بسم الله الرحمن الرحیم

Kermanshah University of Medical Sciences

Journal Club
Department of Medical Physics

Title:

Digital Subtraction Angiography

By:

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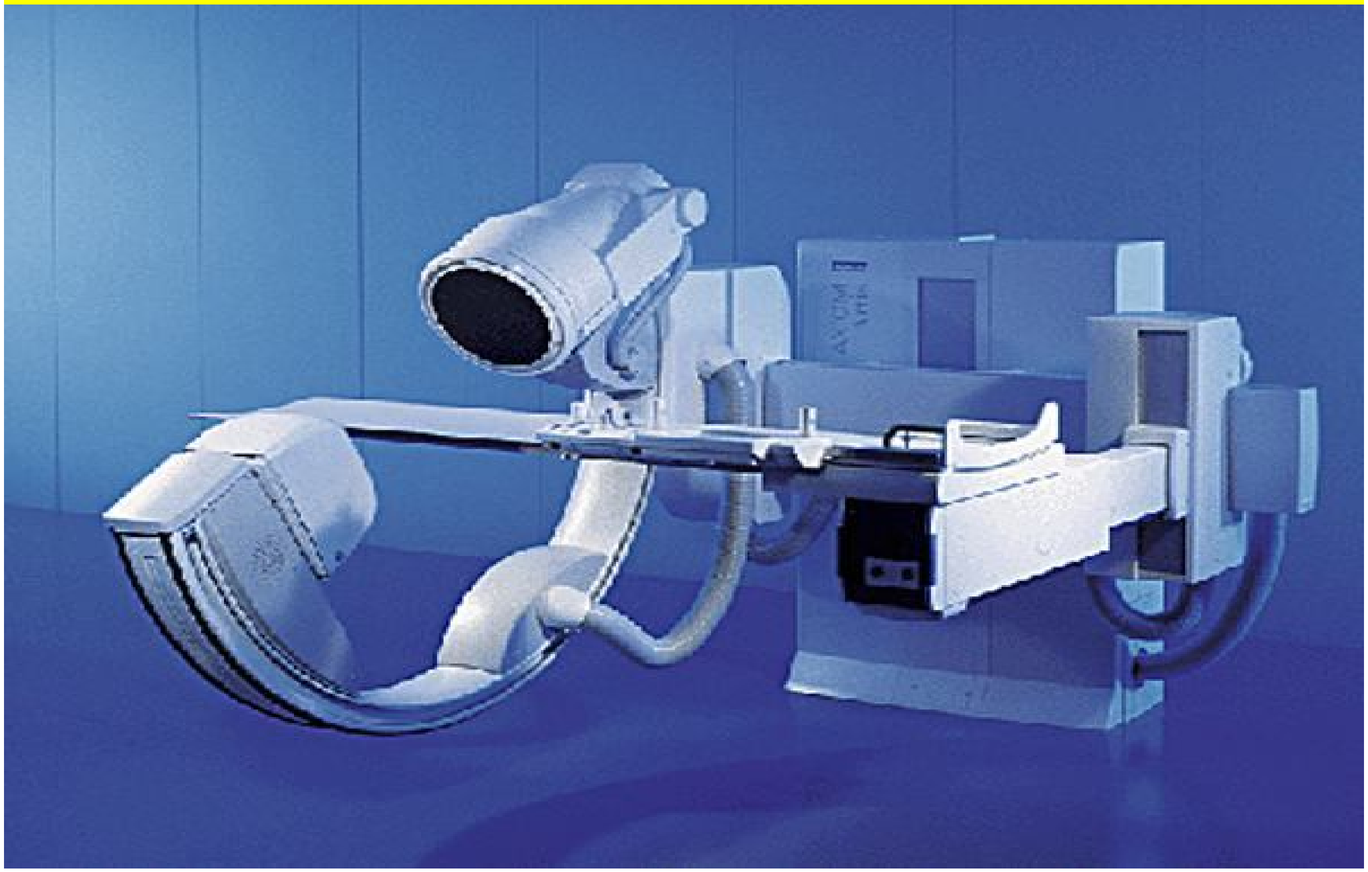
Introduction

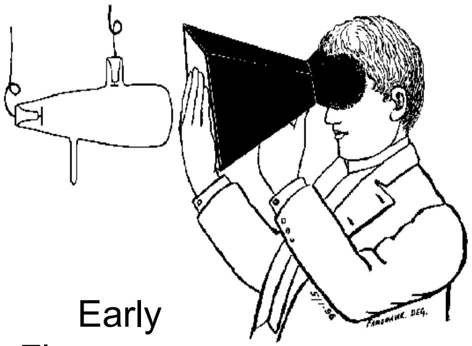
Fluoroscopy



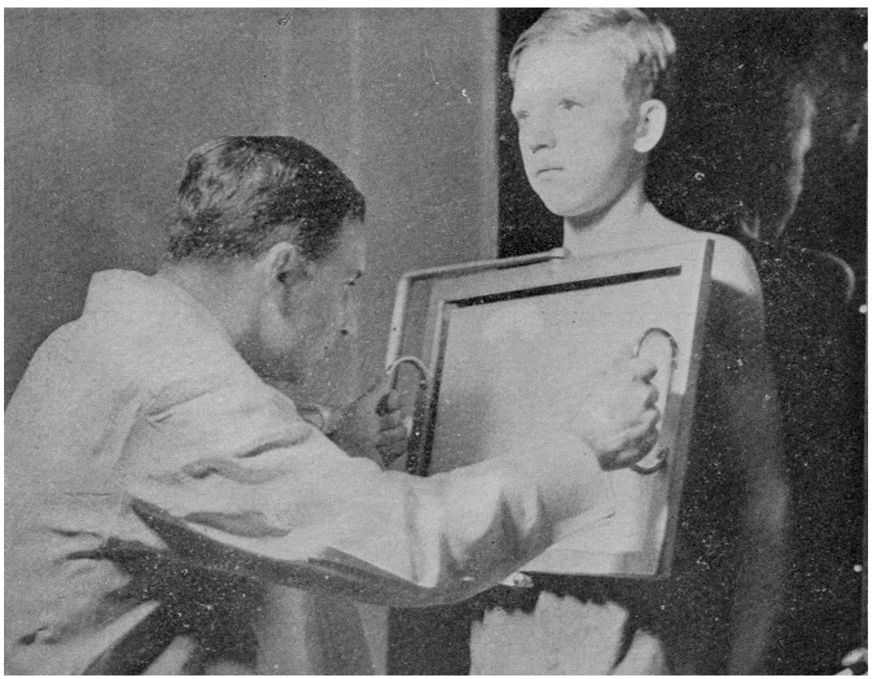
Fluoroscopy

- Fluoroscopy is used where real-time examination of the patient's body is required.
- Some of the uses include:
  - positioning of orthopedic implants during surgery,
  - positioning of catheters and pacemakers,
  - viewing the movement of contrast agents, such as barium, through the body
  - and studying the movement of parts of the body.

CONVENTIONAL FLUOROSCOPY INVENTED BY THOMAS EDISON



Early Fluoroscopy

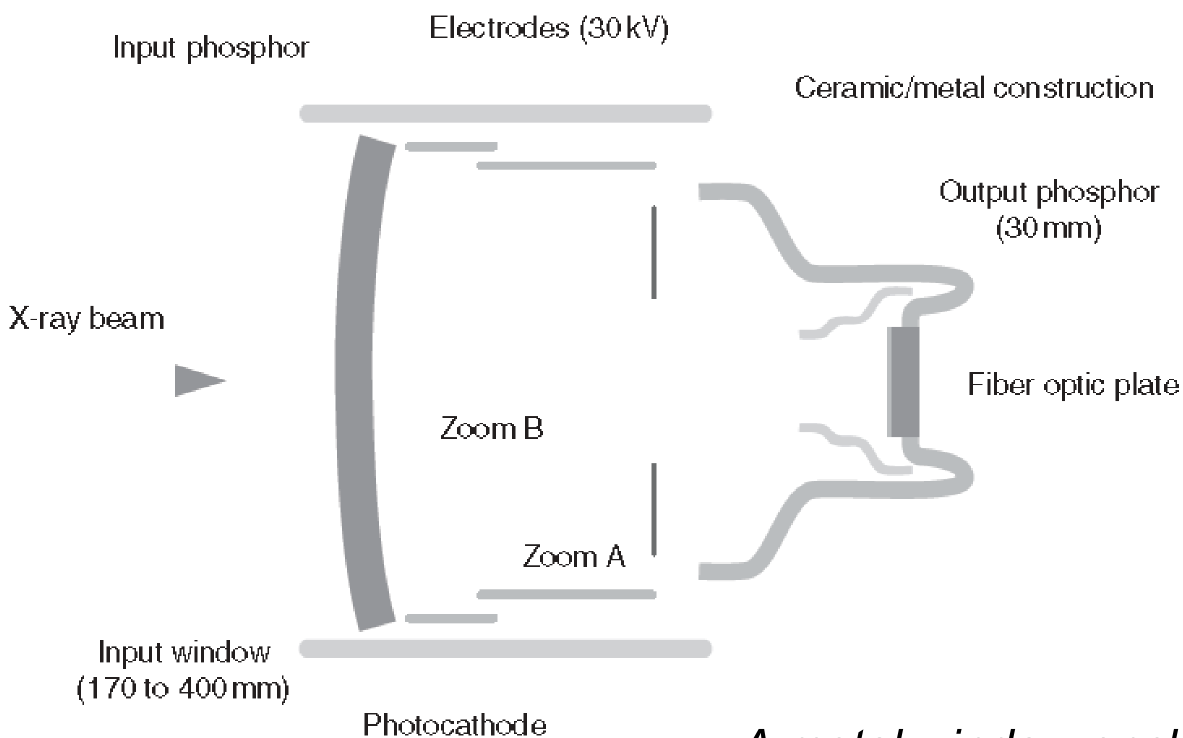


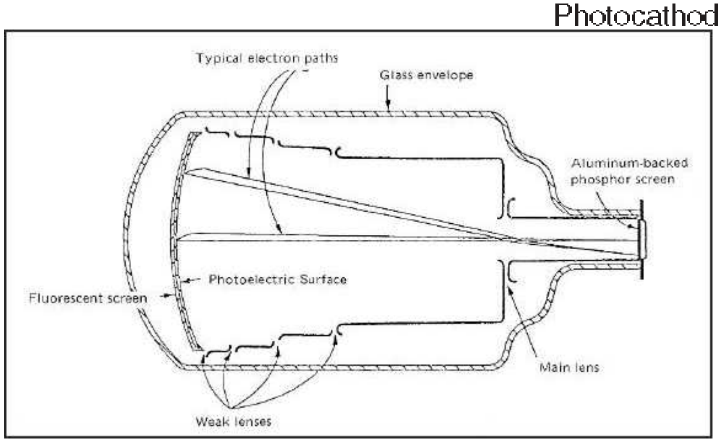
Fluoroscopy

A C-arm fluoroscope is a device used by a physician to guide a needle to a specific area while watching that needle on a live x-ray screen.

