DIAGNOSTIC IMAGING OVERVIEW

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Outline

- Introduction
- Role of imaging in patient management
- History of introduction of imaging in medical practice
- Imaging equipments/Modalities
- Interventional imaging and therapeutics

Introduction

- Diagnostic Imaging is the study of healthy and diseased organs and tissues by imaging. The interventional branch provides treatment to certain disease processes.

- The information imaging provides makes it a primary tool in clinical medicine at primary, secondary and tertiary care.

- The images are an extension of patient examination.

- The practicing physician must know from history from the patient and physical examination when to opt for an imaging Test, which imaging modality to order and its contribution to patient management.

Role of Radiology in Medicine.

Indeed every speciality of medicine utilizes imaging at one point or other to:

- Help establish a diagnosis.
- Assess disease extend.
- Provide information on prognosis especially in cases of malignancies and their spread to other areas.
- The interventional branch can offer treatment in certain disease processes.

Radiology in patient management

As a student in your clinical years of study you should be able to answer the following questions in every given clinical case.

- Does the patient require an imaging examination?
- If so which imaging modality will be most suitable and cost effective?
- What is the selected imaging modality likely to confirm or exclude and thus contribute to patient management ?

Entry of Imaging in medical practice

- Imaging joined the practice of medicine following the discovery of X-rays by Roentgen in 1895

Wilhelm Conrad Roentgen
1845-1923

- Won Nobel Prize in 1901.
- Jan. 13, 1896 – Images needle in patient's hand – X-ray used presurgically.

The first radiograph January 1896

- Radiograph of the hand of Roeontgen's wife.
- January 1896 - First x-ray made in public

Comparison of initial 1896 radiograph and current

January 1896 - First x-ray made in public

Routine x-ray current technology

It is from this early beginnings that imaging has grown such that it now plays two major roles in Diagnostic and Interventional imaging procedures

Imaging Equipment

Imaging equipment use electromagnetic radiation or sound waves.

- Electromagnetic Radiation
  - X-ray & Computed Tomography (CT)
  - Magnetic Resonance Imaging (MRI)-radio-waves
  - Nuclear Scintigraphy (Nuclear Medicine)

- Sound Waves (not radiation)
  - Ultrasound

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Imaging Modalities.

- Conventional modalities
  1. Plain X-rays --conventional and Digital
  2. Contrast studies
- Newer cross-sectional Modalities
  1. Computerised tomography(CT)
  2. Ultrasound
  3. Magnetic resonance imaging(MRI)
- Radionuclide Imaging
  1. SPECT
  2. PET

Modalities that use X-rays

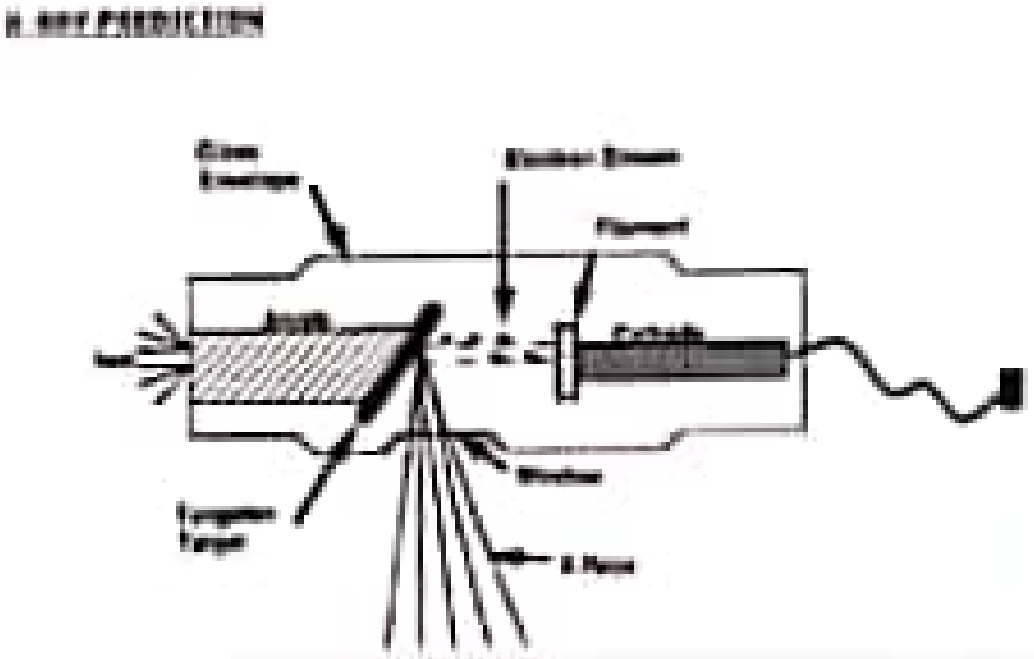
Plain Radiography
1. X-ray production
2. inherent contrast
3. film
4. digital

Contrast Radiography
1. barium
2. iodine

Fluoroscopy

CT (Computed Tomography)

Mammography



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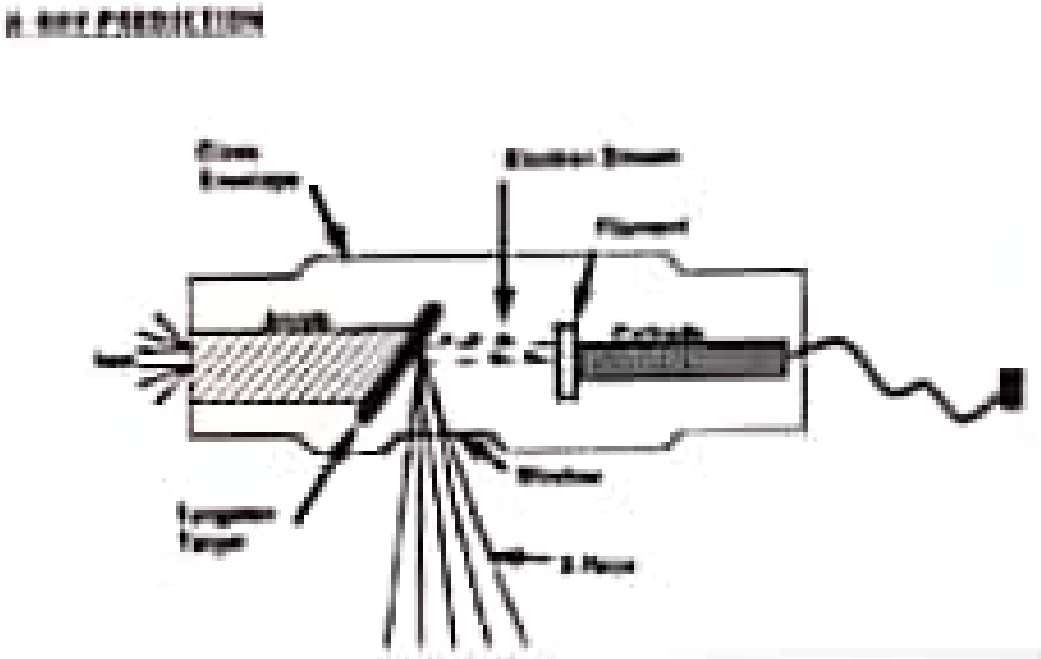
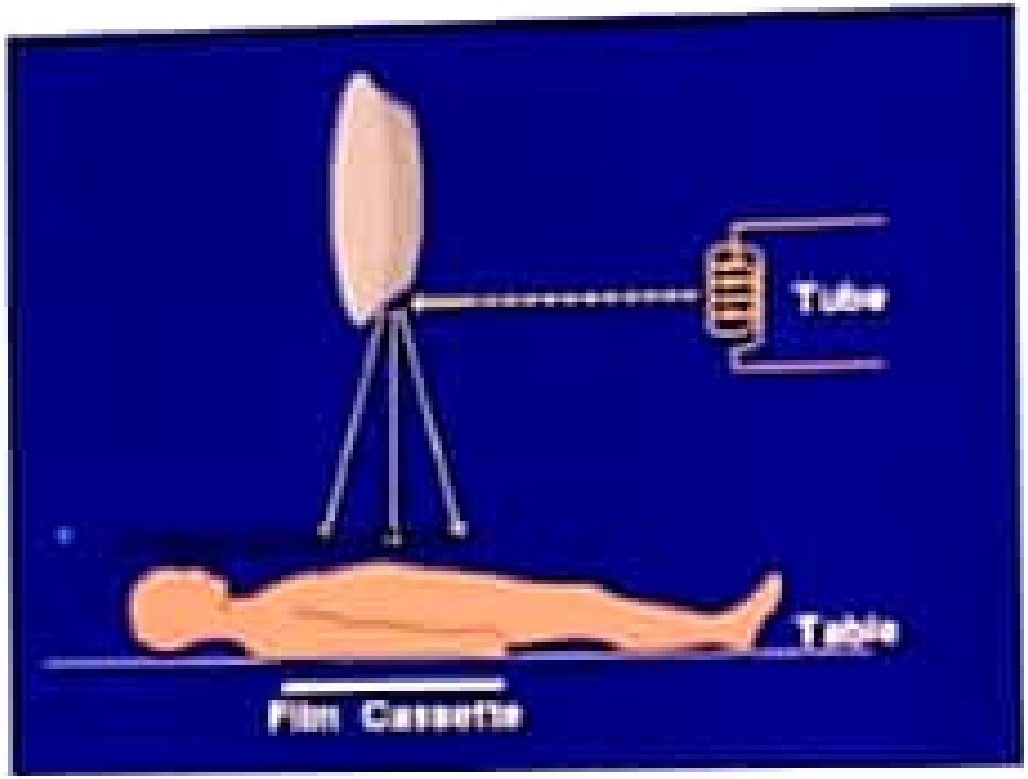


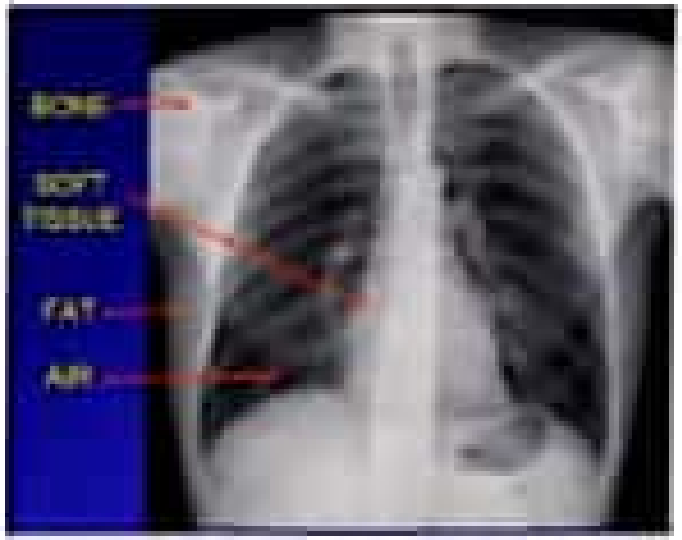
X-ray production and interaction with body tissues

- Electrons generated at filament
- Negatively charged electrons move toward anode and strike target at high speed
- 99% result in heat dissipated by the rotating target
- 1% create x-rays which are directed through the window
- X-rays pass through patient to a receptor (film, digital, fluorescent screen, etc



