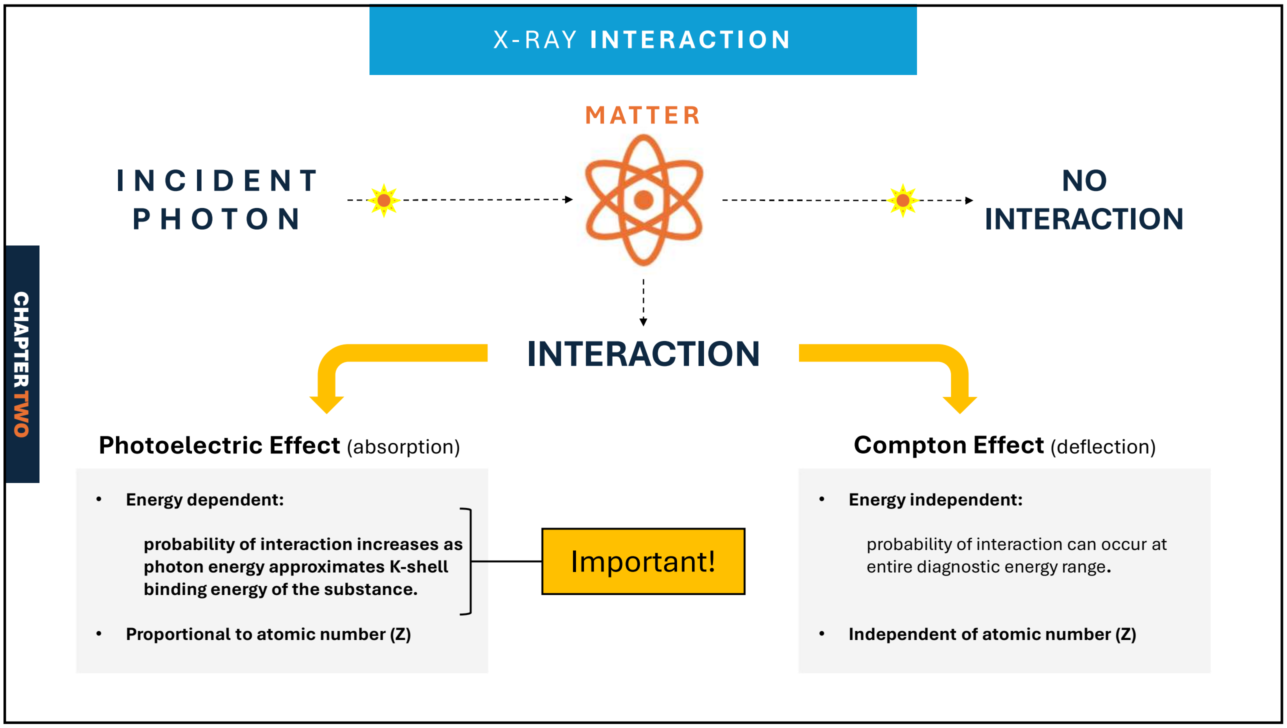
X-RAY INTERACTION
CHAPTER TWO
MATTER
INCIDENT PHOTON
NO INTERACTION
INTERACTION
Photoelectric Effect (absorption)
• Energy dependent:
probability of interaction increases as photon energy approximates K-shell binding energy of the substance.
• Proportional to atomic number (Z)
Important!
Compton Effect (deflection)
• Energy independent:
probability of interaction can occur at entire diagnostic energy range.
• Independent of atomic number (Z)

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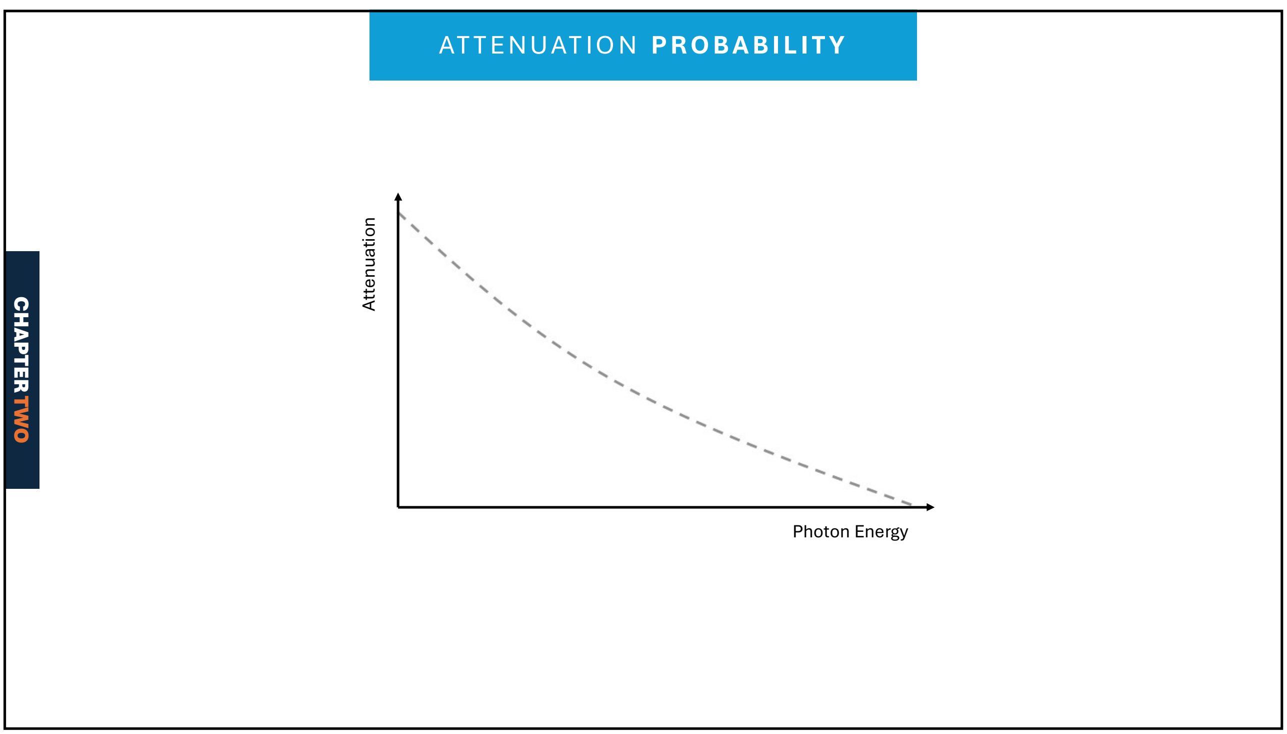
ATTENUATION PROBABILITY
CHAPTER TWO
Attenuation
Photon Energy