Fluoroscopy Unit

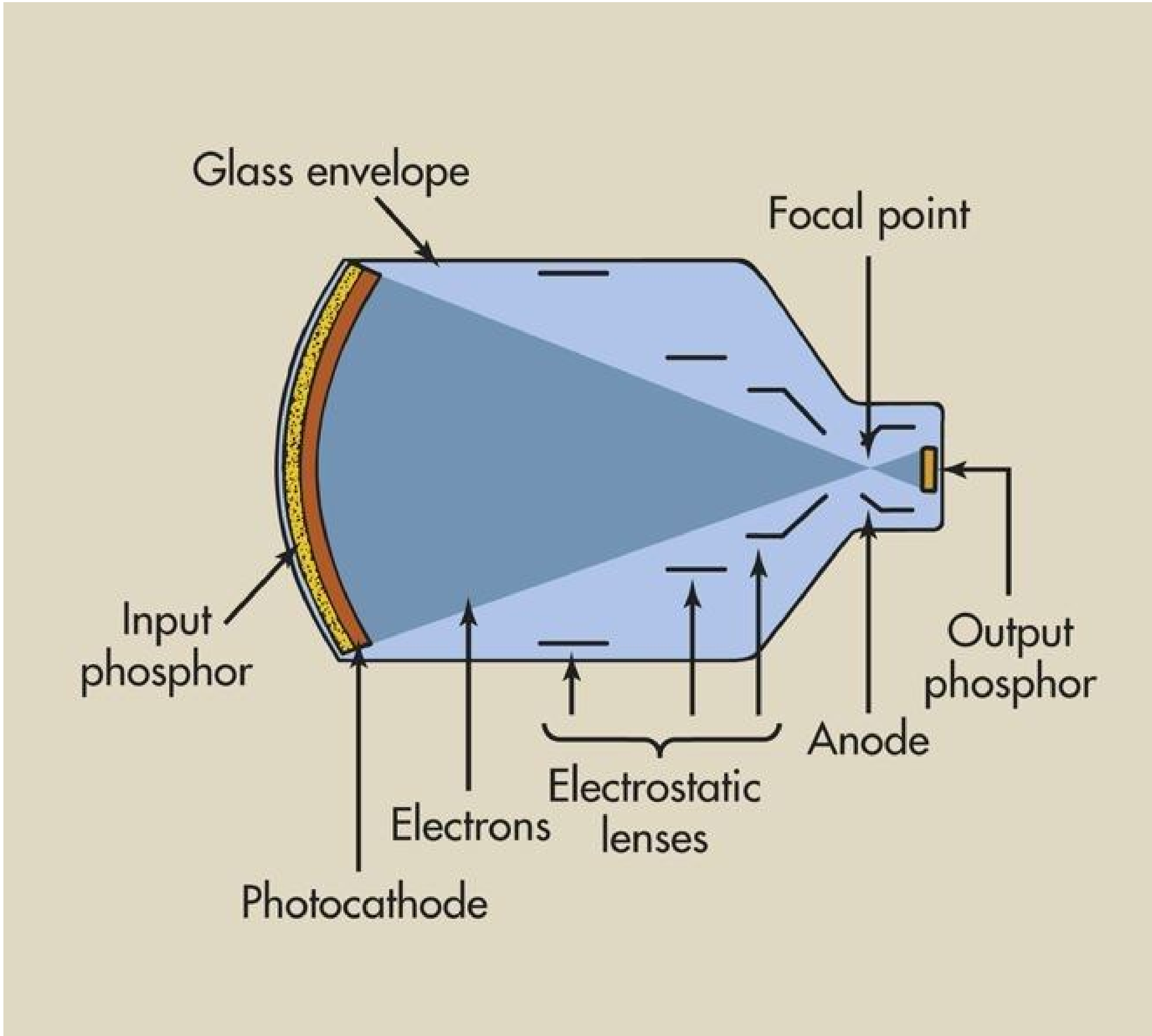
Image intensifier design





- *A metal window encloses the input phosphor (CsI:Na) and photocathode. Electrons ejected from the photocathode are accelerated by the electrodes towards the anode and onto the output screen.*

Image intensifier design



Digital fluorography

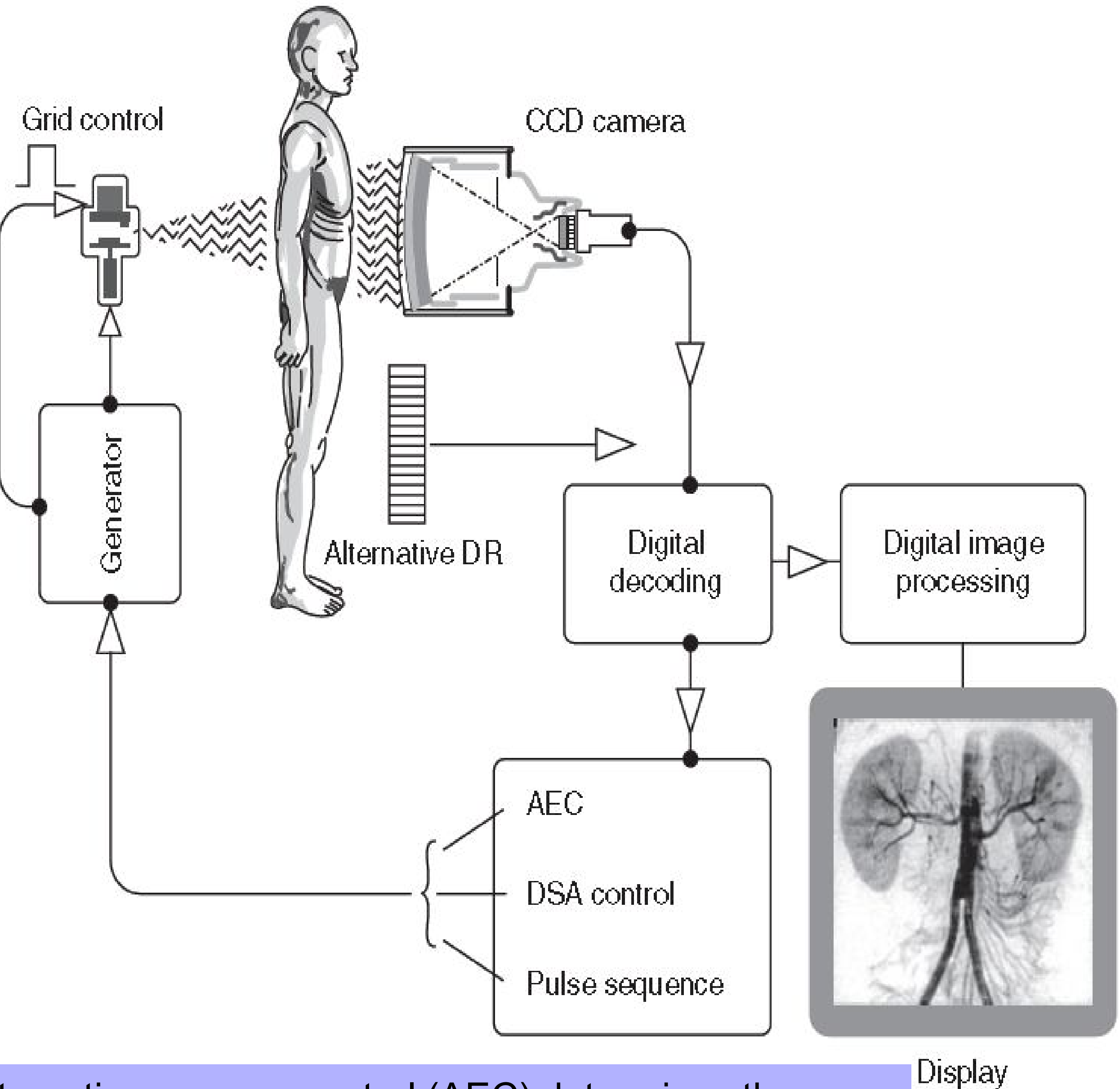


Figure: ***Basic components for a digital fluorography imaging system. The image intensifier output influences exposure settings maintaining a fixed exposure rate at the image intensifier face. Image data are digitized and stored in memory.***

The automatic exposure control (AEC) determines the optimum exposure required for the chosen acquisition protocol (frame rate and dose etc.).

Digital Subtraction Angiography

- In order to distinguish vascular pathology and separate vessel detail from background anatomy a digital image is taken before and after contrast medium injection and the two images subtracted to reveal the isolated vessels.