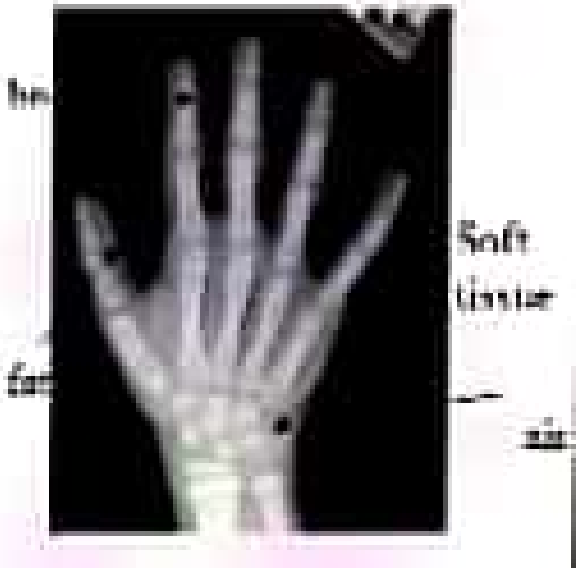
Plain X-ray image of the chest

- A diagnostic image is composed of differences in contrast between tissues which result from differences in radiation interaction in the tissues



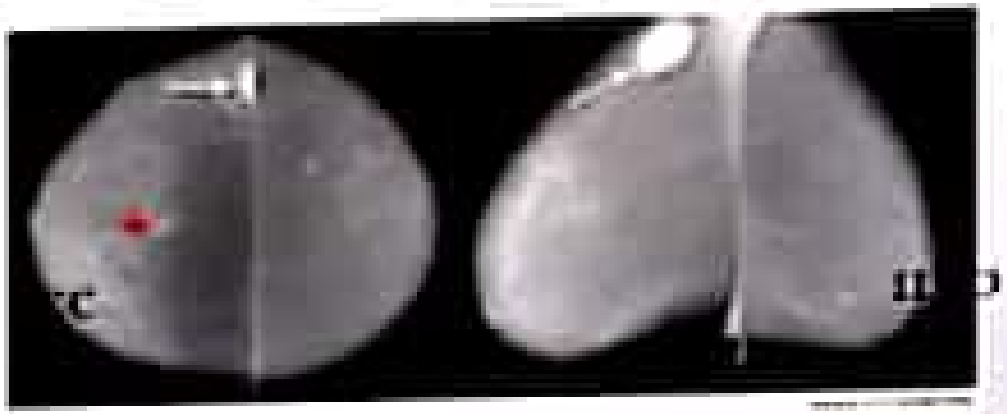
Inherent Contrast

Tissue	Appearance on XRAY
Air	Black
Fat	Dark Gray
Soft Tissues	Gray
Bone, Calcium	White
Metal	Really White



Mammography

- *Mammography* is the study of the breast using x rays.
- The actual test is called a *mammogram*. It is an x ray of the breast which shows the fatty, fibrous glandular tissue



mammogram

'Digital' Radiography (currently) in most centres locally

Two types

- Computed radiography, called CR
  - Uses existing equipment to make exposures
  - Film cassette is replaced with a charged metal plate
  - After exposure, plate is 'read in a special device
- Digital radiography, called DR
  - Requires conversion of the entire x-ray room
  - Film cassette is replaced by a CCD sensor (like in a digital camera or video camera)

Contrast Agents

- Anything that enhances the differences between tissues of similar densities is a contrast agent
- For XRAY there are TWO commonly used contrast agents: Note they are both METALS. Air is also used as a contrast agent
  - Barium
  - Iodine
- Ways in which they are introduced
  - Swallowed: barium swallow, upper GI
  - By enema: barium enema
  - In vein: Intravenous urogram
  - In artery: Arteriogram

Use of contrast in radiography

Plain lateral chest radiograph

A

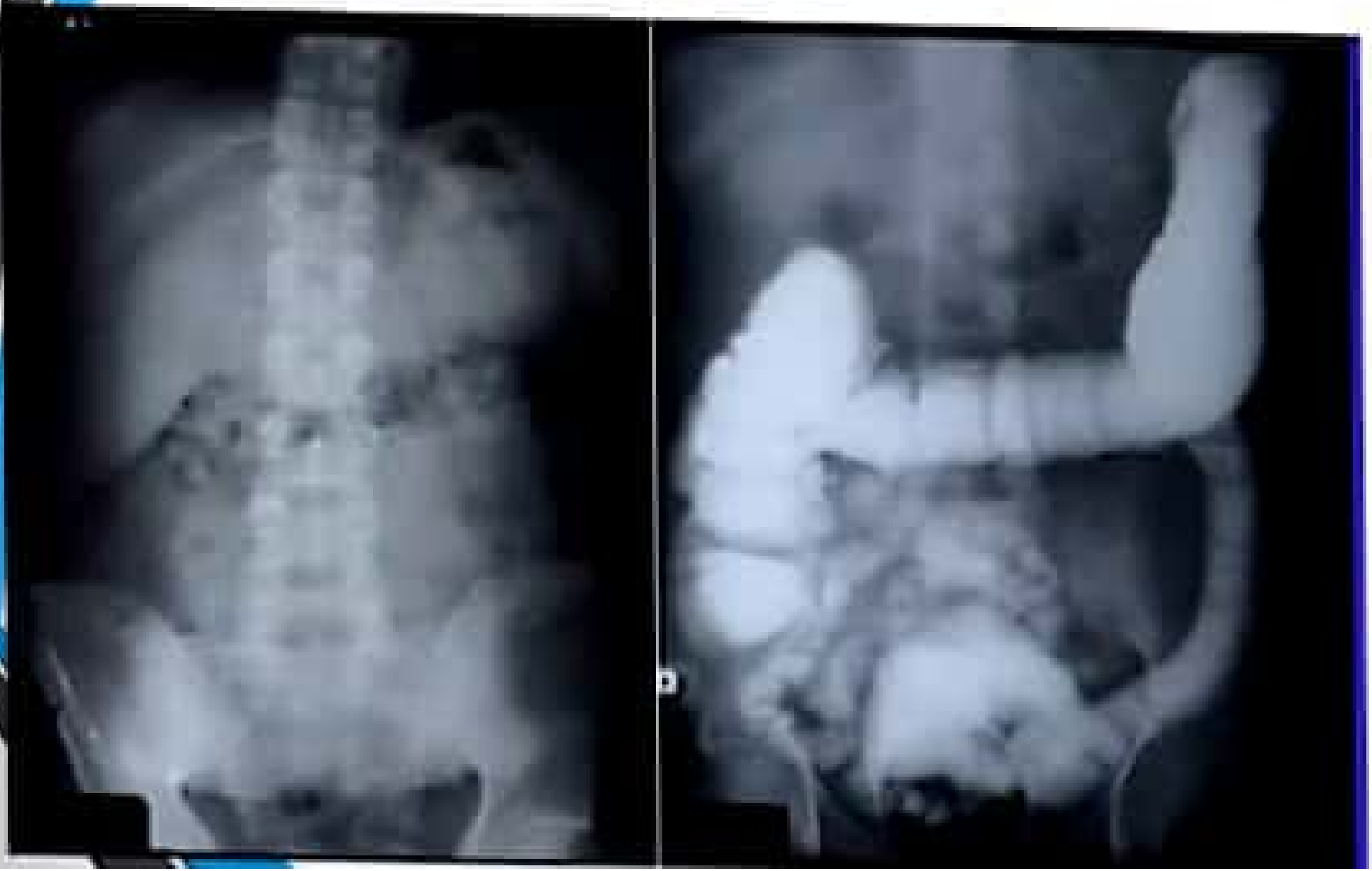
Lateral chest with barium

B

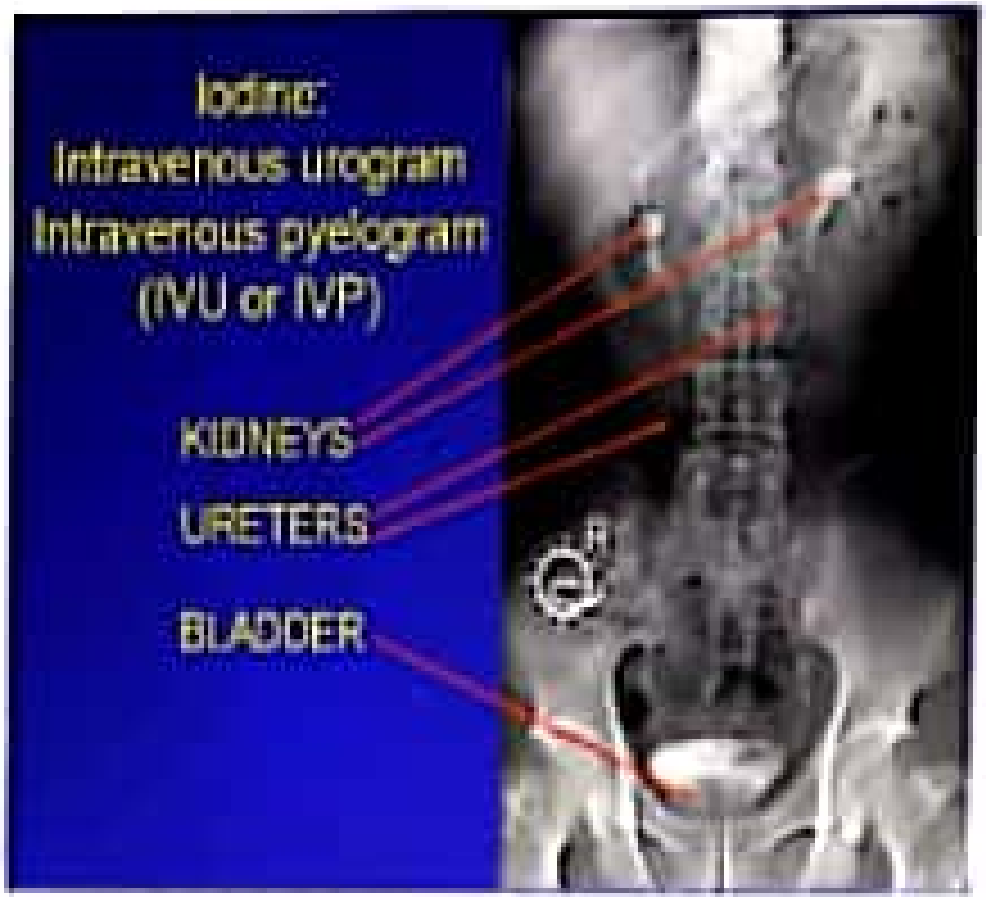
In B, the oesophagus is visualized due to the barium