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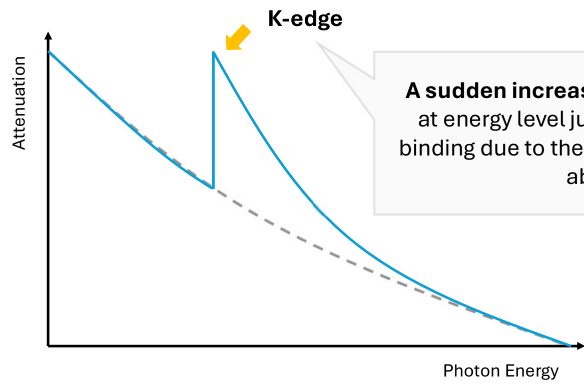
CHAPTER TWO

ATTENUATION **PROBABILITY**



A sudden increase in attenuation occurs at energy level just greater of the K-shell binding due to the increase in photoelectric absorption

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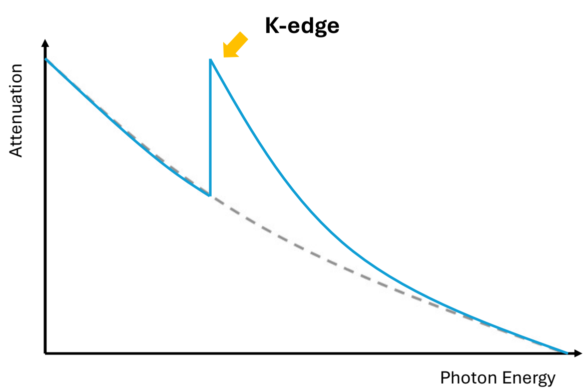
CHAPTER TWO

ATTENUATION **PROBABILITY**



K-edge values are unique for each element.

↑ K-edge ↑ Atomic no. (Z)

Substance	K-edge	Atomic no. (Z)
Hydrogen	0.01	1
Carbon	0.28	6
Nitrogen	0.40	7
Oxygen	0.53	8
Calcium	4.00	20
Iodine	33.20	53
Barium	37.45	56

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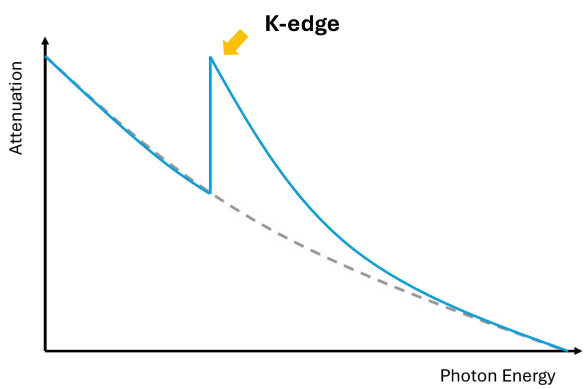
ATTENUATION **PROBABILITY**

CHAPTER TWO



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⬆ K-edge ⬆ Atomic no. (Z)

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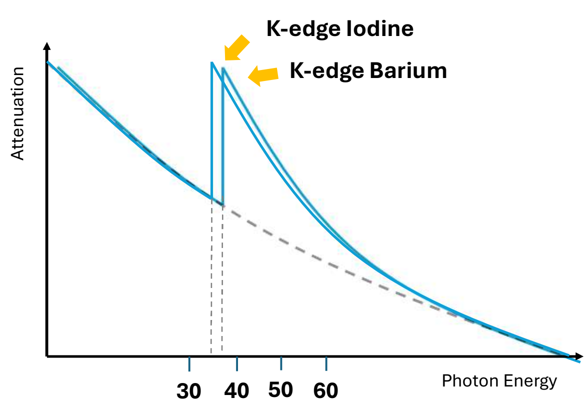
ATTENUATION **PROBABILITY**

CHAPTER TWO



Substance	K-edge	Atomic no. (Z)
Iodine	**33.20**	**53**
Barium	**37.45**	**56**

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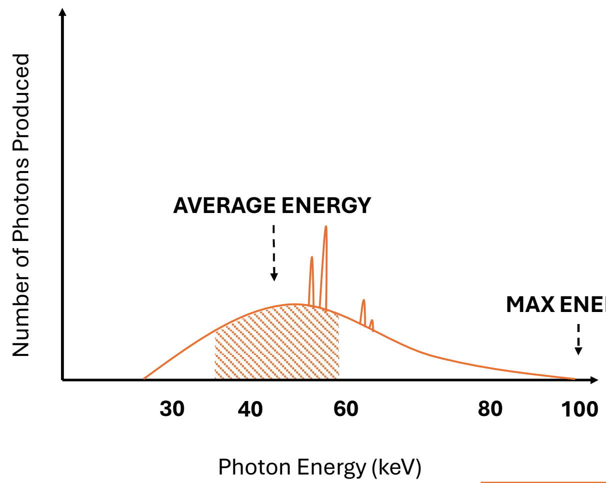
CHAPTER TWO