Mask image

- **This is a technique for producing images of the blood vessels isolated from overlying structures.**
- **To achieve this, two images of the same region, separated in time, are acquired:**
- **The first image, called the mask, is taken prior to the injection of a contrast agent.**
- **The second image, called the contrast image, is the mask but it now contains the contrast agent.**

The digital subtraction angiography system

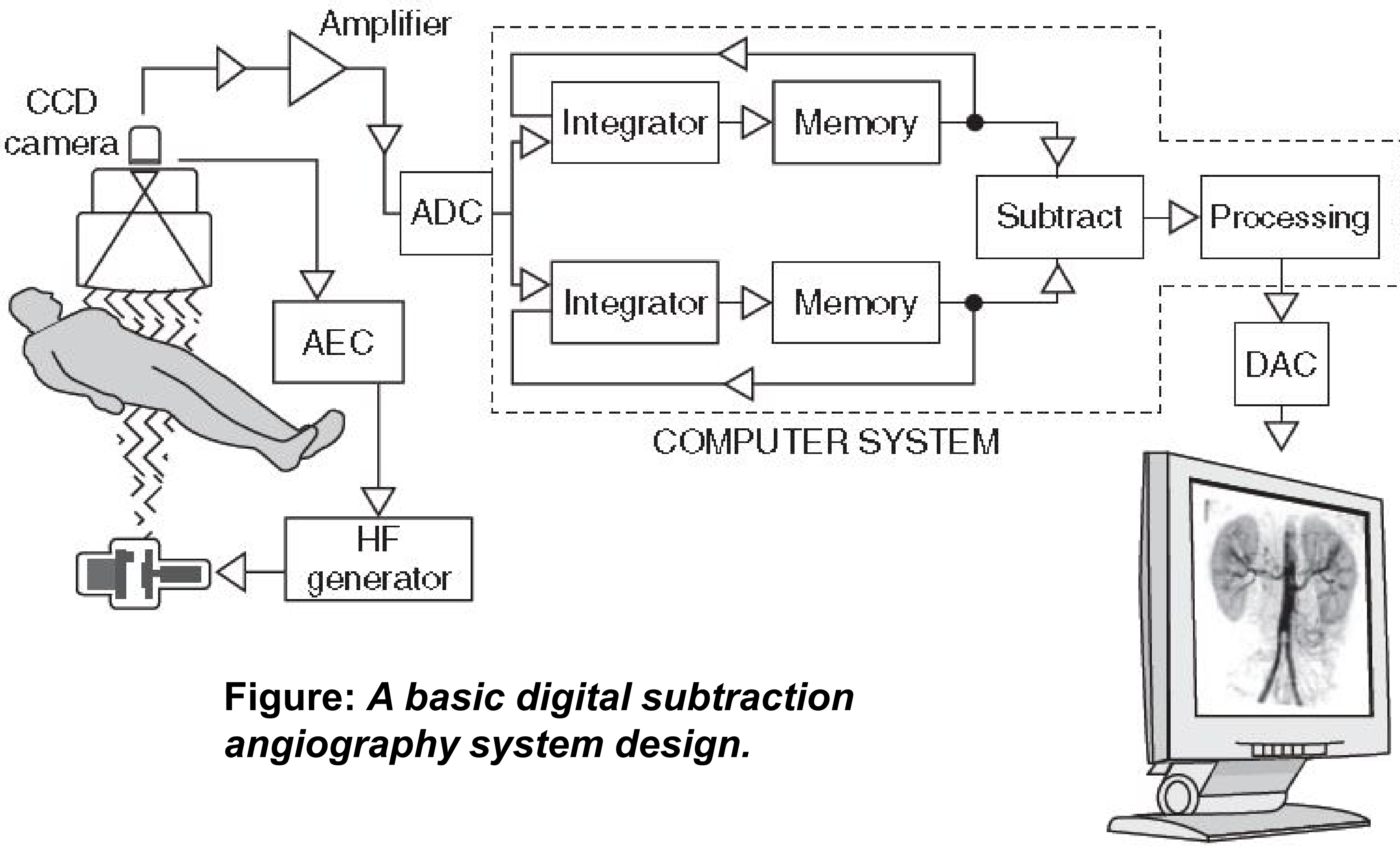


Figure: ***A basic digital subtraction angiography system design.***

Digital subtraction angiography

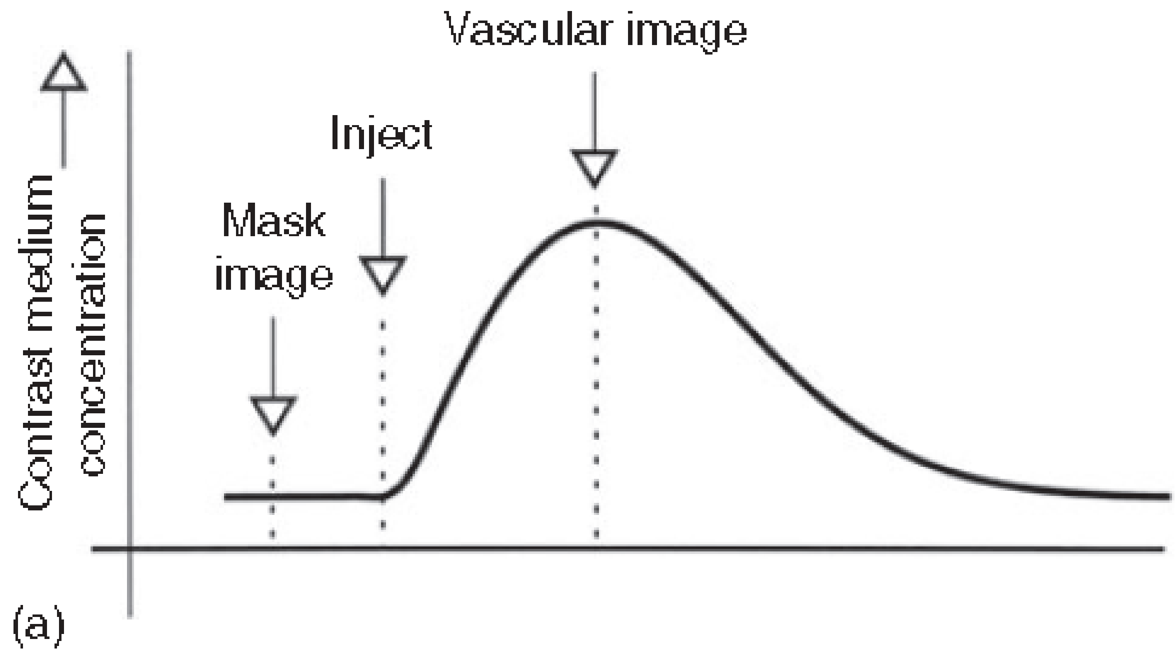


Figure *(a) The arterial and venous phases of a digital subtraction angiography study.*

Digital subtraction angiography

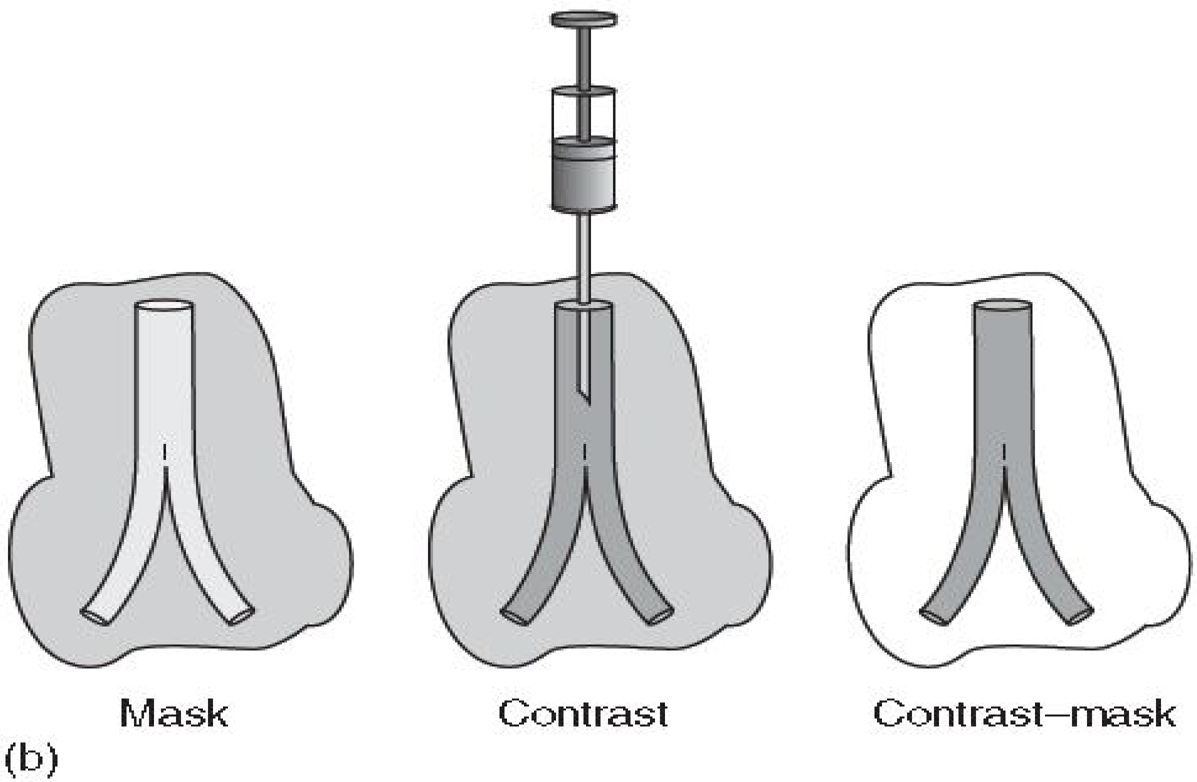


Figure ***(b)*** *In the basic DSA technique a mask image (M) is first stored then the relevant vessels are injected with contrast medium and a second image stored (C). Subtracting these images yields the difference image free of surrounding anatomy(D).*

Digital subtraction angiography

- The signal-to-noise ratio of the final DSA image (SNR) depends also on the concentration of contrast medium *C (iodine or barium) and the radiation dose D (photon density) so that:*

$$\mathrm{SNR} = C \times \sqrt{D}$$

- Increasing the concentration of contrast material is therefore a more effective improvement than increasing patient dose.
- An effective way to improve image SNR is to integrate (add) image frames.
- Noise reduction depends on the number of similar frames added. If N frames are integrated, each having a noise value of σ then the noise in the summed image is σ /N.