PLAIN RADIOGRAPH OF ABDOMEN

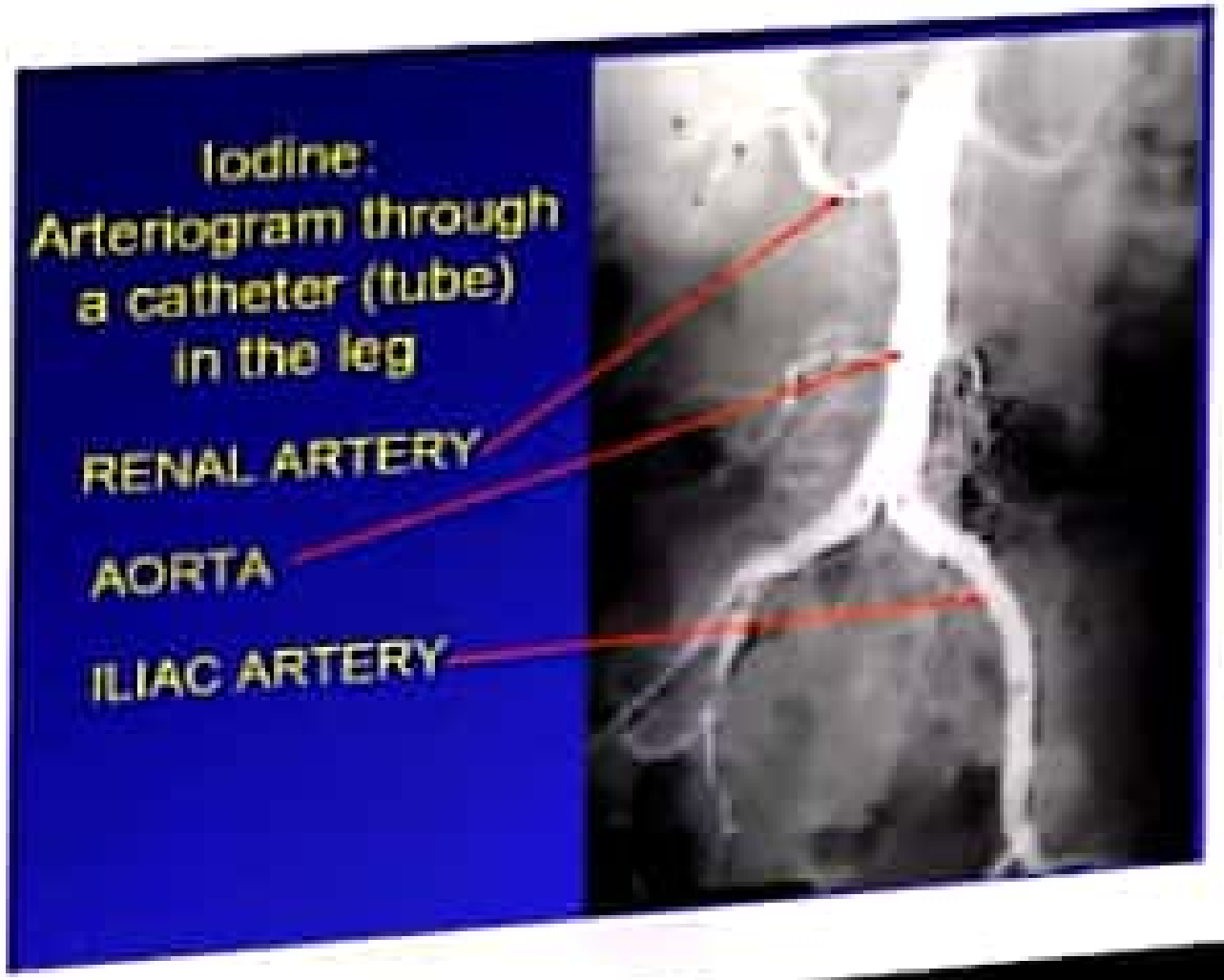
BARIUM ENEMA



Iv contrast for renal system



Iv contrast for vascular structures



Computerised Tomography(CAT)

- It was introduced into clinical use by a British physicist, Godfrey Hounsfield, in 1972.
- It is an imaging procedure where detailed information is obtained from thin sections of the body using ionising radiation, the "X-ray Beam."

- Since its inception it has undergone refinement improving image quality and shortening image acquisition time. From the conventional CT scanners we now have:

- It is used to image all parts of the body. Before the advent of MRI ,CT played, and still has, a vital role in neuro imaging.

- It provides more information than conventional radiography.

Technological advancements of CT

- The first-generation CT scanners used in the 1970's and 1980 were slow each slice taking a minute to produce an image.
- Marked technological advancements have been made to this single slice equipment's to multi-slice equipment up to 640 slice in which the whole body can be scanned in a minute and image reconstructions can be achieved.

At the KNH Radiology our latest is a 128 slice CT

Computerised Tomography(CT)

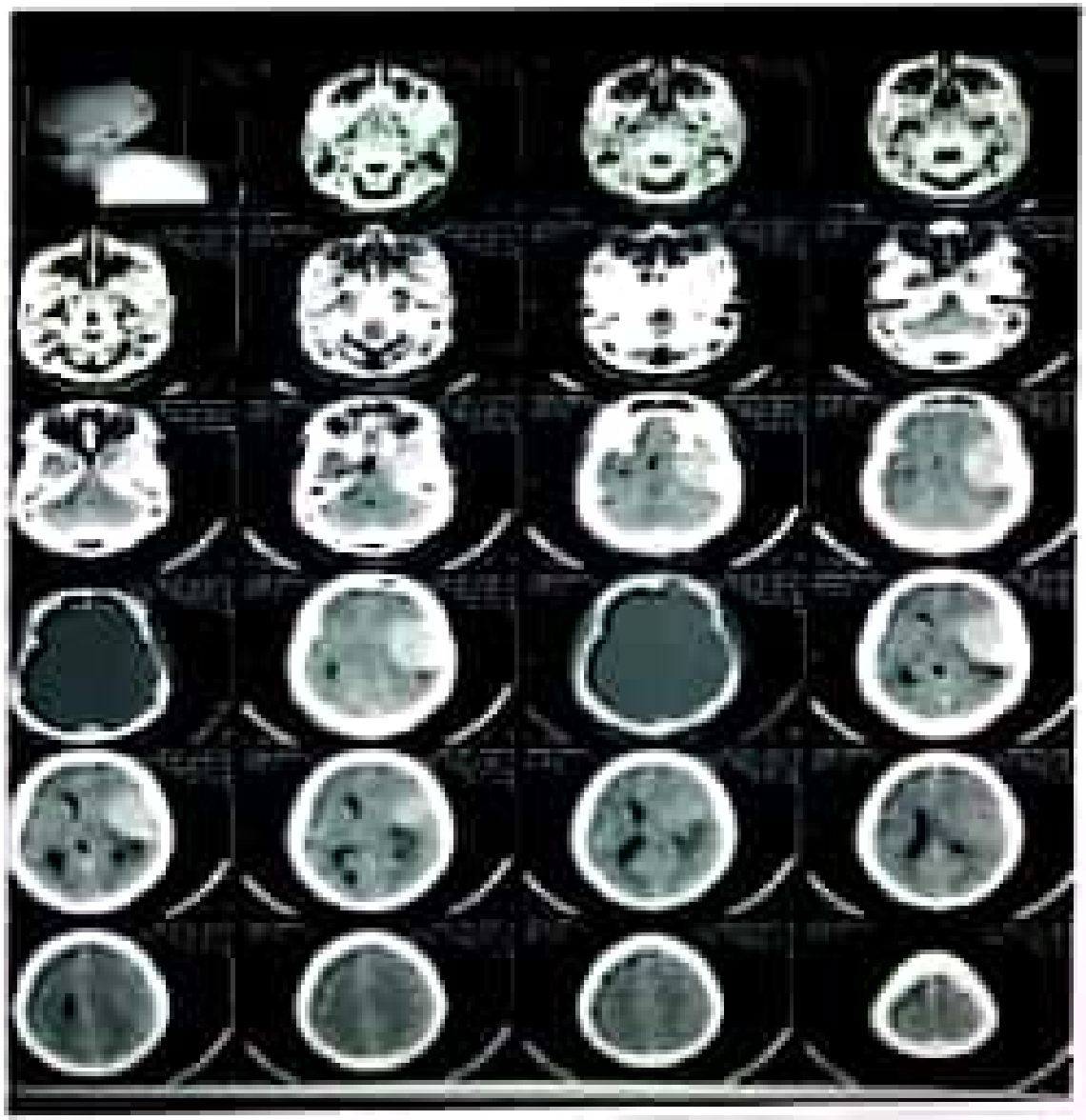
- CT uses X.rays to produce images
- In the initial equipments, the x-ray tube spins around the patient while detectos moved around the patient in opposite direction to the tube
- A computer then performs calculations of densities in each square of a slice to produce the images

CT Equipment

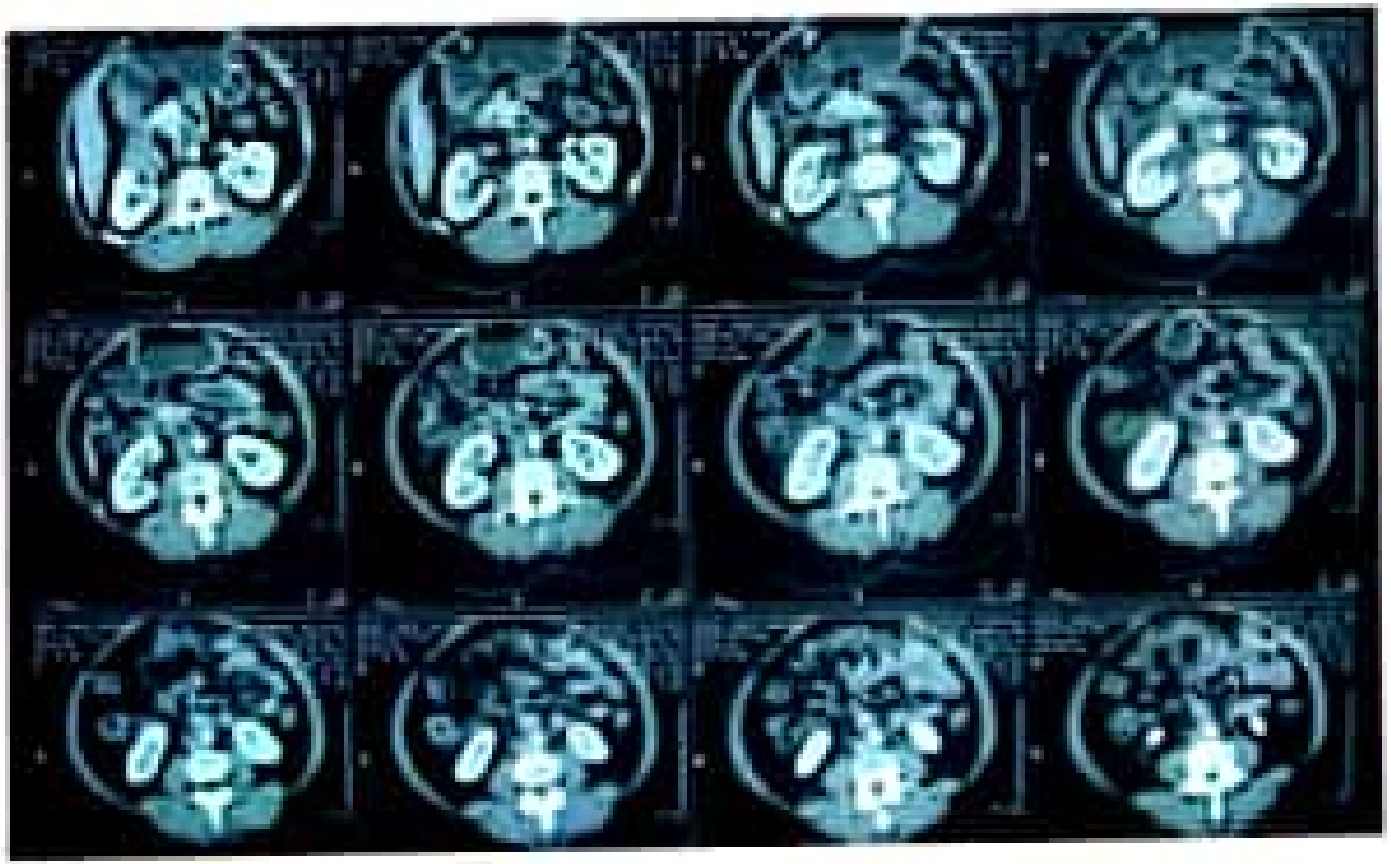
In computerised tomography (CT) the X-ray source rotates around a plane of the body, taking serial pictures with a detector (instead of a film) which are synthesized by a computer.