Substance	K-edge	Atomic no. (Z)
Iodine	33.20	53
Barium	37.45	56

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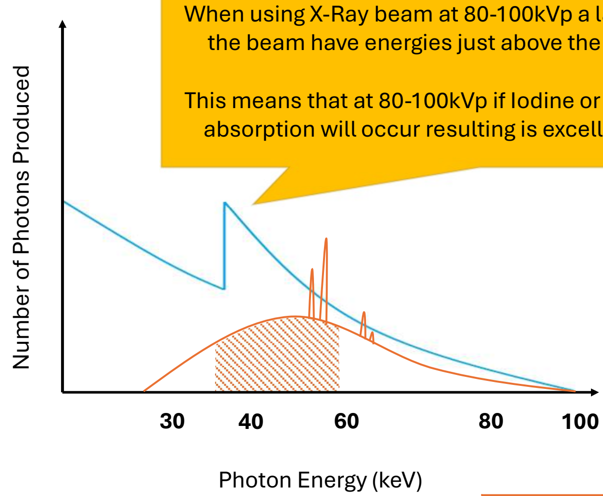
CHAPTER TWO

OVERLAY OF ATTENUATION VS ENERGY CURVE (IODINE / BARIUM)
When using X-Ray beam at 80-100kVp a large portion of the photons in the beam have energies just above the K-Edge of Iodine & Barium.

This means that at 80-100kVp if Iodine or Barium is present, maximum absorption will occur resulting is excellent contrast enhancement.



Substance	K-edge	Atomic no. (Z)
Iodine	33.20	53
Barium	37.45	56

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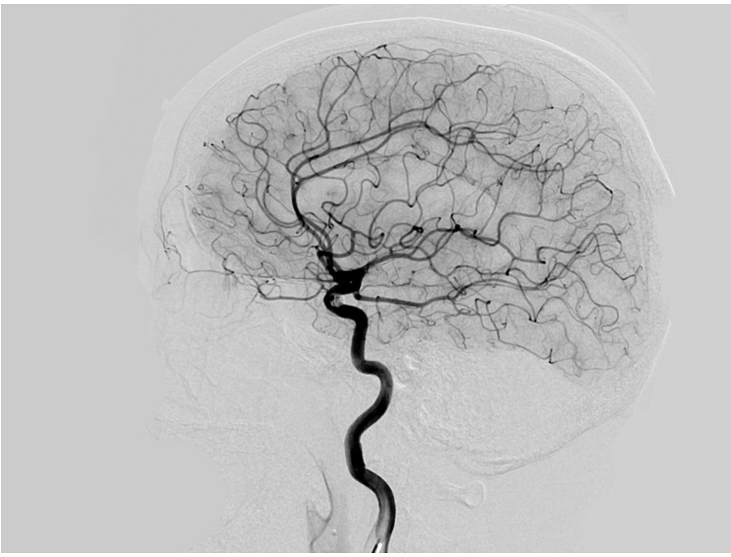

IMPROVED SUBJECT CONTRAST

Contrast agents like iodine and barium enhance the visibility of specific tissues, organs, or blood vessels. These agents work by altering the way X-rays interact with the body, leading to improved contrast in the images.

- **Iodine:** used to visualize blood vessels and organs.
- **Barium:** used to visualize GI tract

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CHAPTER TWO

CONCENTRATION OF CONTRAST

Refers to the amount of iodine per unit volume of solution. It's expressed in mg/mL. Common concentrations include 270 mg/mL, 300 mg/mL, and 350 mg/mL.

CONTRAINDICATIONS OF CONTRAST

- **Allergy:** history of allergy to iodinated contrast is a major contraindication.
- **Renal Impairment:** Patients with kidney disease are at increased risk of contrast-induced nephropathy (CIN).
- **Pregnancy:** generally avoided during pregnancy unless necessary.
- **Other Conditions:** Certain medications, diabetes, and other conditions may require special precautions.

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CHAPTER TWO

CONTRAST POWER INJECTORS

Automated injectors are commonly used to deliver contrast media precisely and consistently. They allow for controlled flow rates, volumes, and injection pressures.

FACTORS INFLUENCING CONCENTRATION & FLOWRATE

Vessel size and type: Larger vessels and arteries generally require higher flow rates

Clinical indication: The specific exam influences the choice of concentration and rate.

Patient factors: Body size, cardiac output, and overall health can affect the choice of parameters.

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CHAPTER TWO

eGFR_ ASSESING IV CONTRAST RISK

Your kidneys filter your blood by removing waste and extra water to make urine. The glomerular filtration rate (GFR) shows how well the kidneys are filtering.

eGFR is a way of "estimating" kidney function. In adults, the normal eGFR number is usually more than 90. eGFR declines with age, even in people without kidney disease.