Road mapping

- **Road mapping involves superimposing real-time images onto a previously acquired mask so that intraluminal manipulation of the catheter *can be followed*.**
- **A static image is used as a reference when advancing a catheter along the vessel being studied.**
- **The current fluoroscopic display is compared with the reference image, which contains contrast and thereby clearly delineates the position of the catheter within the vessel.**
- **The reference image is used as a mask for subtracting from the real-time fluoroscopic display. As the catheter is advanced, it is seen progressing along the vessel lumen.**

Road mapping

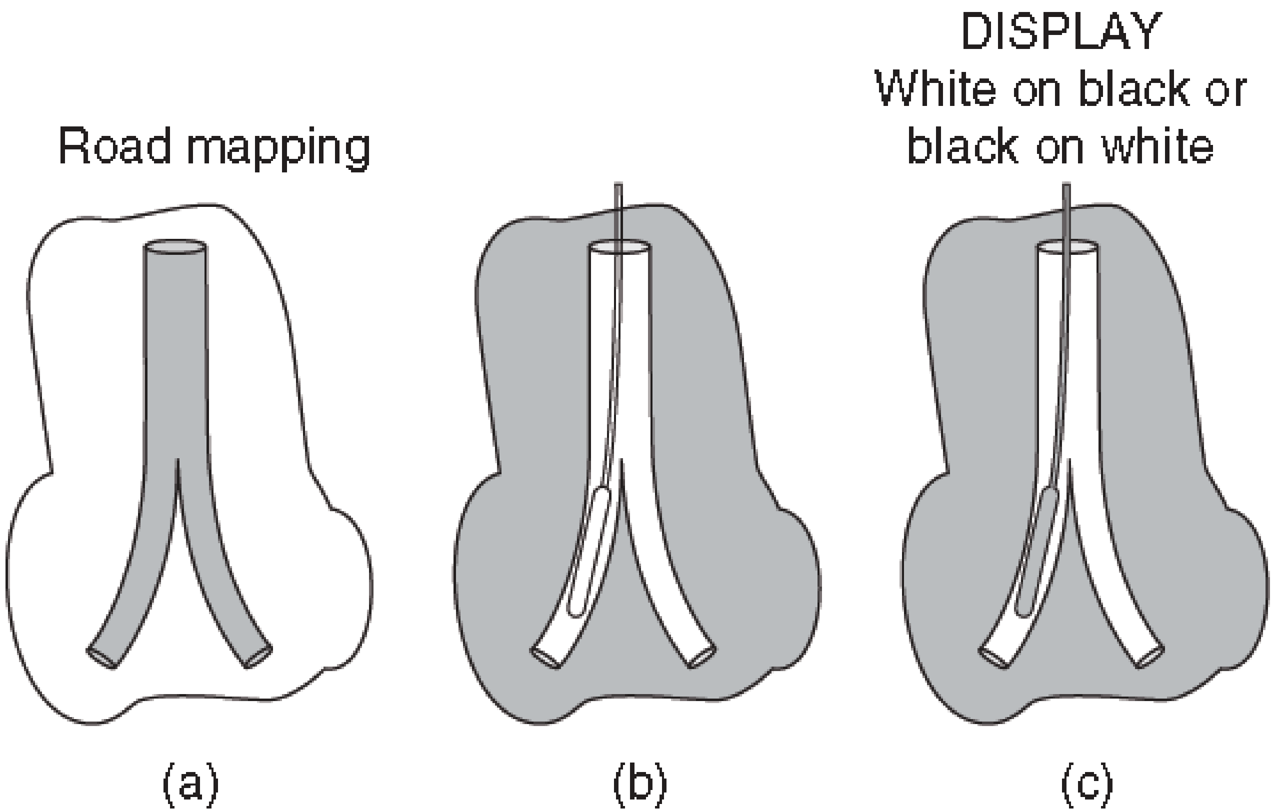


Figure. ***Road mapping used for presenting a real-time image of the catheter position (a). A vessel contrast image is taken which is then continuously subtracted (b) after catheter insertion to give the real-time image (c).***

Road mapping

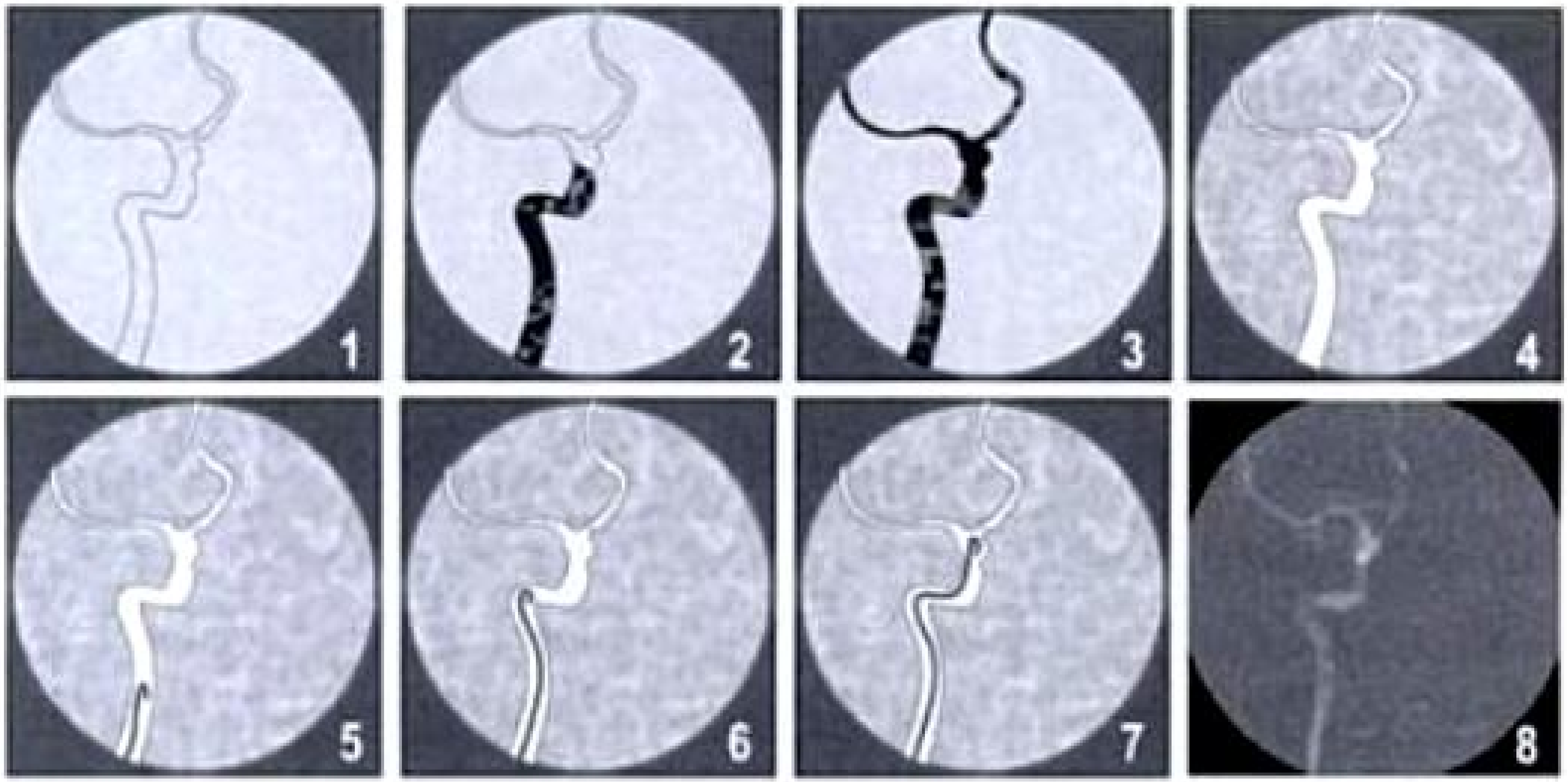
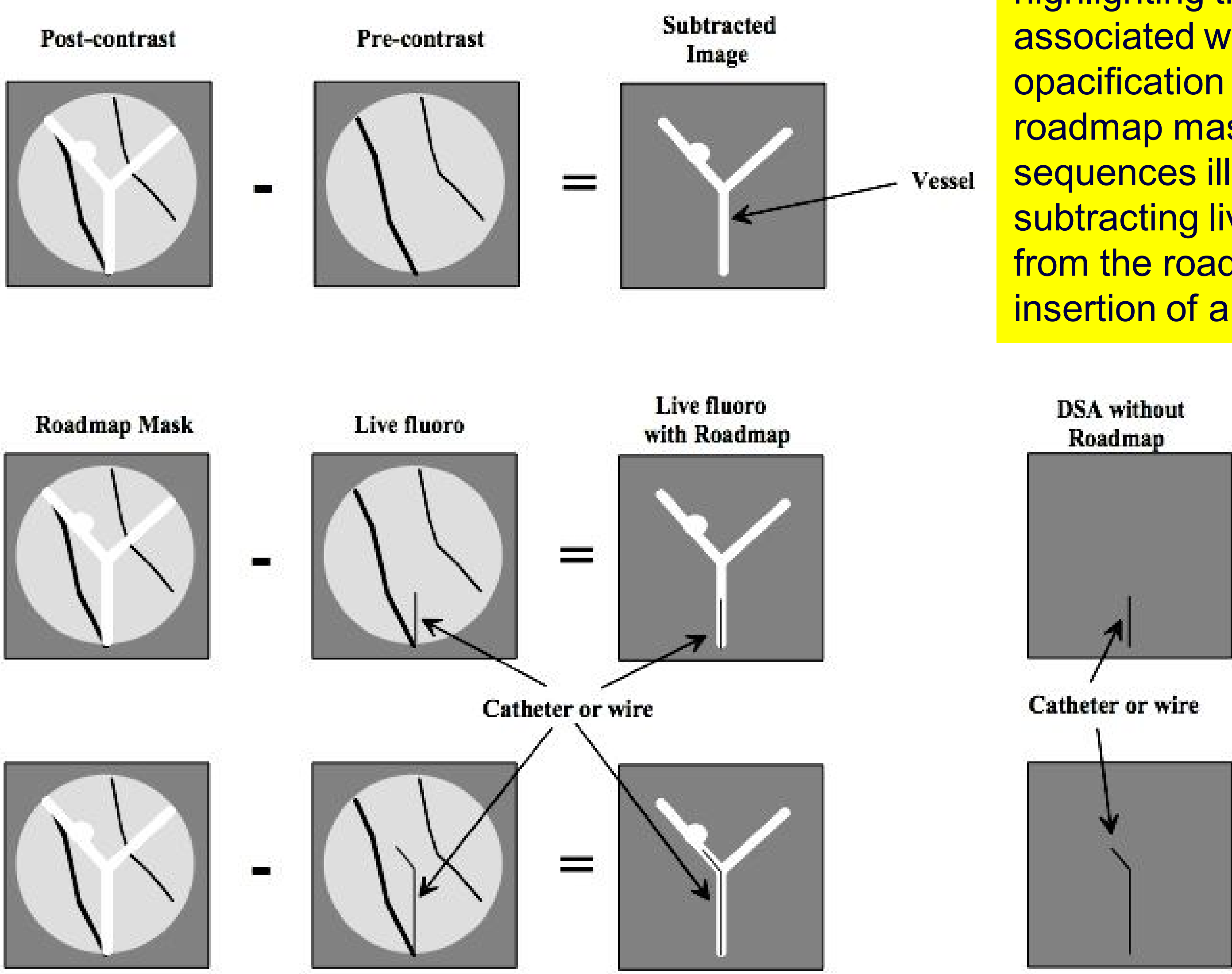