The resulting picture created by the computer is like a section of the body and can be recorded on a film. CT pictures are therefore like X-ray images.

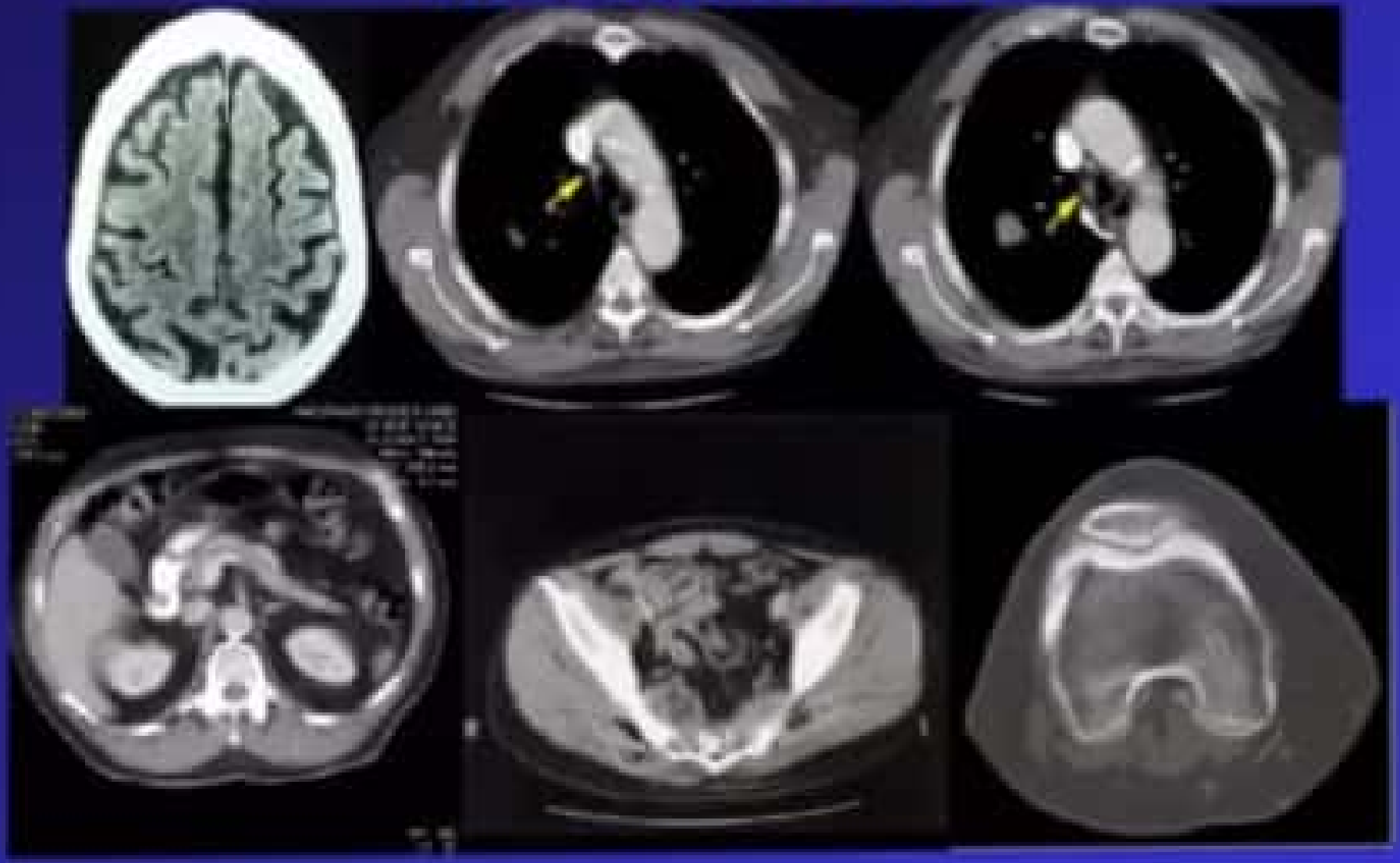
CT HEAD



CT at renal level



CT Of The Entire Body In 2 Minutes



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What more can we can do with CT these days?

- **CT Angiography**
  - Scan rapidly during Iodine injection in vein
- **CT Colonography**
  - Scan colon after filling with air
- **CT Bronchoscopy**
  - Scan chest air is already in bronchi
- **Construct 3D Images**
  - Computer reconstruction