NATIONAL KIDNEY FOUNDATION®

eGFR calculator at Kidney.org

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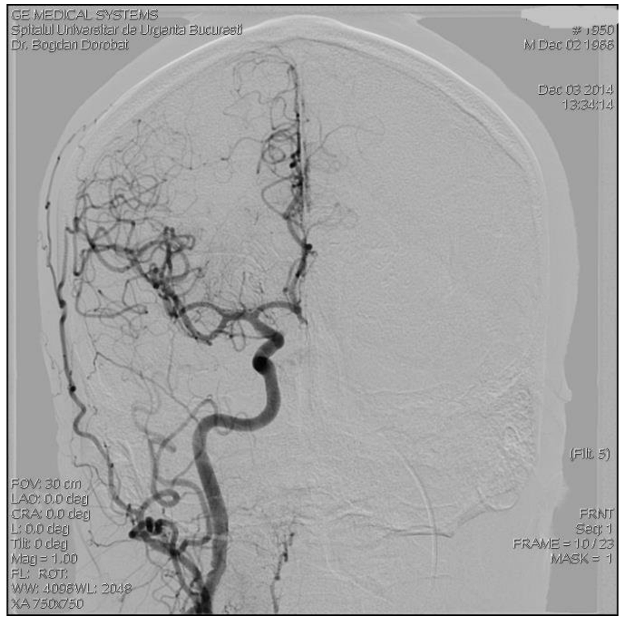
CHAPTER TWO

ANGIOGRAPHY IS A **2D REPRESENTATION** OF A 3D STRUCTURE

Different shades of gray are used to represent the varying intensities of the X-ray signal. Each shade of gray corresponds to a specific pixel value, which is related to the amount of X-ray attenuation.

Thicker portions of the vessel will absorb more X-rays, leading to a higher concentration of contrast appearing in the projected image.

Thinner portions will absorb less, leading to a lower concentration and dimmer areas in the image.



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CHAPTER TWO

CONTRAST MEDIA: PROJECTED THICKNESS & GREY SHADES

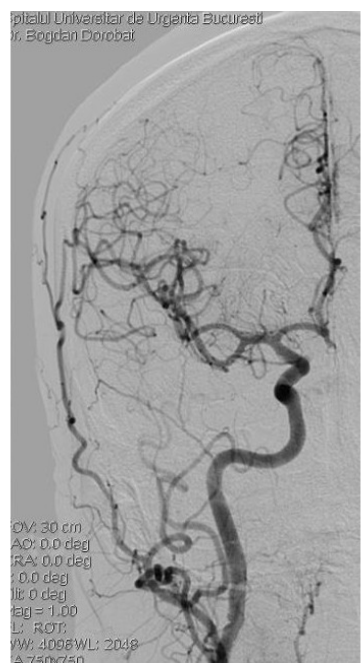
Concentration of Iodine:
Higher concentration is more intense on the grayscale image; while lower concentration is less intense and dimmer.

Thickness of the Contrast Column:
Thicker column is more intense on the grayscale image; while thinner column is less intense and dimmer.

Vessel Overlap:
When vessels containing contrast overlap in the projected image, their densities sum up, leading to an intense appearance.

Surrounding Tissue Density:
If the contrast-filled vessel is surrounded by dense tissue like bone, the contrast may appear less prominent.

Imaging Technique and Settings:
- **X-ray energy:** kVp affect the absorption of iodine and alter its appearance.
- **Image processing:** Post-processing techniques can further enhance or modify the appearance of the contrast.



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CHAPTER TWO

ANALOGY: THE VIMTO DRINK

- Can be concentrated of dilute
- Can look darker if viewed from the top but lighter if viewed from the side
- It looks darker when you stack more than one behind each other
- It looks brighter if you shine a light through it

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CHAPTER TWO

INTERVENTIONAL ANGIOGRAPHY

- OVERVIEW
- KEY PRINCIPLES
- CONTRAST MEDIA
- SUBTRACTION & DSA
- IMAGE QUALITY

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CHAPTER TWO

INTERVENTIONAL **ANGIOGRAPHY**

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CHAPTER TWO

DIGITAL SUBTRACTION ANGIOGRAPHY DSA

An imaging technique to visualize blood vessels:
subtracting a "**pre-contrast**" image (mask) from "**post-contrast**" images.

The goal is to visualize blood vessels for **diagnostic** or **radiologic intervention**

ADVANTAGES

- Minimally invasive
- Real-time observation
- Spatial resolution superior to CT & MRI
- Ability to perform concurrent endovascular treatment of many pathologies

DISADVANTAGES

- High radiation exposure
- Contrast related issues (Allergies, CIN)
- Hematoma, infection, thrombus, pseudoaneurysm at puncture site
- Vessel dissection at puncture site or distal location

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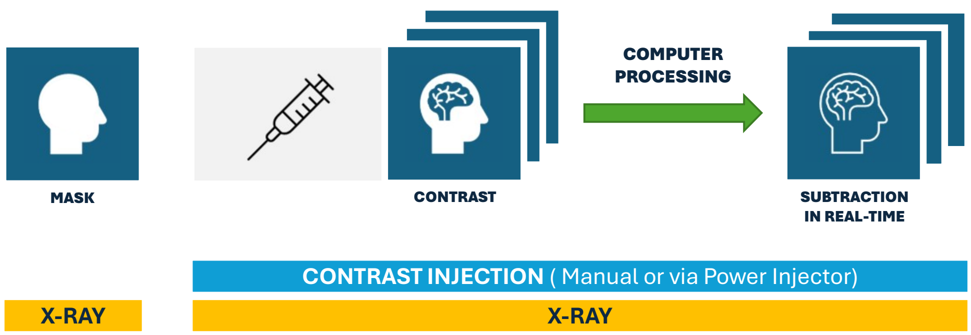
CHAPTER TWO

HOW IT WORKS

DSA involves acquiring a "mask image" before contrast injection and then **subtracting this mask** from subsequent images acquired after contrast administration.

This technique **effectively removes bone and other static structures** from the images, leaving a clear picture of the contrast-filled vessels.