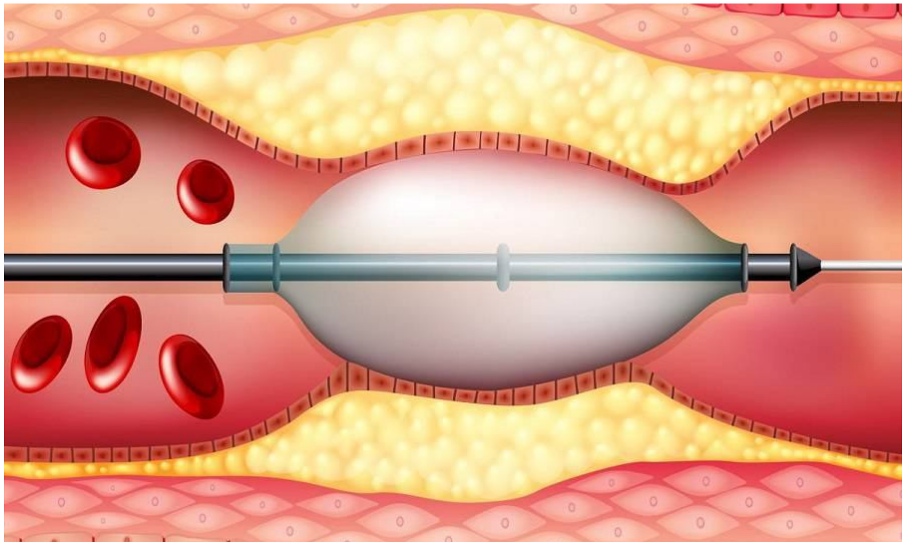
Figure 9.33 Roadmapping. Principle based on the example of an aortography; right bottom: Subtracted and inverted mask image.

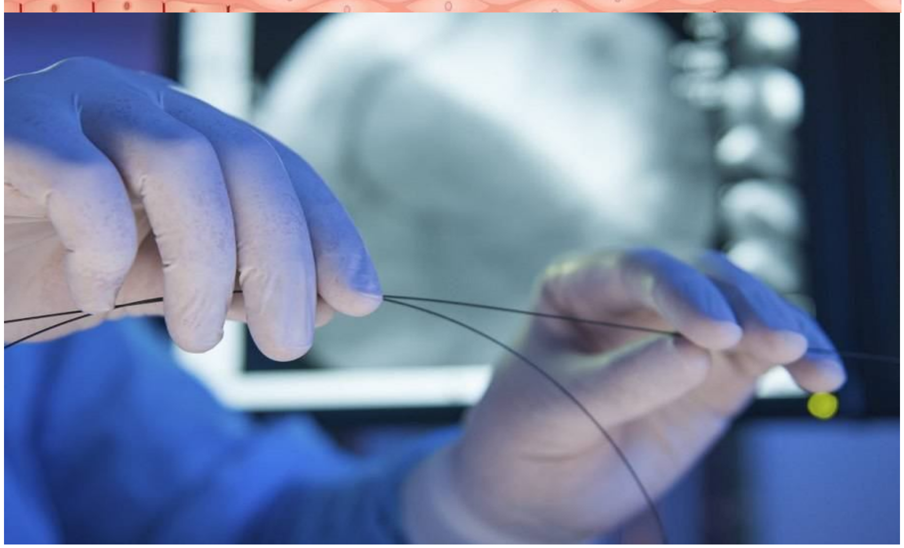
Road mapping



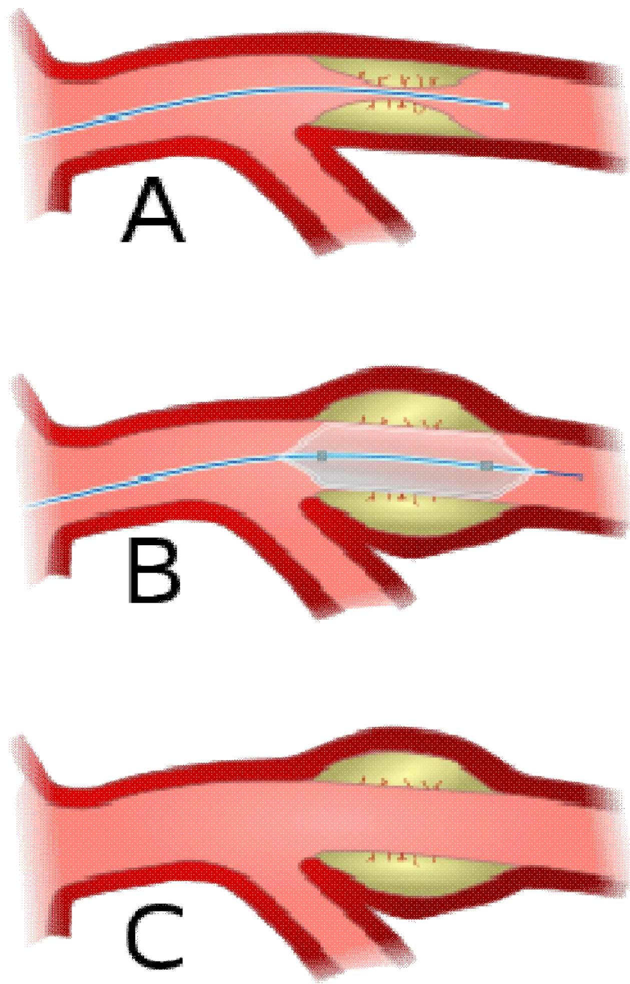
Road Mapping: The top sequence illustrates conventional DSA highlighting the post-contrast image associated with maximum vessel opacification which becomes the roadmap mask. The lower sequences illustrate the result of subtracting live fluoroscopic images from the road map mask during insertion of a guidewire.