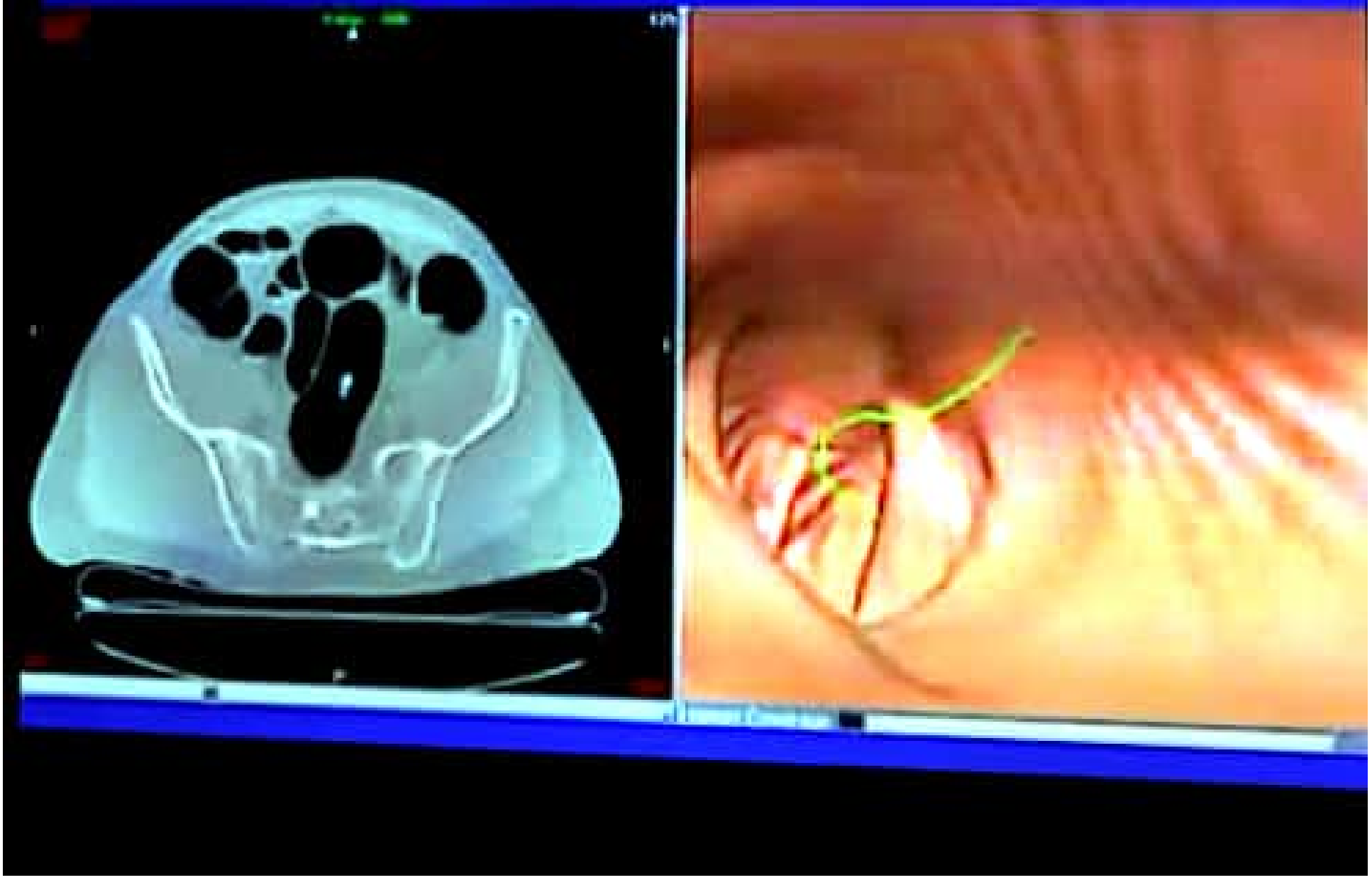
CT ABDOMINAL AORTA ANGIOGRAM

Coronal view

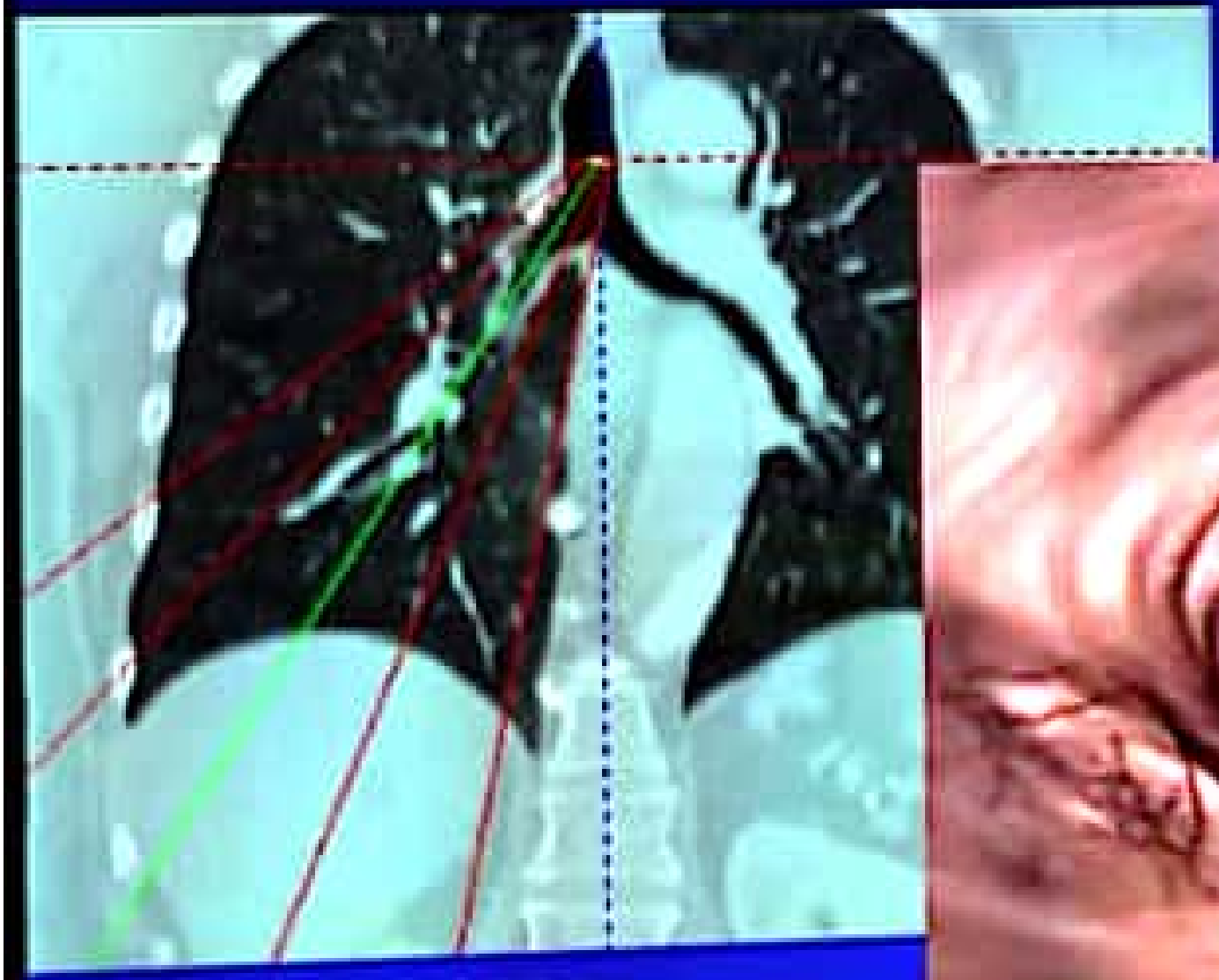
CT angiogram Rt renal artery

CT angiogram showing aneurysm

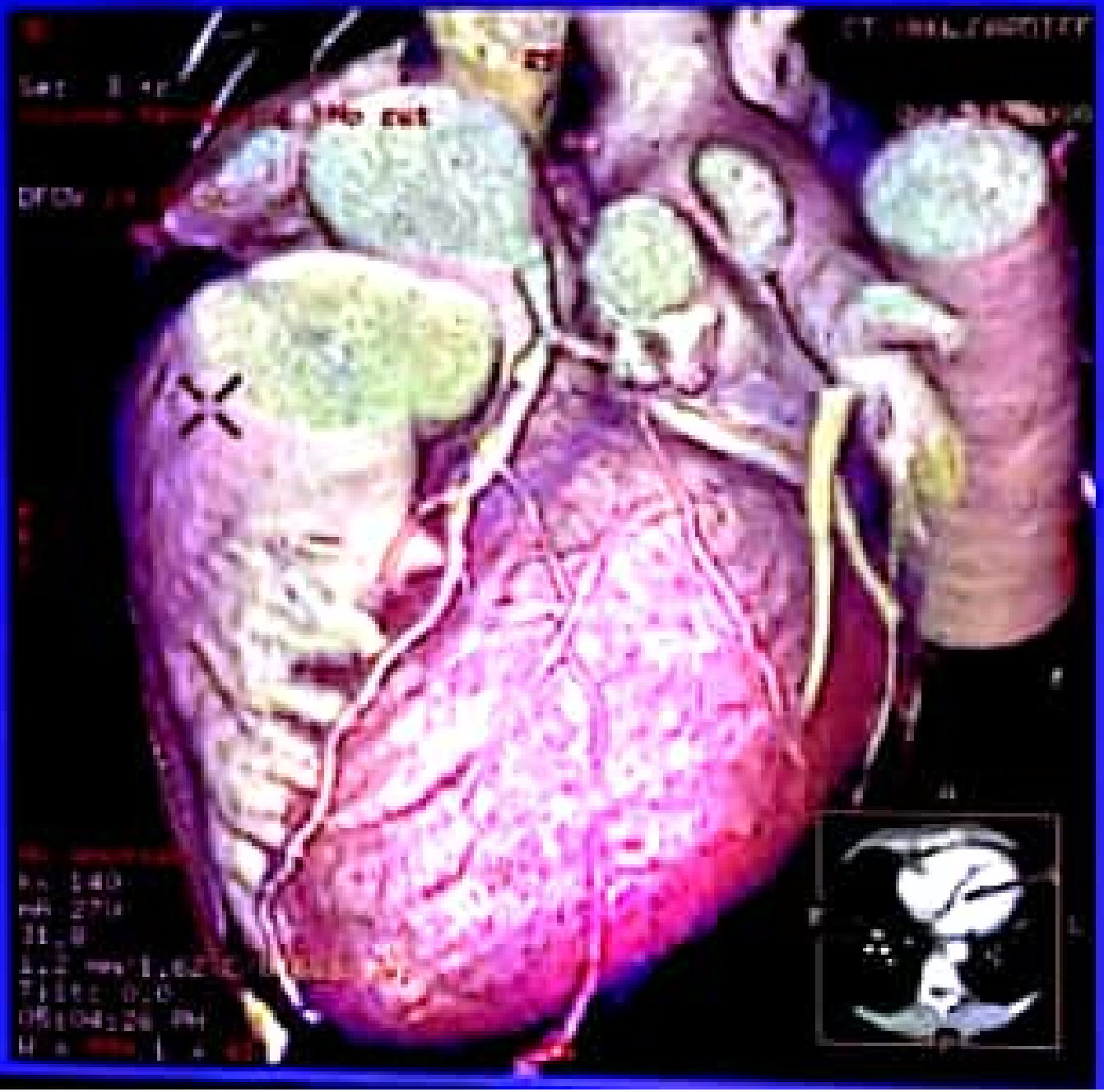
CT Colonography



CT Bronchoscopy



3D CT of the heart



Ultrasound

- Uses high frequency sound to make images
  - 2-15 MHz typically used
- The sound is produced and detected with the same device: TRANSDUCER
- Transducer
  - Speaker: sound into patient
  - Microphone: sound coming back from patient
- Analogous to SONAR used in undersea warfare

Ultrasound cont

- Ultrasound uses mechanical waves of frequencies beyond the audible range.
- These waves are reflected to various degrees from junctions of tissues of different nature.
- Ultrasound pictures require considerable skill to Produce and interpret.
- Ultrasound has a great advantage – it does not cause cellular damage when used in quantities required for imaging

Ultrasound cont

Although ultrasound was first introduced in medicine in the 1950's it developed slowly becoming practical in the late 60's mainly in cardiology and obstetrics.

Advantages

- It is now used in all parts of the body except bone.
- It is a none invasive imaging modality.
- It does not use ionising radiation.
- It is relatively cheap compared to the other modalities.
- It is easy to install.
- Has greatly revolutionised practice of medicine especially in obstetrics and gynaecology.

Ultrasound indications

Ultrasound is often used to evaluate:

1. Pregnancy
2. Abnormalities in the heart and blood vessels
3. Organs in the pelvis and abdomen neck , infant intracranial structures.
4. Symptoms of pain, swelling and infection
5. Guide interventional procedures