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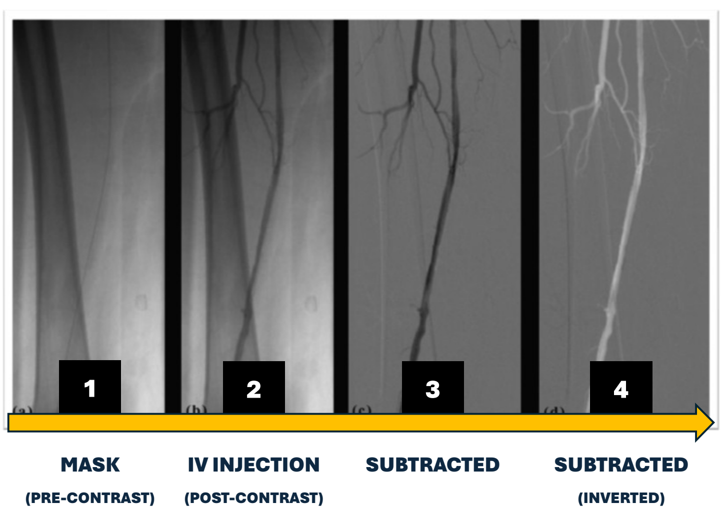

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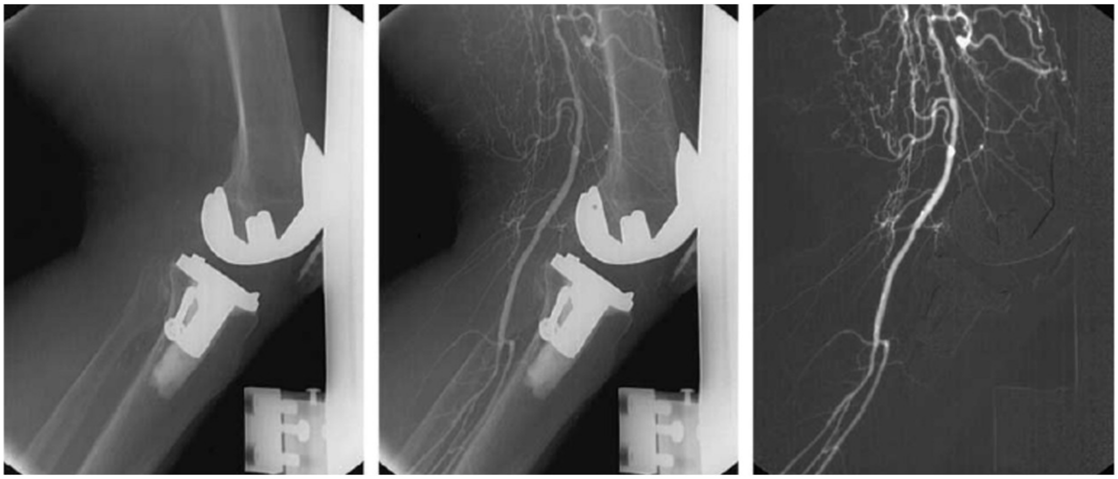

MASK

(PRE-CONTRAST)

IV INJECTION

(POST-CONTRAST)

SUBTRACTED

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CHAPTER TWO

SUBTRACTION TECHNIQUES

TEMPORAL SUBTRACTION	The most common DSA technique, temporal subtraction involves subtracting a pre-contrast mask image from post-contrast images acquired at the same time point in the cardiac cycle.
ENERGY SUBTRACTION	This technique utilizes two different X-ray energies to differentiate between contrast and bone. However, it is less commonly used due to technical limitations.
HYBRID SUBTRACTION	This technique combines temporal and energy subtraction to optimize image quality.

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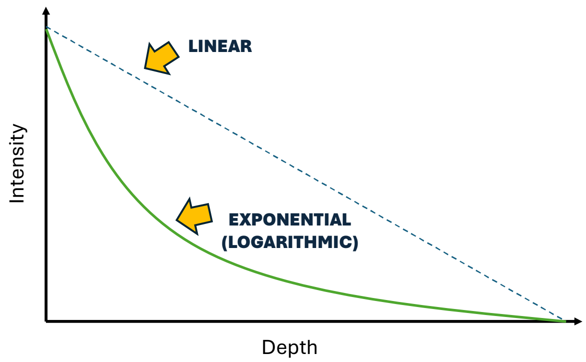
CHAPTER TWO

X-RAY ATTENUATION IS EXPONENTIAL NOT LINEAR



When X-rays pass through the body, their intensity doesn't decrease in a simple, straight-line fashion. Instead, it decreases exponentially or in logarithmic fasion (curve).

If X-ray attenuation were linear, simple subtraction (contrast image - mask image) would work perfectly. But the exponential nature makes it tricky.

Therefore, there are two methods of subtraction. **Linear** (fast but susceptible to artifacts) or **logarithmic** (requires more processing but more accurate).

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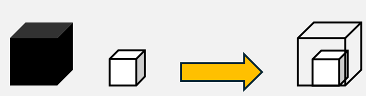
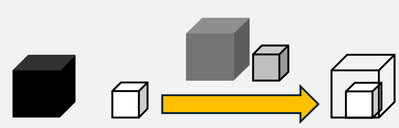
CHAPTER TWO

SUBTRACTION SCHEMES

TEMPORAL
SUBTRACTION

LINEAR SUBTRACTION	**LOGARITHMIC** SUBTRACTION
This is the most straightforward method. It directly subtracts the pixel values of the mask image from the post-contrast image.	This method involves transforming the pixel values of both the mask and post-contrast images into a logarithmic scale before subtraction. Compressing the dynamic range and normalizing the data **making it more linear**.