Angioplasty

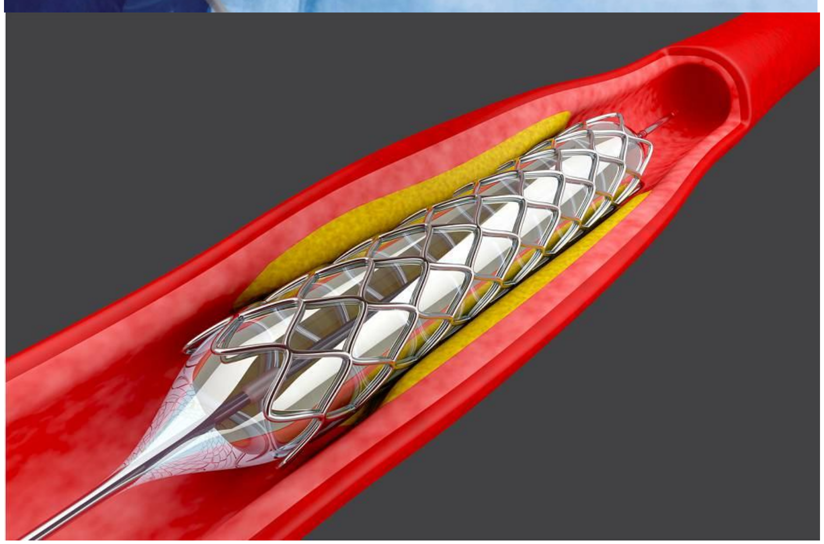


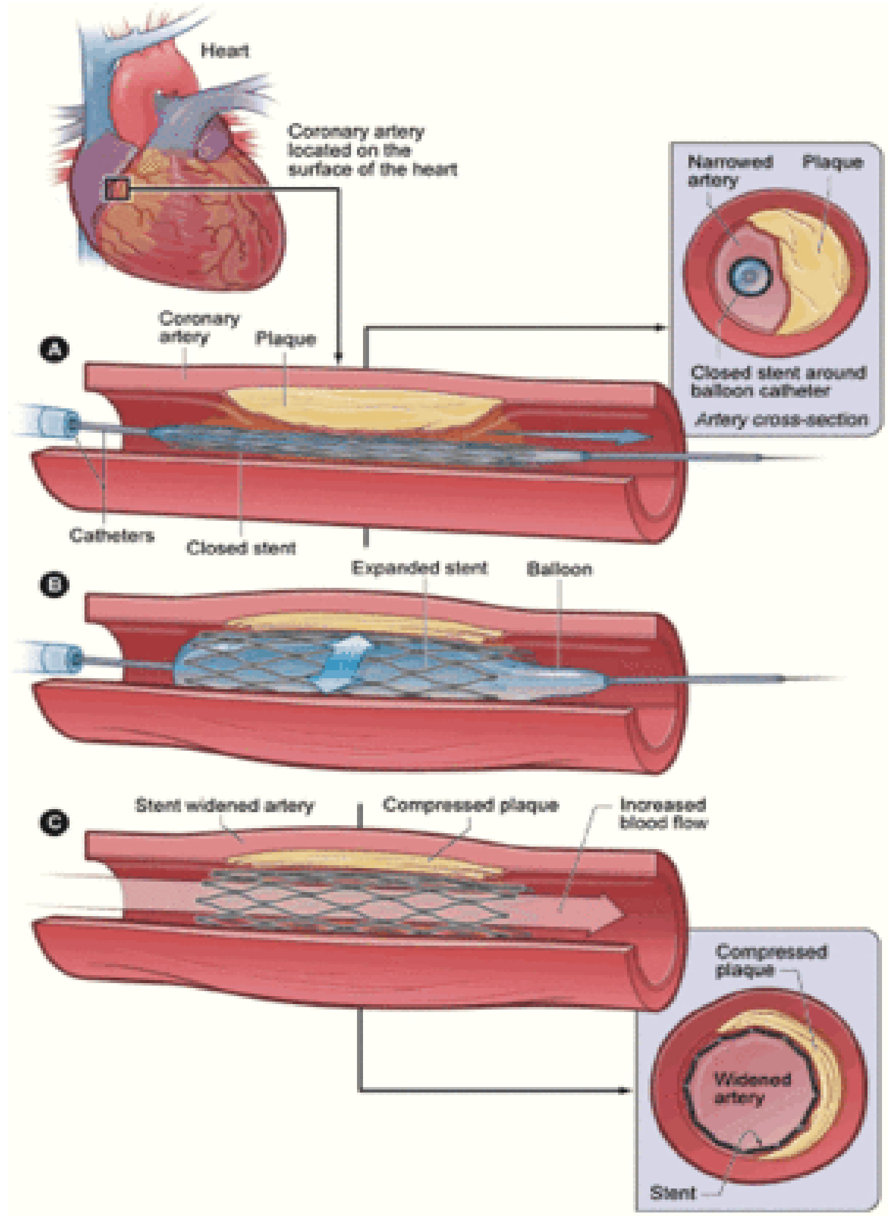


Balloon angioplasty

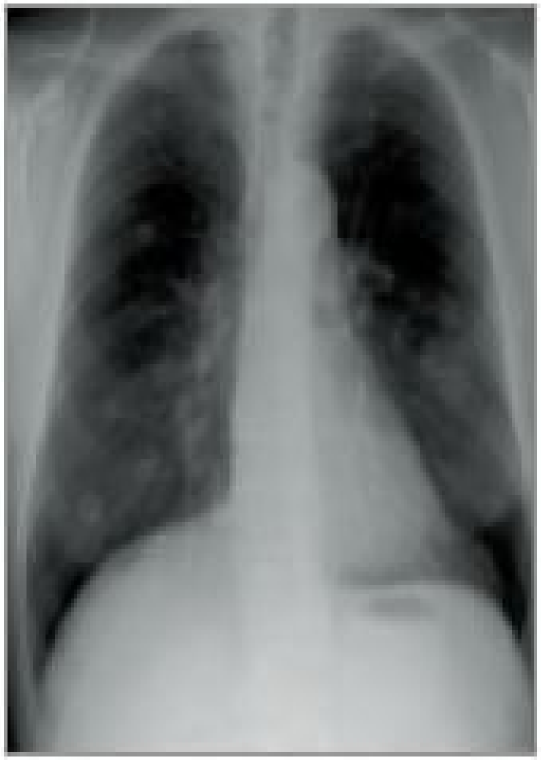


Angioplasty



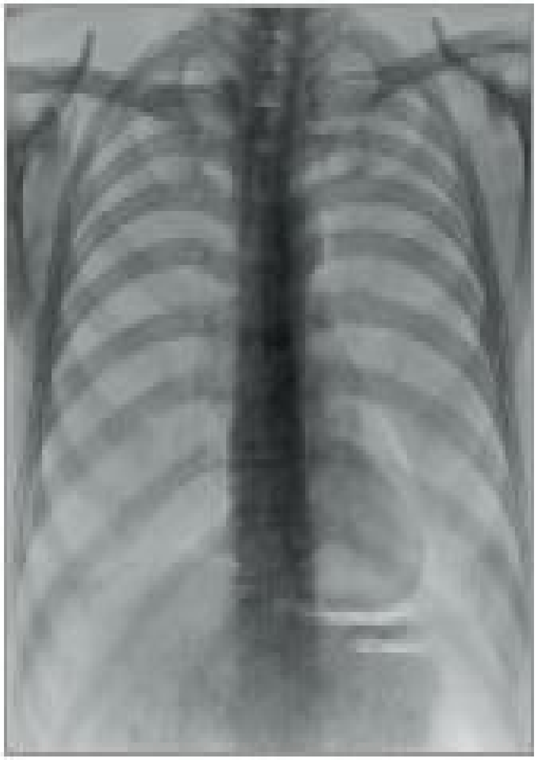


Dual Energy Radiography



Standard image

Soft tissue image



Bone image

Dual Energy Radiography

Soft tissue image showing numerous lung nodules

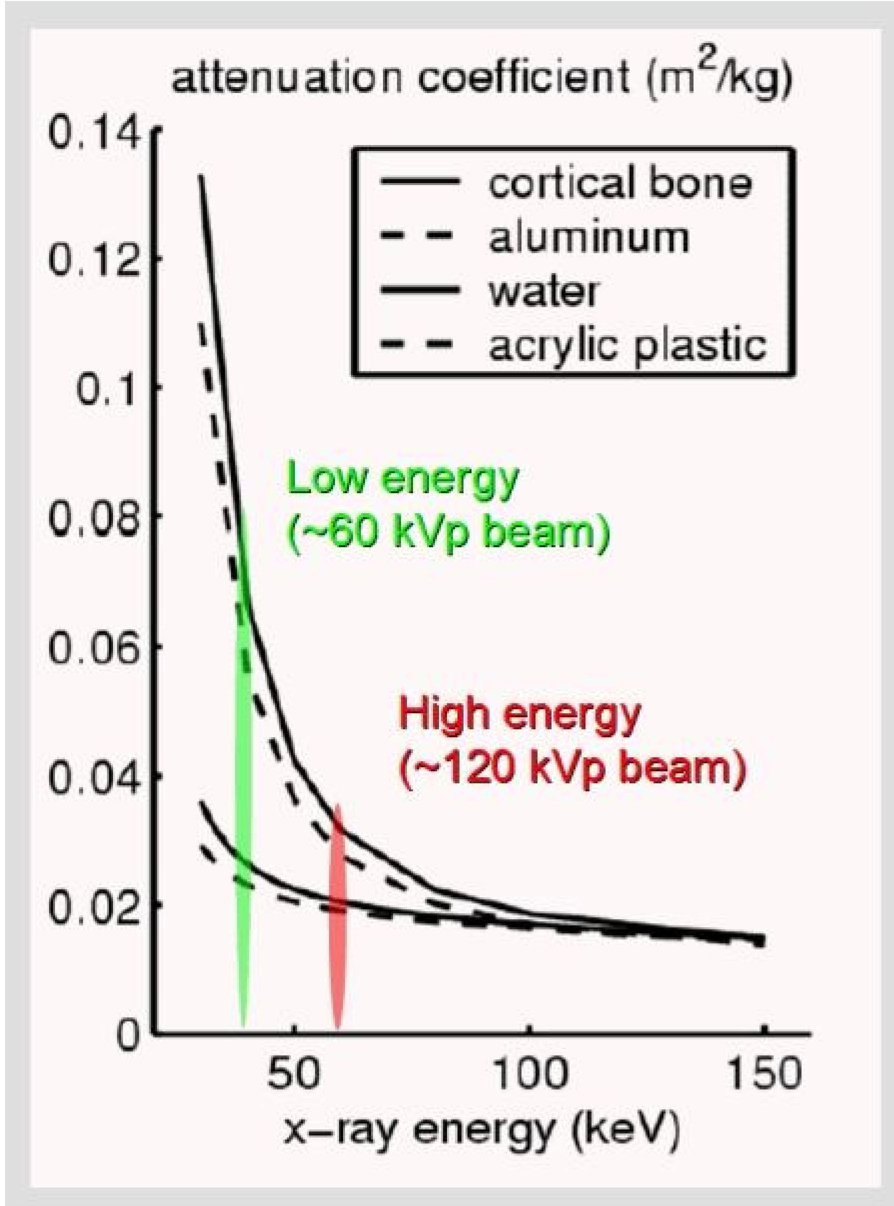
Bone image showing extensive asbestos-related disease

Dual Energy Radiography Acquisition and Processing

- **A major limitation of projection radiography is the projection of the 3-D patient volume and anatomy on a 2-D image plane.**
- **In chest imaging, for example, the bony structure of the ribs, clavicle, etc. will often hide subtle soft-tissue lesions in the lung because of anatomical overlap caused by the projection process.**
- **Removing the bony structure, therefore, might aid in the visualization of otherwise undetectable lesions; similarly, removing the soft-tissue components and emphasizing the bony structures might allow the discrimination of soft versus calcified lesions.**