Ultrasound equipments

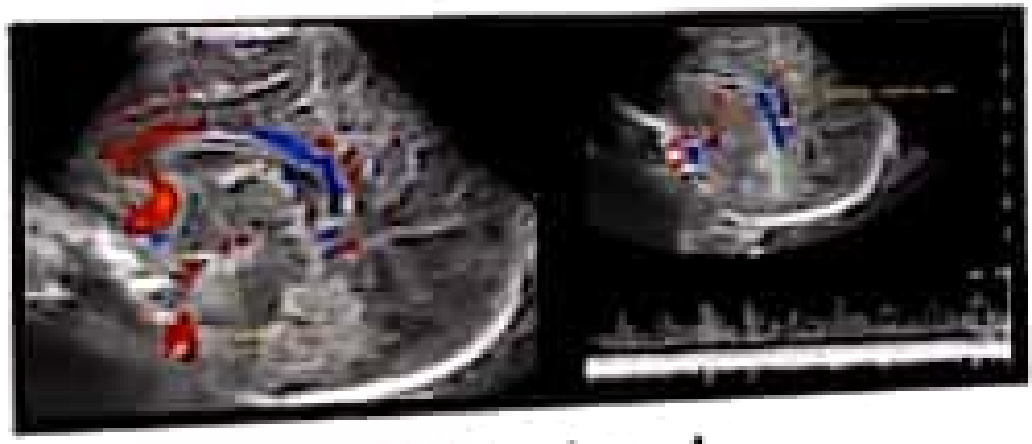
Ultrasound in the villages

Ultrasound in in small centres

ultrasound to assess pregnancy

Neonatal cranial ultrasound

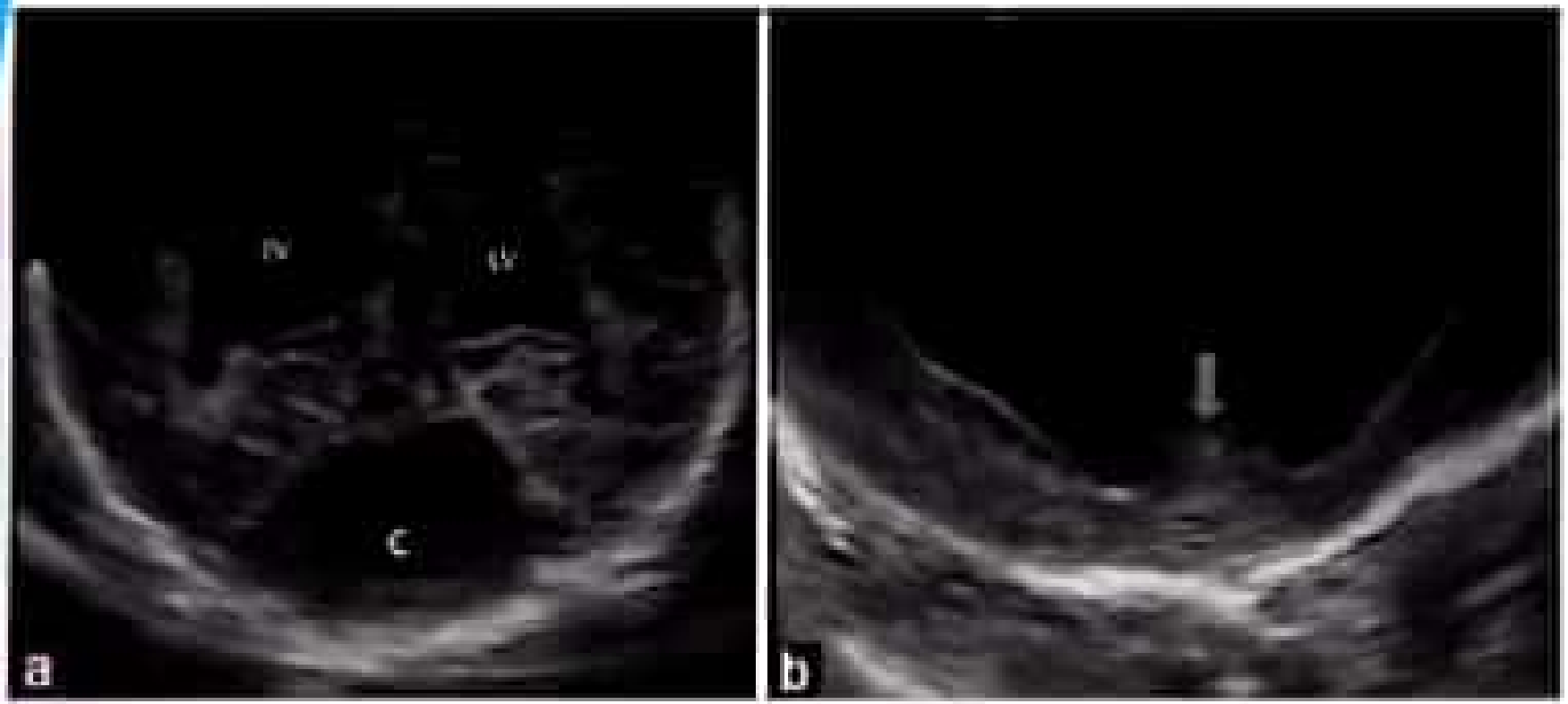
Coronal view



Main blood vessels

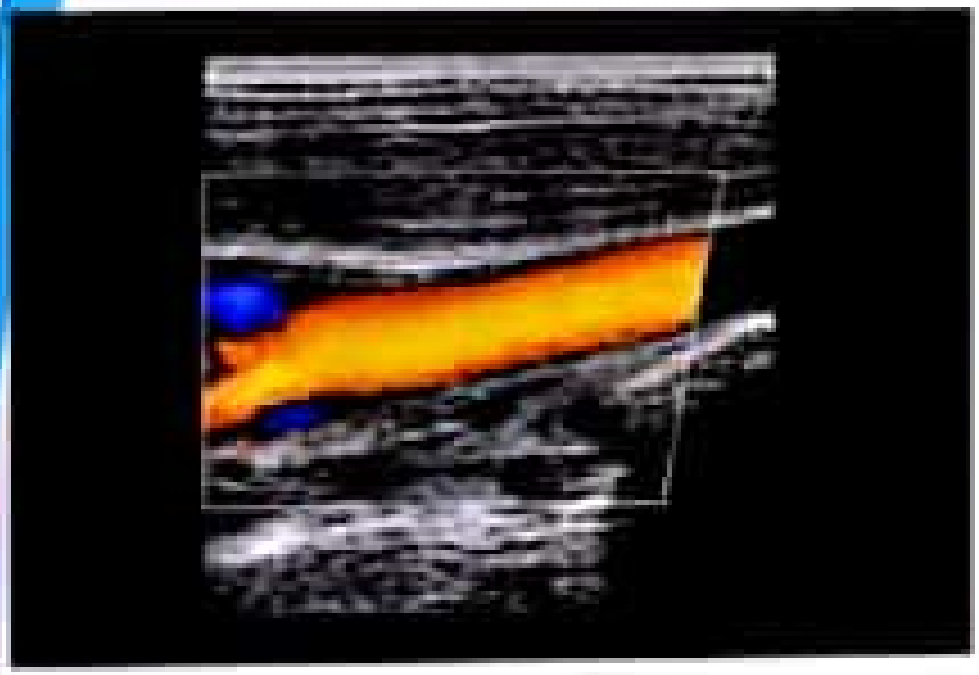
Sagital views

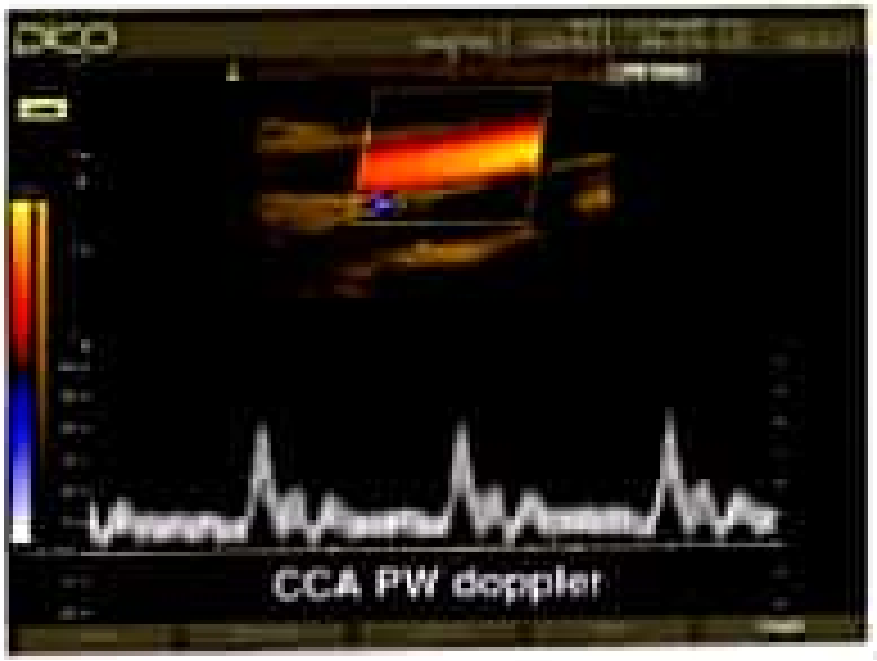
Neonatal brain US



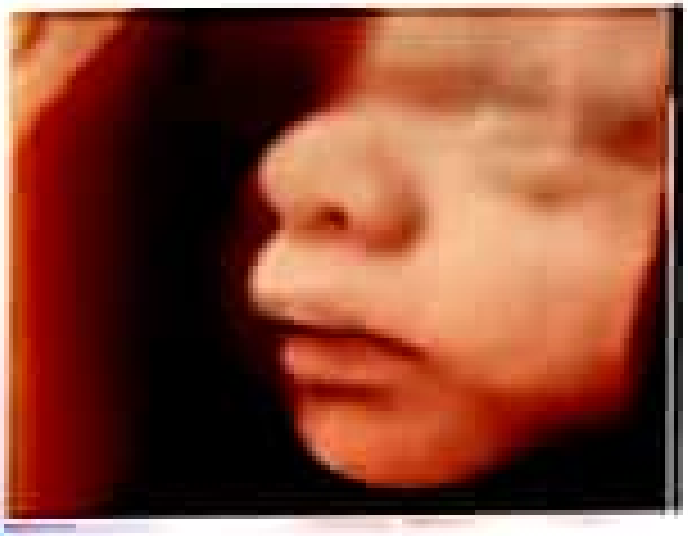
Dandy Walker malformation

Blood flow in vessels





4D high resolution images



Magnetic Resonance Imaging(MRI)

Magnetic resonance imaging exploits the existence of induced nuclear magnetism in the patient.

Magnets with an odd number of photons or neutrons possess a weak but observable nuclear magnetic moment.

Hydrogen nucleus is the most commonly imaged, although (13C, Phosphorous (P) sodium (Na) and Fluorine (F) are also of significant interest.

The nuclear moments are normally randomly oriented, but they align when placed in a strong magnetic field (typically 0.2-3 T).

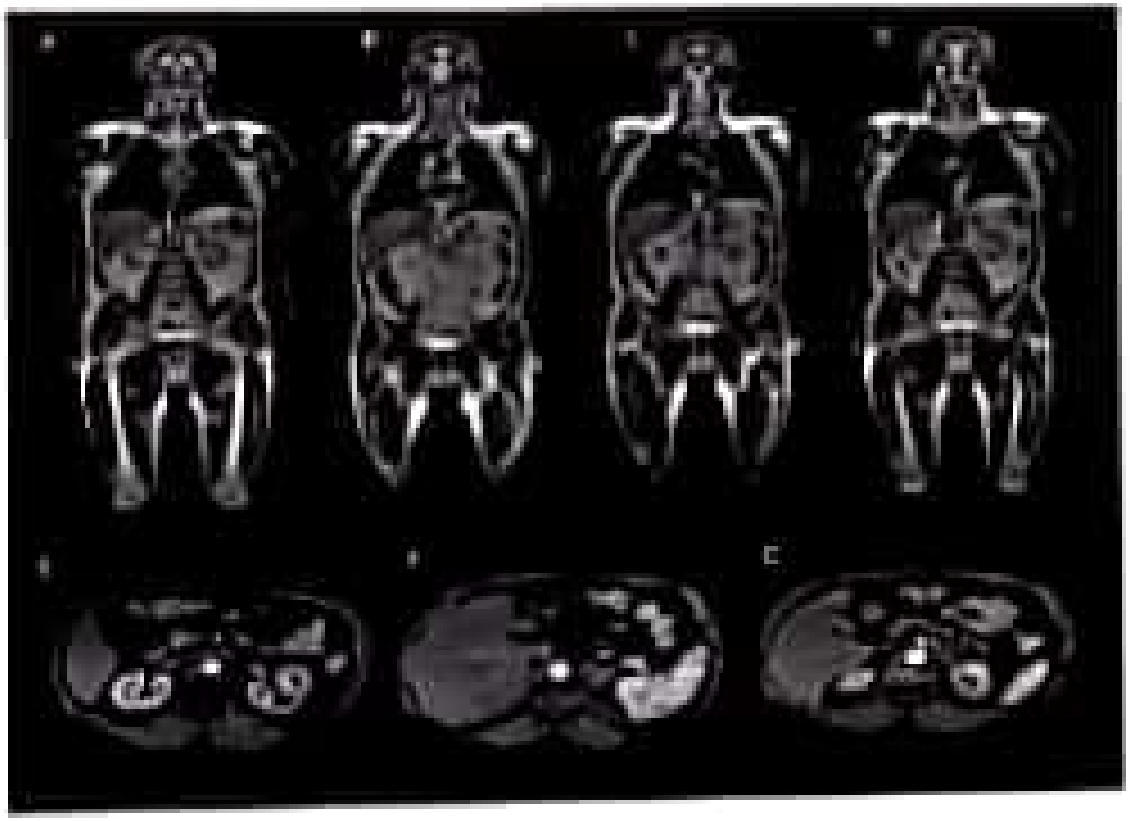
The NMR signal from a human is due predominantly to water protons.

frequency.