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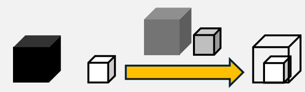
CHAPTER TWO

LINEAR SUBTRACTION	LOGARITHMIC SUBTRACTION
	
BENEFITS	
• Simple to implement • Computationally efficient	• Less sensitive to noise and movement • Reduced artifacts (especially at high-contrast interfaces like bone edges) • Enhanced visualization of subtle contrast differences (stenosis or collateral vessels)
DRAWBACKS	
• Very sensitive to noise and movement • Can lead to artifacts (especially at high-contrast interfaces like bone edges) • May not be adequate to handle large variations in thickness (limited dynamic range)	• More computationally intensive • Can sometimes over-enhanced low contrast detail; potentially leading to misinterpretation. • Subtle contrast differences might be less apparent after logarithmic transformation.

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CHAPTER TWO

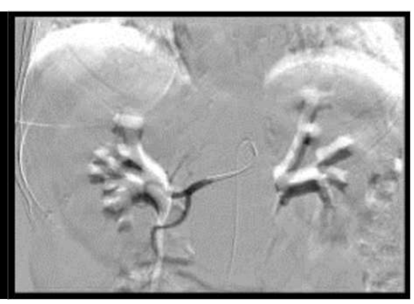
IMAGE NOISE & ARTIFACTS IN DSA IMAGING

The noise level in the subtracted images is generally higher than the noise level in the original images. Therefore; to maintain the noise levels as the non-DSA images, DSA imaging will require **higher exposures**.

Frame averaging can be used to reduce exposure requirements for DSA

Major source of artifacts in DSA is patient motion between the mask and contrast images (**Mis-registration**)

In some cases, mis-registration can be corrected retrospectively through "**Pixel-Shifting**" the mask image or re-masking through selecting a different masking frame.



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ROADMAPPING IN DSA IMAGING

A DSA imaging mode used to create a "**map**" of vascular anatomy that aids in the **navigation** of catheters and instruments. It can be created from:

1. **Stored image of contrast-filled vessels. (simple)**
2. **A series of images combined to create a map from peak enhancements in each pixel (complex) – also known as "Image Summation"**

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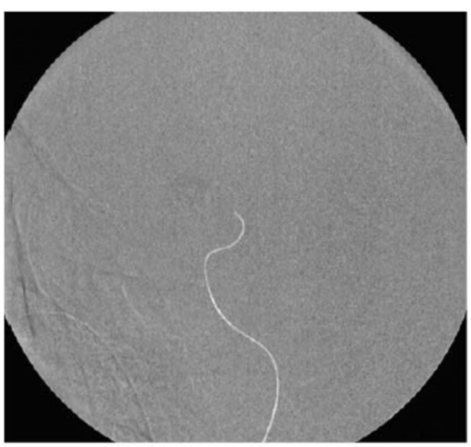
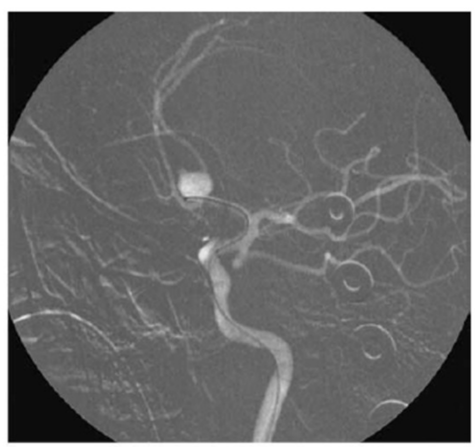
ROADMAPPING IN DSA IMAGING



DSA with Guide-wire only



DSA with Guide-wire + Map Overlay

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CHAPTER TWO

ROADMAPPING IN DSA IMAGING

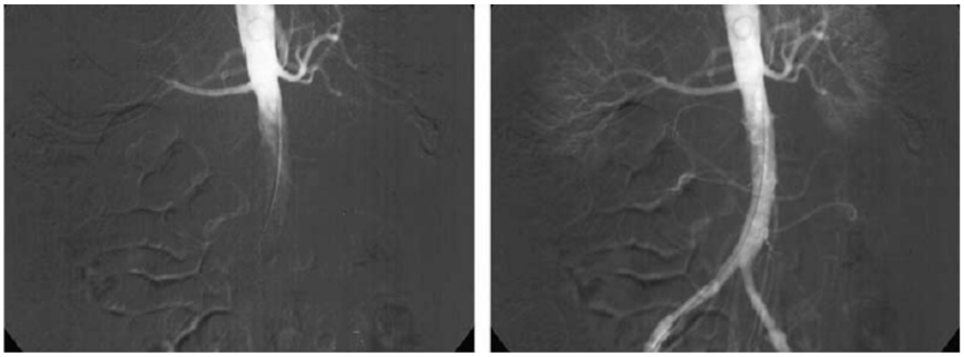

Image Summation: combining contrast phases from a series of frames to create one frame that should the complete vessel

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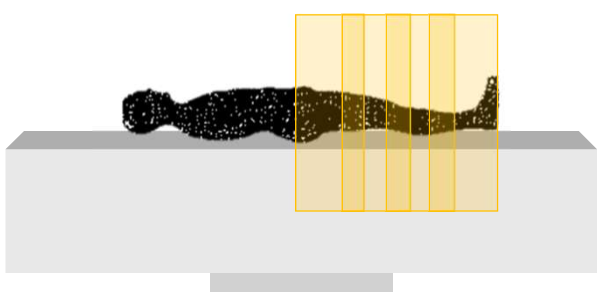
CHAPTER TWO