Dual Energy Radiography Acquisition and Processing

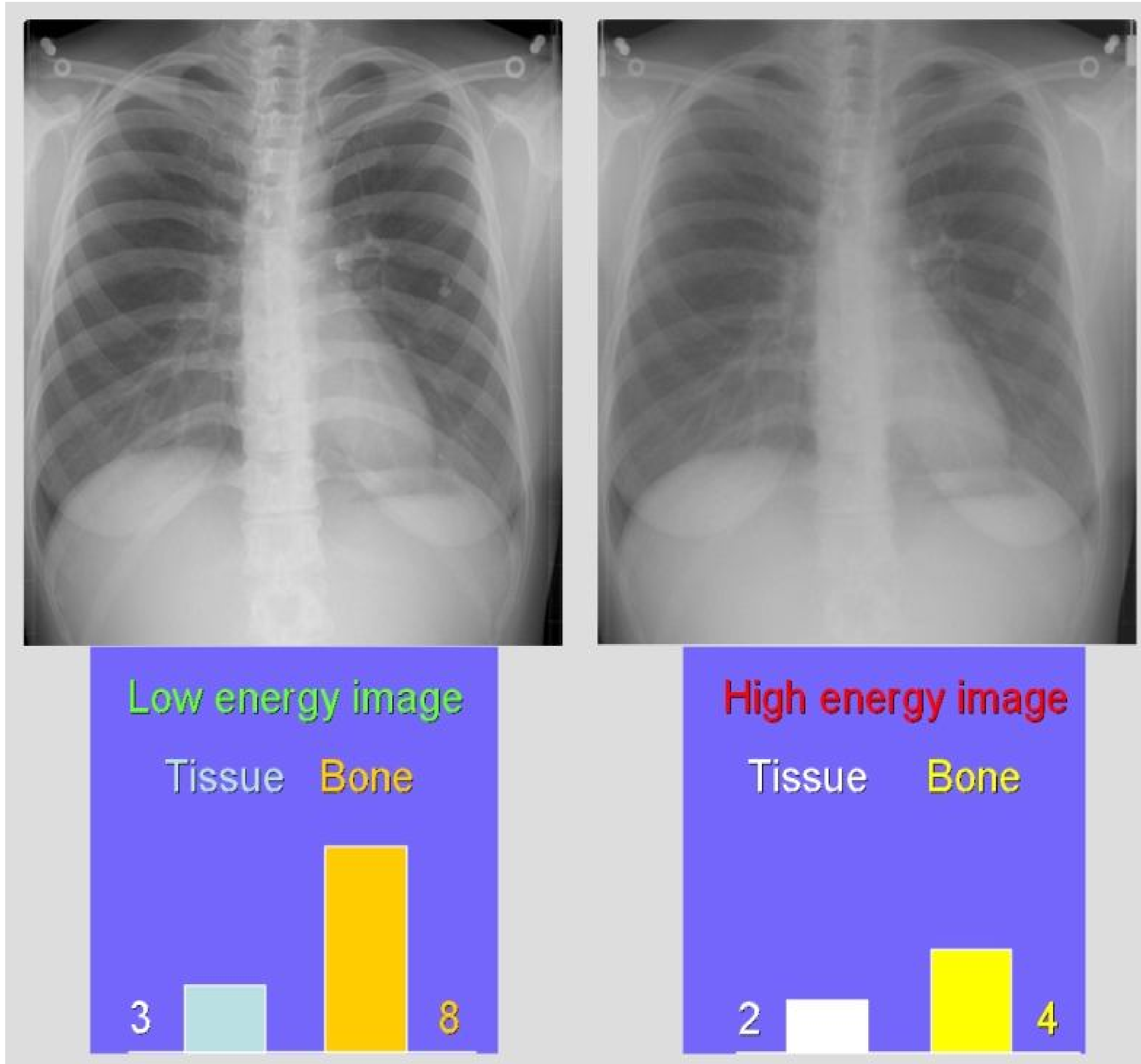
- The higher differential attenuation of bones as a function of energy compared to soft tissue allows the ability to decompose two images taken at different x-ray energies into tissue-selective representation of the anatomy,
  - namely "soft-tissue only" and "bone-only" images.



Dual Energy Radiography Acquisition and Processing

❖ **Two images acquired at low energy and high energy using a Computed Radiography dual-energy system**

- *If two x-ray images are acquired at these energies, one can "weight" one image relative to the other that when subtracted, will null the signal due to either bone or soft tissues, depending on the weighting factors.*



Dual Energy Radiography Acquisition and Processing

Weighted subtraction and scaling

Tissue only: remove bone signal

Choose constants to remove bone:

(high * 2 - low * 1) * k_t → Tissue signal scaling factor, k_t

(4 * 2 – 8 * 1) = 0 (bone residual)

(2 * 2 – 3 * 1) = 1 (soft tissue residual)

Dual Energy Radiography Acquisition and Processing

Bone only: remove tissue signal

Choose constants to remove tissue:

$(\text{low} * 2 - \text{high} * 3) * k_b$

Bone signal

scaling factor, k_b

$(8 * 2 - 4 * 3) = 4$ (bone residual)

$(3 * 2 - 2 * 3) = 0$ (soft tissue residual)

Dual Energy and Hybrid Subtraction

- Using two X-ray energies for acquiring image data is a technique that can be used to eliminate either bone or soft tissue detail.
- The technique depends on the energy dependence of X-ray attenuation through matter.
- One low kVp and a high kVp, images are acquired of the same anatomical region.
- When the low energy image is subtracted from the high energy image the soft tissue detail cancels leaving mainly bony detail.

Dual Energy and Hybrid Subtraction

Table 13.3 *Dual energy subtraction image series.*

Mask and contrast	Bone	Soft tissue	Iodine
Mask			
M_L, low kV mask	High	Medium	NA
M_H, high kV mask	Medium	Medium	NA
Contrast			
C_L, low kV image	High	Medium	High
C_H, high kV image	Medium	Medium	High

Dual Energy and Hybrid Subtraction

- **Using energy subtraction these two images are combined to eliminate soft tissue and leave only bone structures as a pre-contrast mask:** $M_L - M_H \rightarrow \text{bone image } M_B$
- **A series of low and high energy image pairs is then acquired as the contrast bolus flows through the region of interest. Each of these pairs is processed to suppress soft tissue components and to yield a post-contrast image of iodinated vessels plus bone residuals:** $C_L - C_H \rightarrow \text{bone} + \text{iodine } C_{(B+V)}$
- **Finally, a temporal subtraction of the dual-energy mask and post-contrast images removes the bone structures and successfully isolates the iodine-filled vasculature:**

$$C_{(B+V)} - M_B \rightarrow \text{iodine image } C_V$$

Dual Energy and Hybrid Subtraction

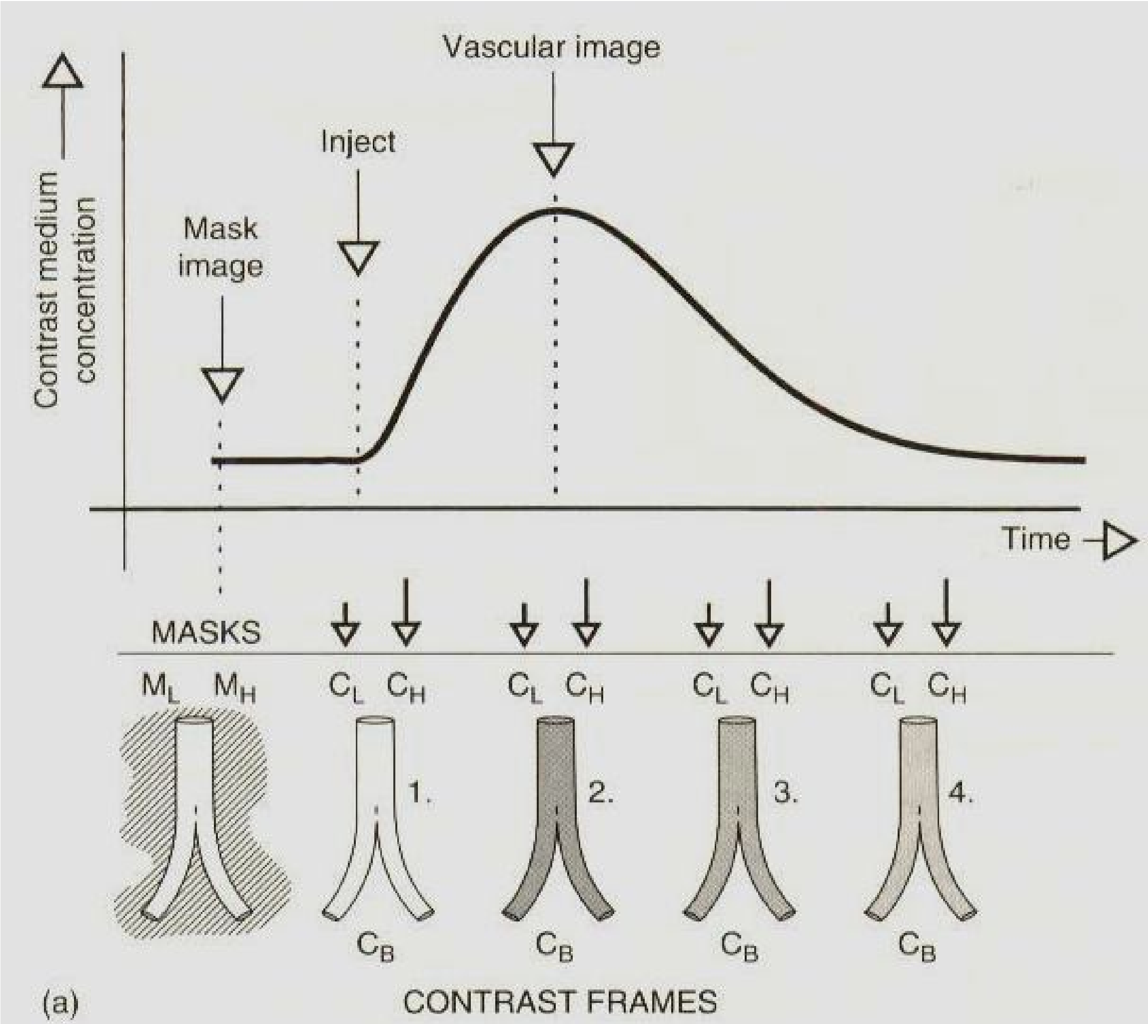
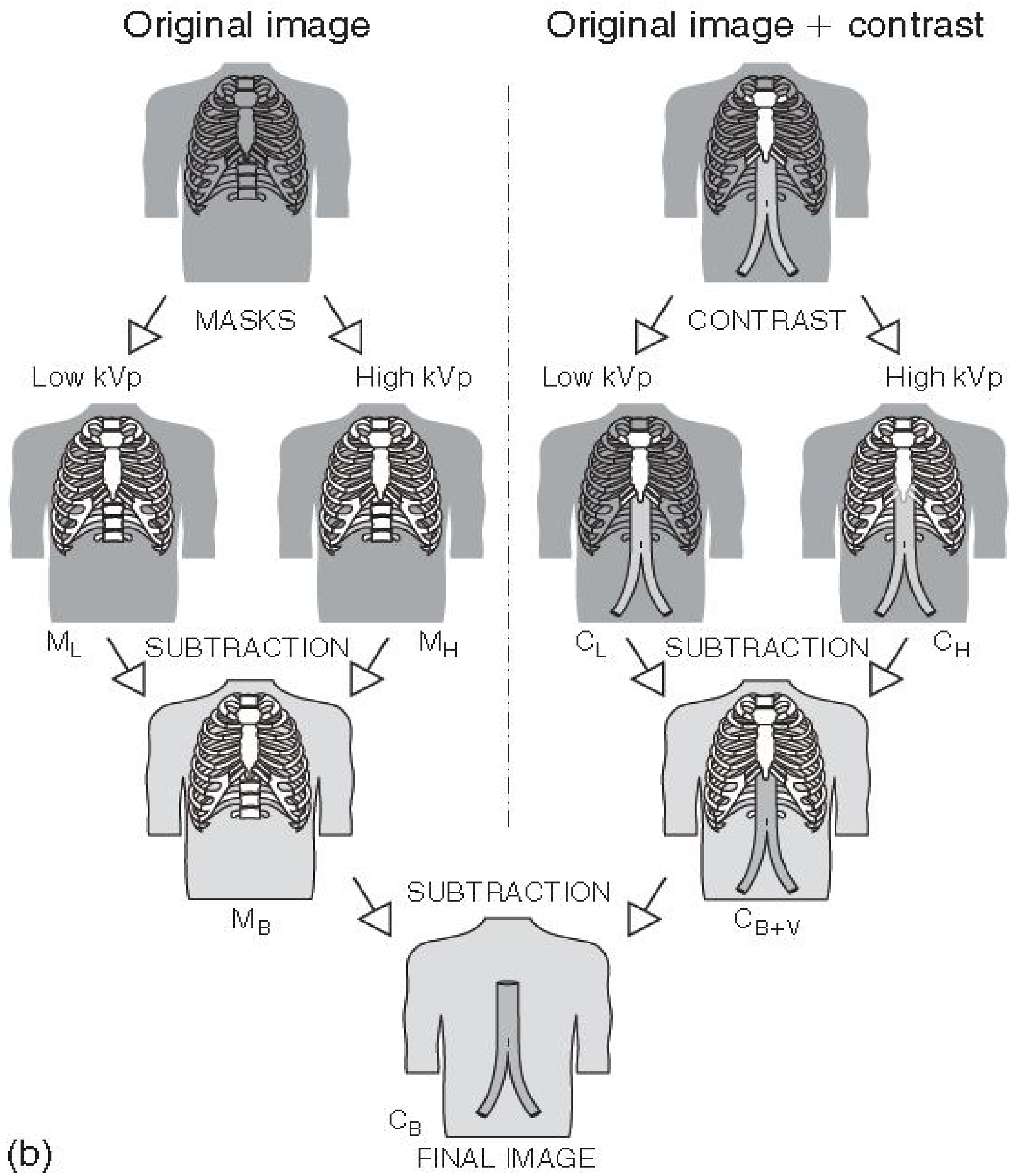