Whole Body MRI

Normal coronal STIR (A) and HASTE (B) image

Whole body MRI

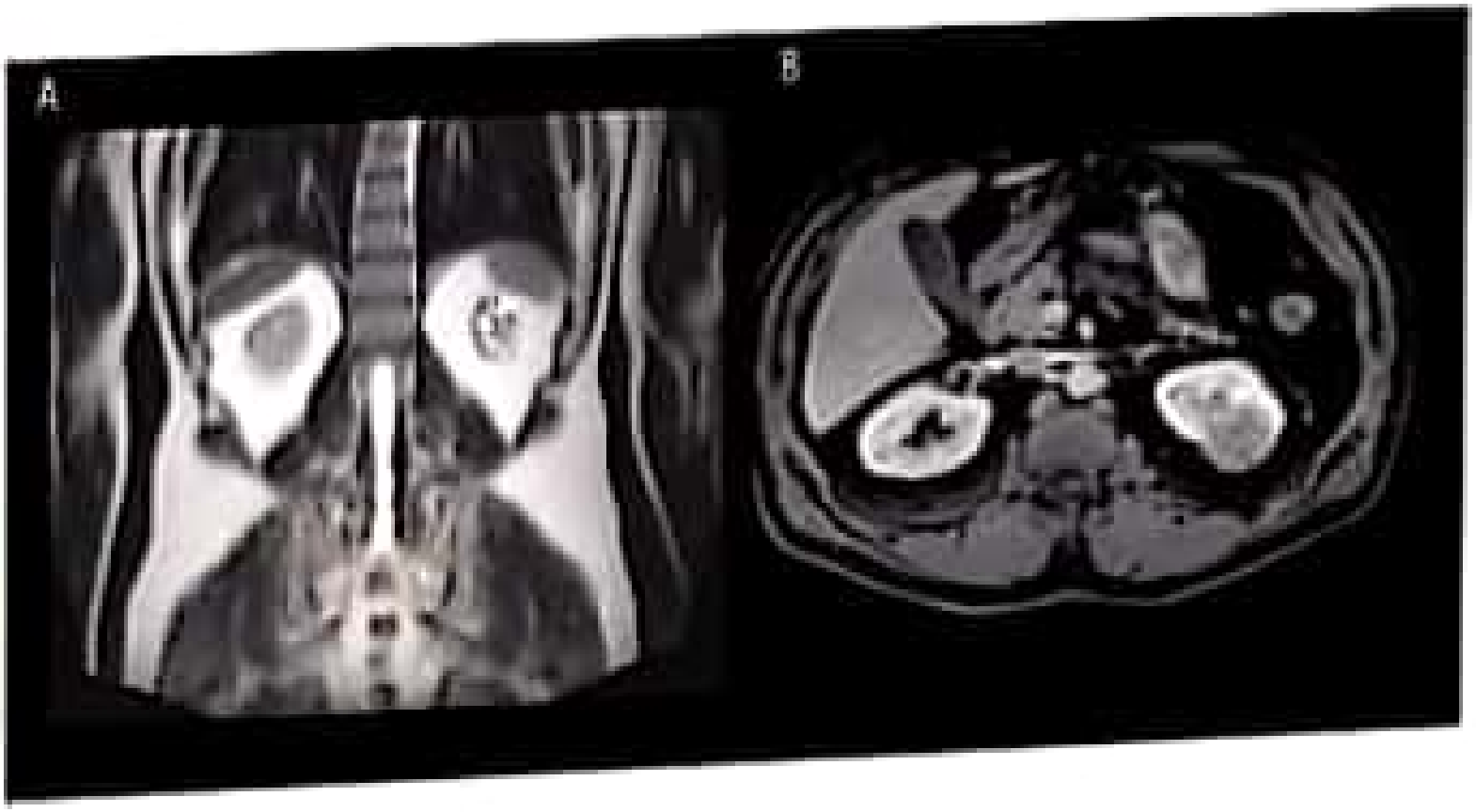


A left adrenal mass Invading the renal vein and vena cava was detected in one subject .

Dedicated contrast-enhanced sequences were added for comprehensive evaluation.

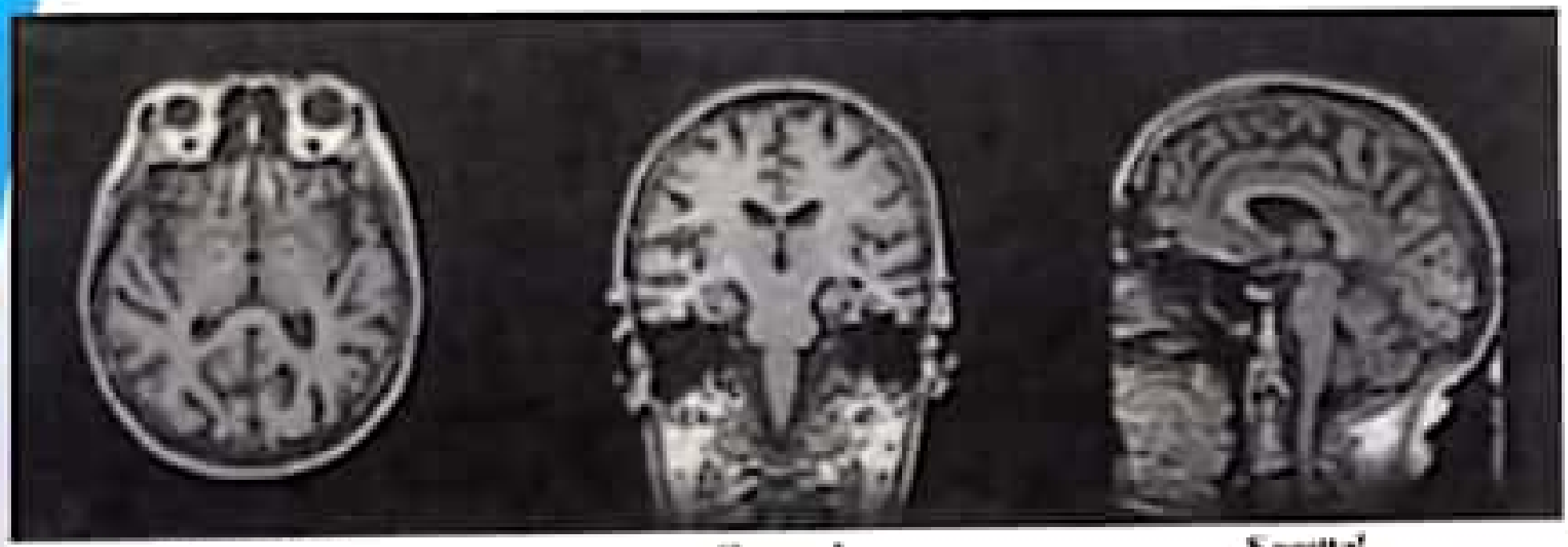
The patient was operated on and the pathology result was consistent with adrenal carcinoma.

MRI Abdomen



Renal mass left kidney

MRI Multi-Slice Images



Magnetic resonance cholangiopancreatography (MRCP)

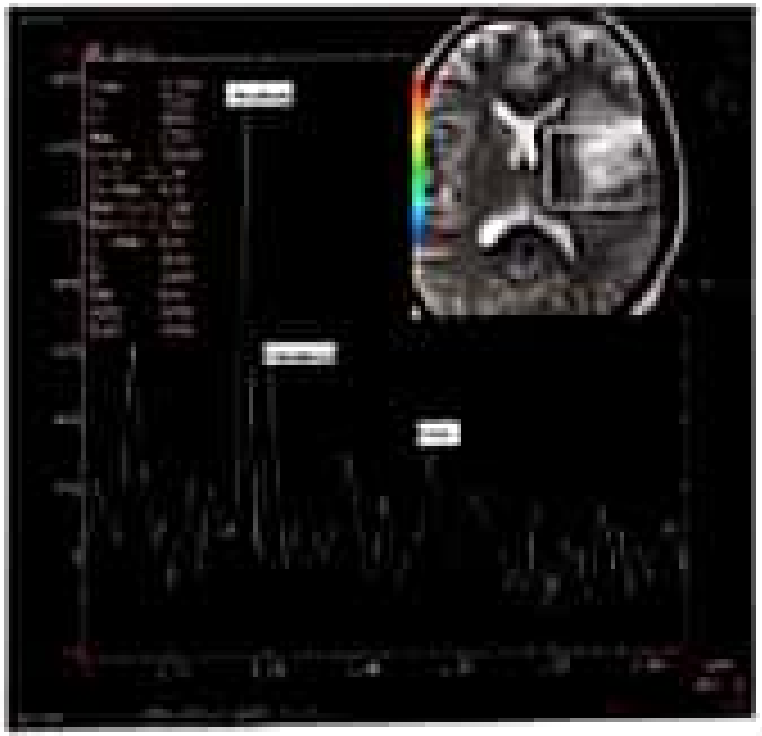
Gallbladder and bile ducts clearly shown

MR Angiography (MRA)

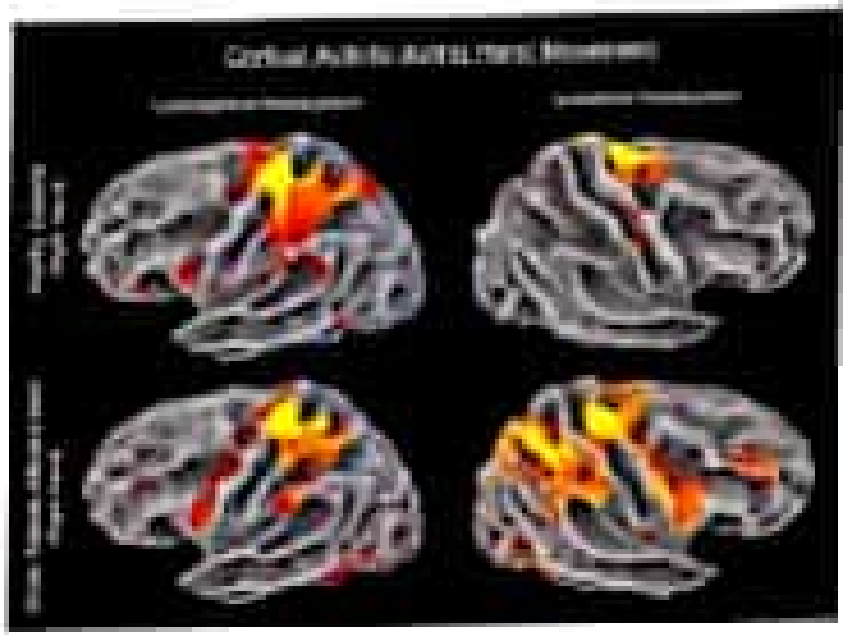
MR SPECTROSCOPY

How does MR spectroscopy work?

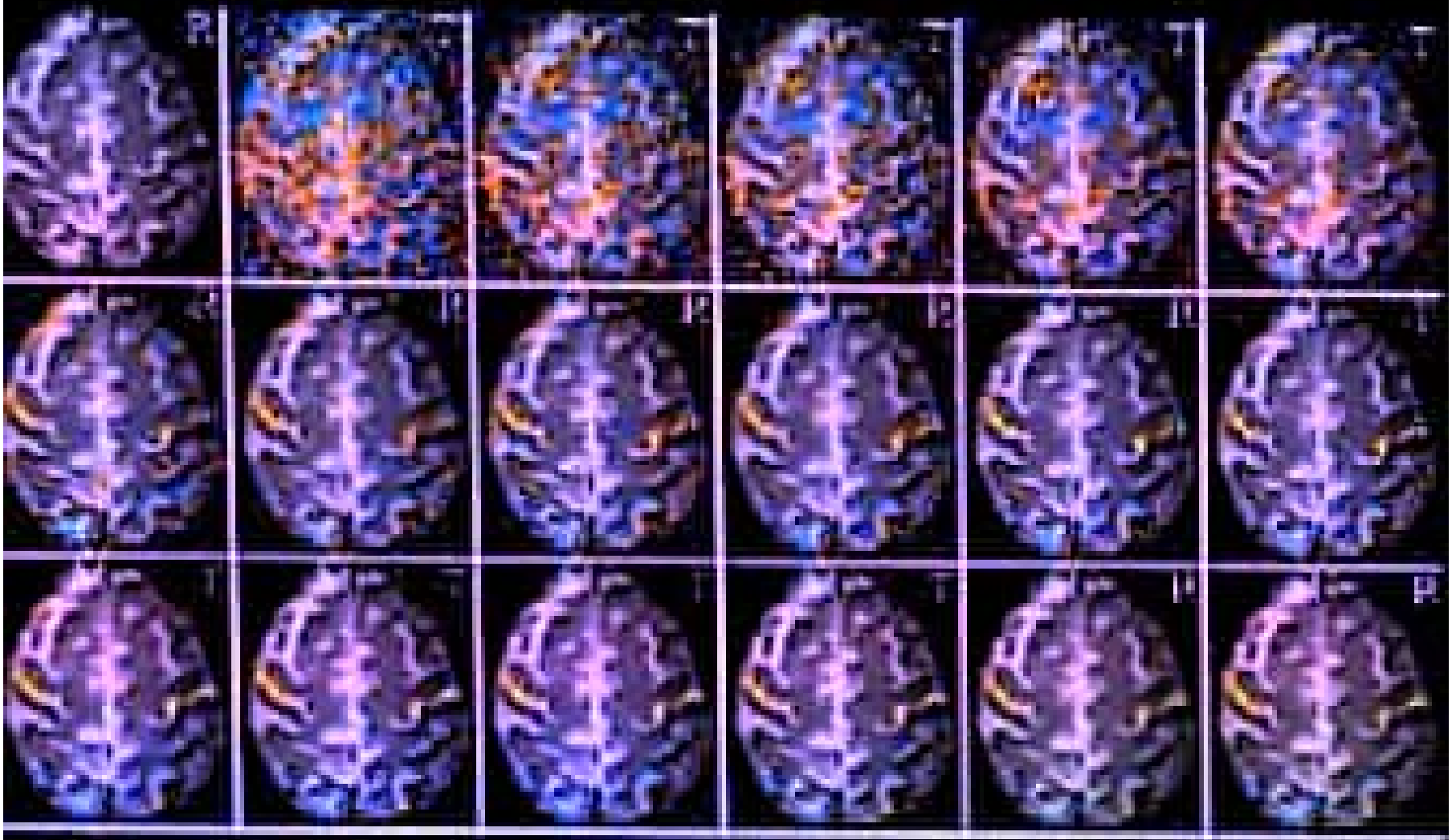
- MR spectroscopy is conducted on the same machine as conventional MRI.
- Spectroscopy is a series of tests that are added to the MRI scan of brain or spine to *measure the chemical metabolism of a suspected lesion.*
- There are several different metabolites, or products of metabolism, that can be measured to differentiate between tumor types.