PERIPHERAL RUN OFF IN DSA IMAGING

A DSA imaging mode that follows IV Contrast bolus as it travels from the injection site into peripheral vessels (commonly the legs)

- **Stepping action; sequentially moving along the patient and acquiring images.**
- **Images must overlap to ensure seamless anatomical coverage and stitching of images (usually 30% overlap).**



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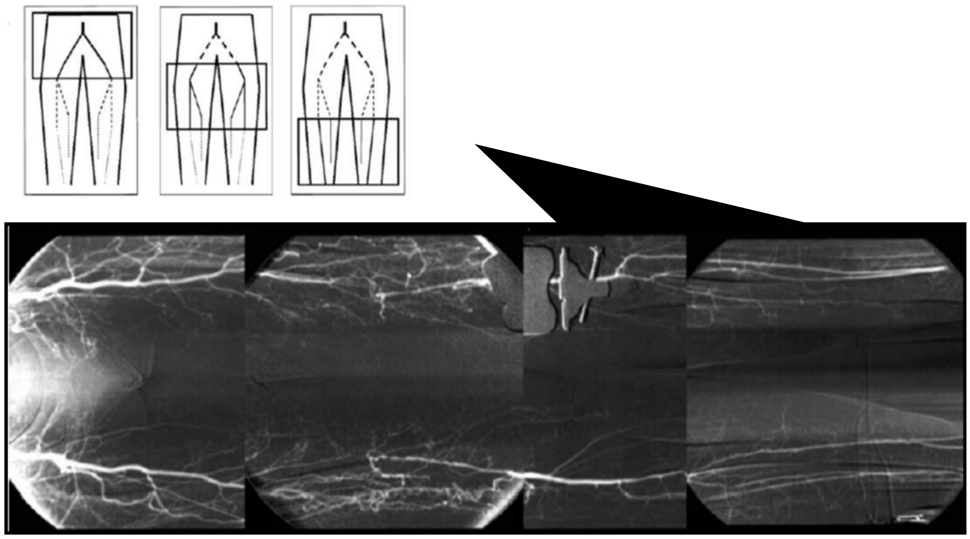
CHAPTER TWO

PERIPHERAL RUN OFF IN DSA IMAGING



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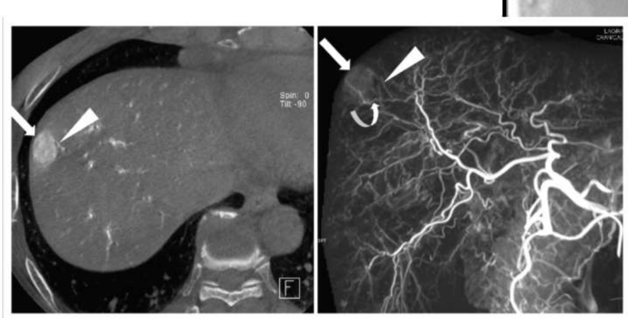
CHAPTER TWO

ROTATIONAL DSA IMAGING

A DSA imaging mode that acquires a series of images as the C-arm rotates around the patient.

- **Images viewed as a Cine Loop.**
- **Often used to reconstruct Cone-Beam CT Images; viewed as axial / coronal / sagittal images and MIPs**



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CHAPTER TWO

% STENOSIS CALCULATION: GEOMETRIC & DENSITOMETRIC

Two methods to analyzing angiograms and determining the severity of stenosis:

Geometric:

focuses on **measuring the dimensions of the blood vessel**, such as its diameter, at the point of narrowing and comparing it to a normal segment of the vessel. This relies on accurate visualization of the vessel's edges.

Densitometric:

analyzes the density of the contrast material within the blood vessel. A narrower area will have less contrast and therefore appear less dense on the image. This method can be helpful when the vessel edges are not clearly defined.

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CHAPTER TWO

% STENOSIS CALCULATION: GEOMETRIC & DENSITOMETRIC

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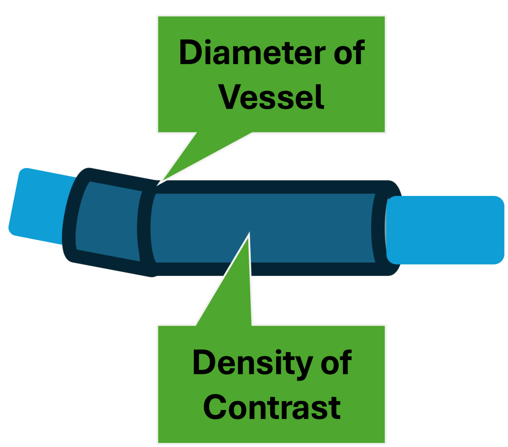

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CHAPTER TWO

% STENOSIS CALCULATION: GEOMETRIC & DENSITOMETRIC

Two methods to analyzing angiograms and determining the severity of stenosis:

Geometric: Benefits	Geometric: Drawbacks
•**Intuitive and direct:** It directly reflects the physical narrowing of the vessel. •**Widely used and accepted:** It's a standard approach familiar to most clinicians.	•**Relies on clear vessel edges** •**Subject to foreshortening** •**Inter-observer variability**

Densitometric: Benefits	Densitometric: Drawbacks
•**Less affected by edge clarity** •**Potentially less subjective:** Relies on quantitative pixel data.	•**Affected by contrast concentration:** Variations in contrast injection or dilution can influence reading. •**Sensitive to image quality:** Noise or artifacts •**Requires careful calibration**