Figure (a). The hybrid subtraction sequence representing passage of contrast medium through the vessel and the series of temporal frames CL and CH taken at low and high kilovoltages.

Dual Energy and Hybrid Subtraction

Figure (b): The image series formed during a dual energy subtraction series ending with the final image which contains only the vessel detail free from bone interference.



Dual Energy and Hybrid Subtraction

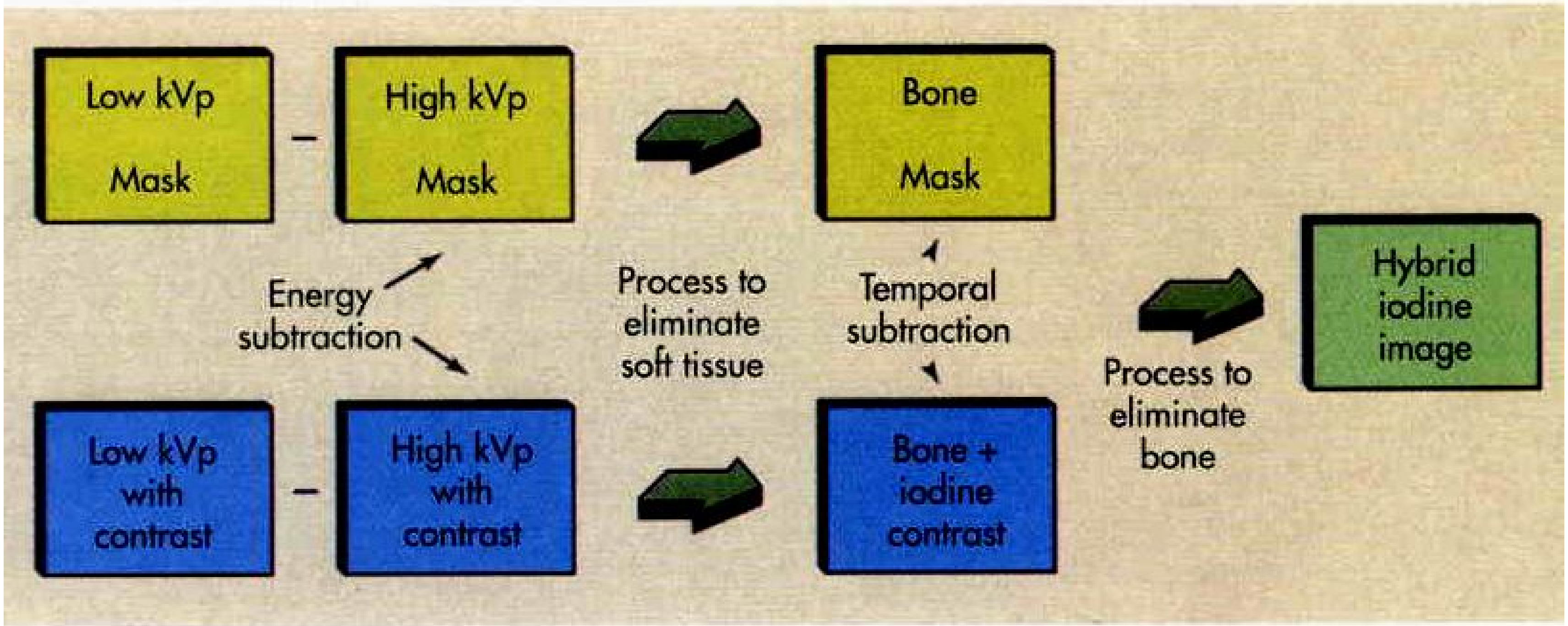
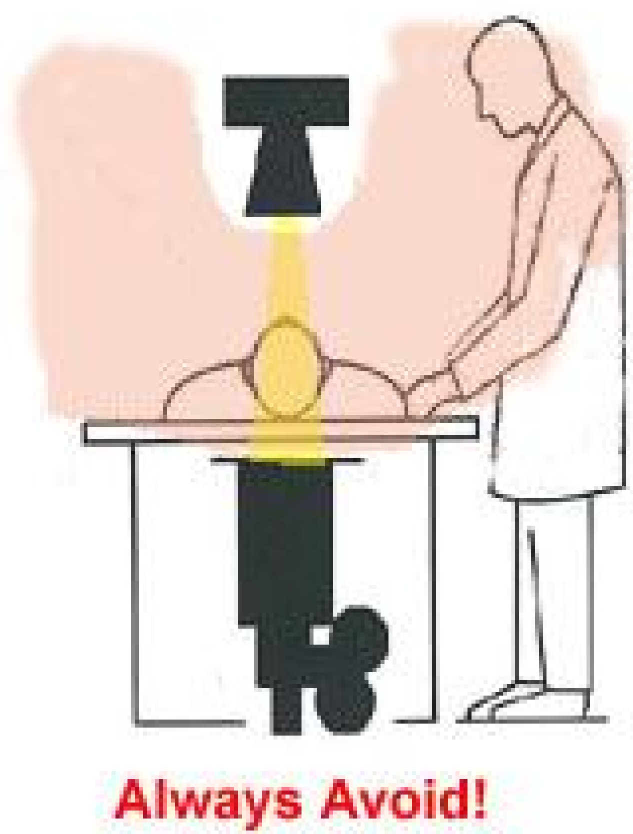
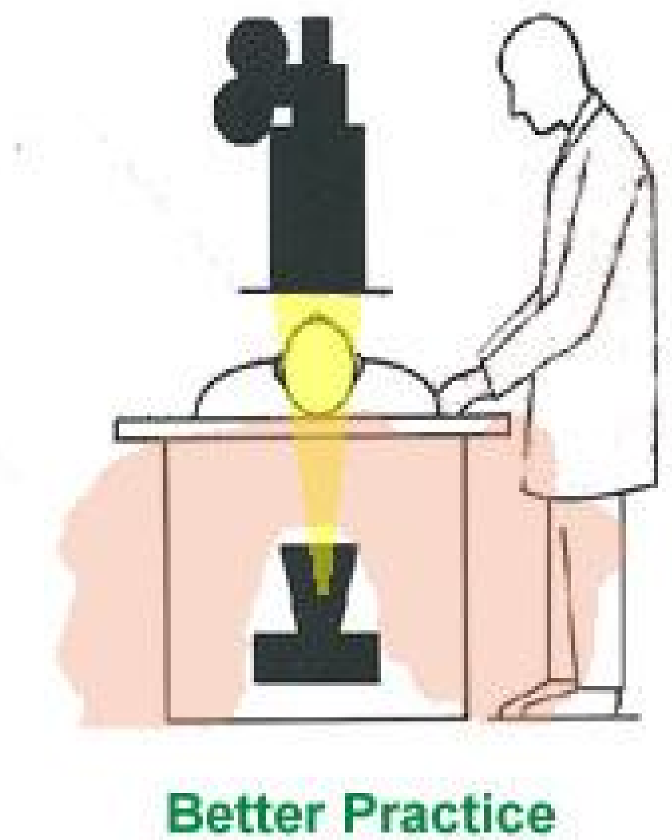


FIGURE 28-31 Hybrid subtraction involves both the temporal- and the energy-subtraction techniques.

Over vs Under the table fluoroscopy tubes & Scatter

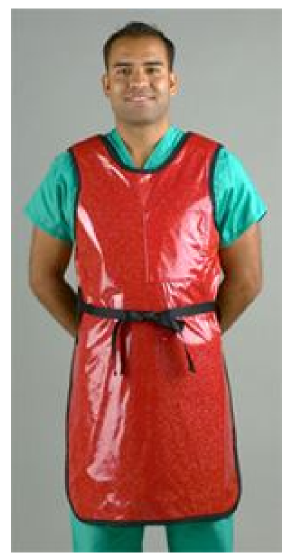




Protection of Radiographer and Radiologist

- Single step away from the table decreases exposure exponentially (inverse sq law)
- Bucky slot cover
- Lead rubber drape
- Radiologist as shielding

- **Used when it is not possible to remain behind a barrier**
  - **Lead aprons**
  - **Lead gloves**
  - **Lead glasses**
  - **Thyroid shields**
- **0.25 –1.0 mm lead eq**



- ***Thank you…***