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CHAPTER TWO

% STENOSIS CALCULATION: AMERICAN VS EUROPEAN Schemes

BOTH SCHEMES PRIMARILY USE THE **GEOMETRIC** APPROACH

	AMERICAN SCHEME (AHA)	EUROPEAN SCHEME (ESC)
FOCUS	• Most severe narrowing	• Overall severity and length
REFERENCE	• Proximal normal segment	• Distal or average segments
CALCULATION	• Simple formula	• Potentially more complex formula
POTENTIAL BIAS	• May overestimate stenosis is long diffuse narrowing	• May underestimate stenosis in the distal segment is also diseases
FORMULA	**% Diameter Stenosis = (1 – [Ds / Dn]) X 100**	

Ds = Diameter at stenosis
Dn = Diameter at normal segment

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CHAPTER TWO

INTERVENTIONAL ANGIOGRAPHY

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- IMAGE QUALITY

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CHAPTER TWO

INTERVENTIONAL ANGIOGRAPHY

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CHAPTER TWO

PULSED FLUOROSCOPY

FRAME RATE

The number of images acquired and displayed per second (fps). **Higher frame rates** provide **smoother motion** but cost of **higher radiation dose**.

SPATIAL RESOLUTION

The ability of an imaging system to accurately depict two distinct objects as separate and distinguishable entities in the image. It essentially defines the smallest that can be visualized. (measured in lp/mm)

CONTRAST RESOLUTION

The ability of an imaging system to differentiate between objects with subtle differences in X-ray attenuation

TEMPORAL RESOLUTION

The ability of an imaging system to capture and display events or changes that occur over time. It refers to how quickly the system can acquire and refresh images.

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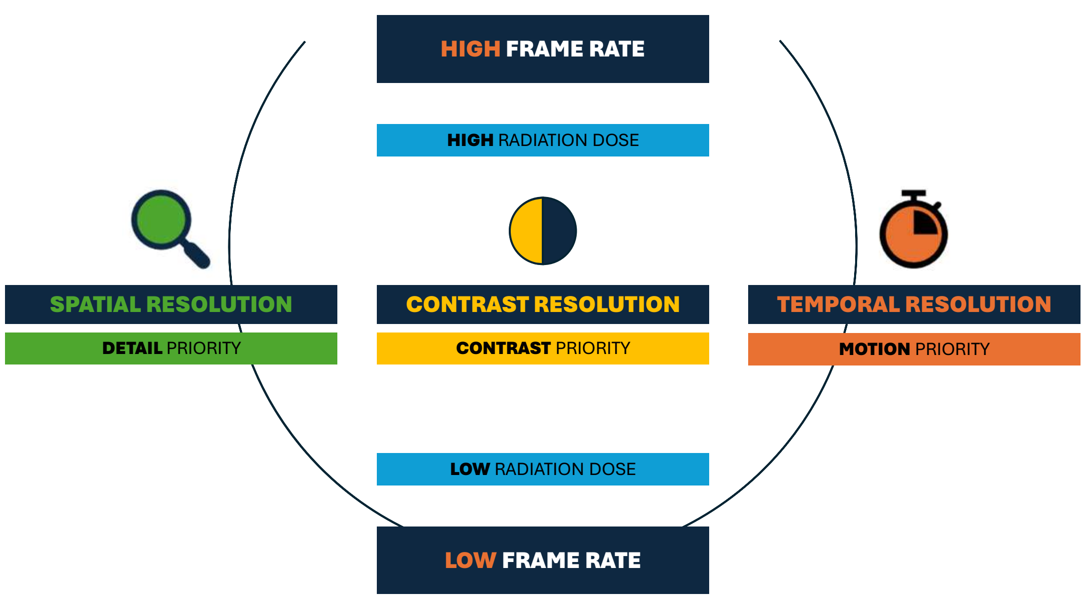
CHAPTER TWO

RADIOLOGISTS MUST FIND AN OPTIMAL BALANCE



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CHAPTER TWO

FACTORS AFFECTING IMAGE SHARPNESS
Display matrix
Field-of-view (FOV)
Video camera matrix
Focal spot size
Geometric magnification
Image noise
Motion

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CHAPTER TWO

ARTIFACTS IN FLUOROSCOPY
Vignetting
Pincussioning
S-Shaped distortion
Blooming
Veiling glare

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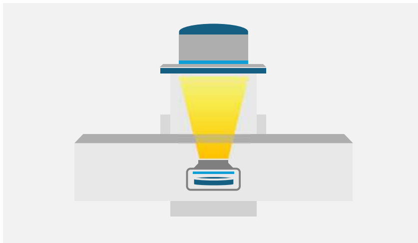
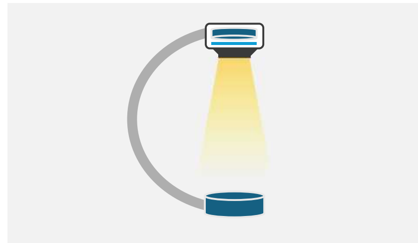
CHAPTER TWO

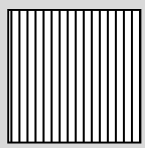
USING GRIDS IN FLUOROSCOPY

CONVENTIONAL	VS	INTERVENTIONAL

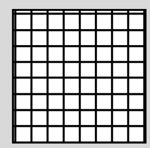




LINEAR GRID



CROSSED GRID



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CHAPTER TWO

Additional image quality considerations…

INFORMATION FROM THE KEY PRINCIPLES SECTION OF THIS LECTURE

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CHAPTER TWO
INTERVENTIONAL ANGIOGRAPHY
CHAPTER
COMPLETED

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