Functional MRI



Functional MRI: Examples



om Medical College of Wisconsin's web page, part of a real time f
= resting. T = finger tapping. See R.W. Cox, A. Jesmanowicz and
eal-time functional magnetic resonance imaging". MRM 33, 230-

Nuclear Scintigraphy

- Often called NUCLEAR MEDICINE
- Uses radioactive tracers that emit radiation
  - Electromagnetic OR particulate
- Often these are injected into the vein
- Different tracers go to different organs or parts of the body
- Images are made by detecting the radiation coming out of the patient

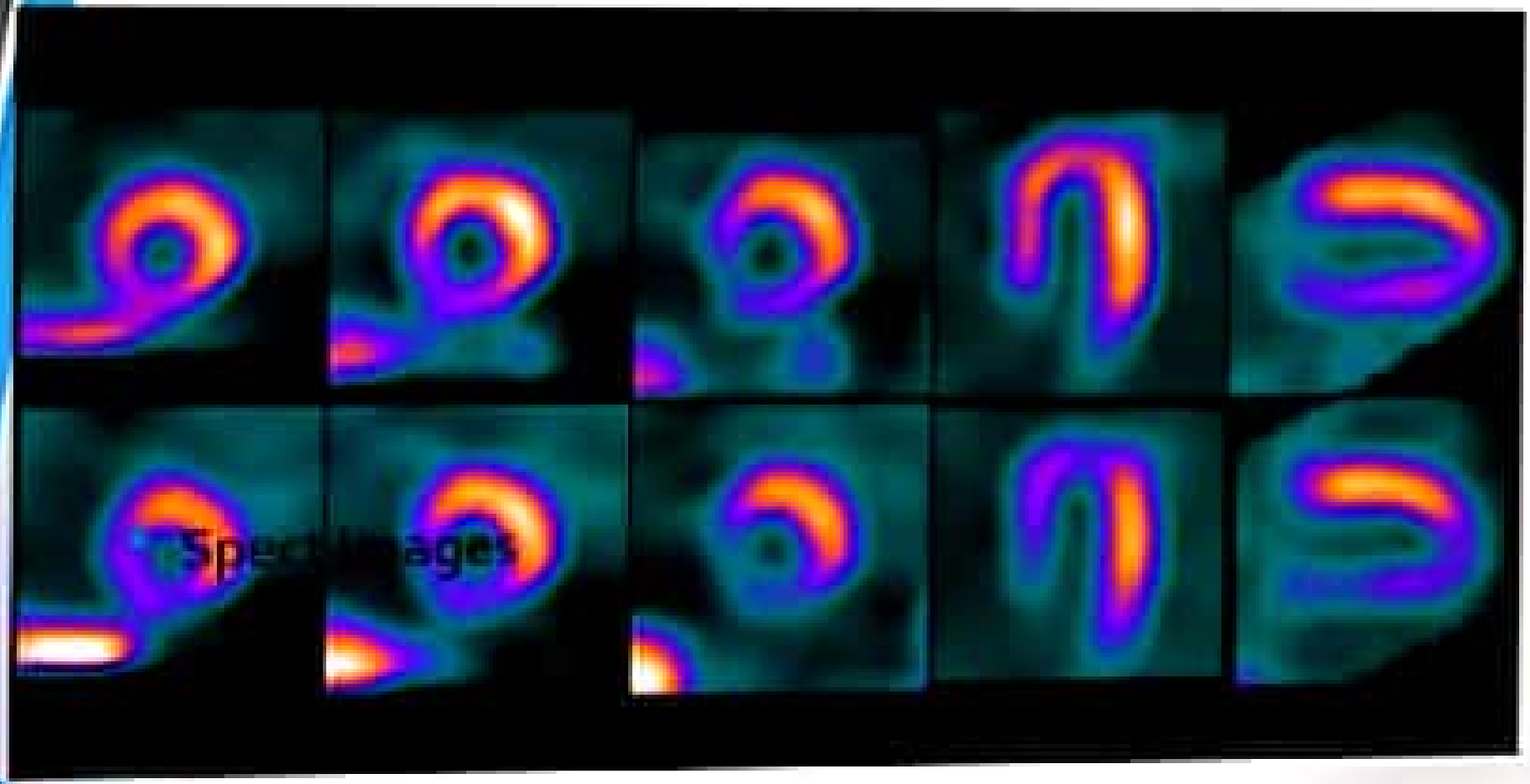
Types of nuclear imaging

- **Bone Scan**: An enhanced form of X-ray technology that is used to measure bone loss or density.
- **Cardiac Spect perfusion**: An evaluation of the blood flow (perfusion) to the walls of your heart. Usually performed using a cardiac stress test.
- **PET CT** Combined PET/CT scans provide images that pinpoint the location of abnormal metabolic activity within the body. The combined scans have been shown to provide more accurate diagnoses than the two scans performed separately.
- **Cardiac PET perfusion, Cardiac PET** viability cardiac sarcoid

Molecular nuclear imaging

Molecular imaging, also called *nuclear imaging*, includes positron emission computed tomography (PET) and single photon emission computed tomograph

Cardiac Spect images



PET CT

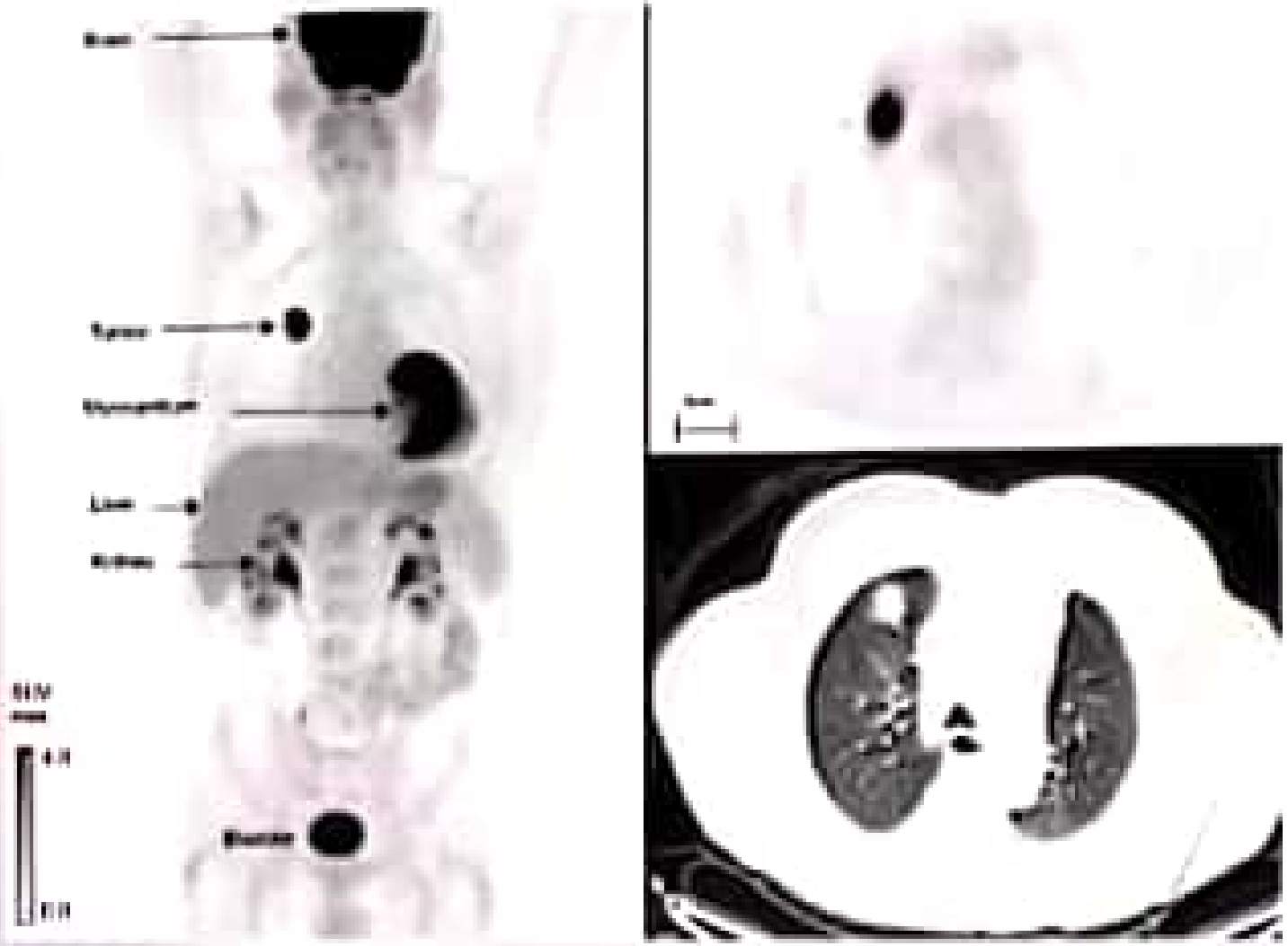
- PET-CT is a combination of cross-sectional anatomic information provided by CT and the metabolic information provided by positron emission tomography (PET).
- PET is most performed with 2-[F-18]fluoro-2-deoxy-D-glucose (FDG). Fluorine-18 (F-18) is an unstable radioisotope and has a half-life of approximately 110 minutes.

Indications for PET CT

The indications for F-18 fluorodeoxyglucose (FDG) PET-CT imaging include:

- Staging of cancer which potentially can be treated radically (e.g. small cell lung cancer)
- Establish baseline staging before commencing treatment (e.g. GIST)
- Evaluation of an indeterminate lesion (solitary pulmonary nodule)
- Assessing response to therapy
- Evaluation of suspected disease recurrence, relapse and/or residual disease (e.g. lymphoma, testicular seminoma) to guide a biopsy (e.g. pleural biopsy for mesothelioma)

Whole body PET CT



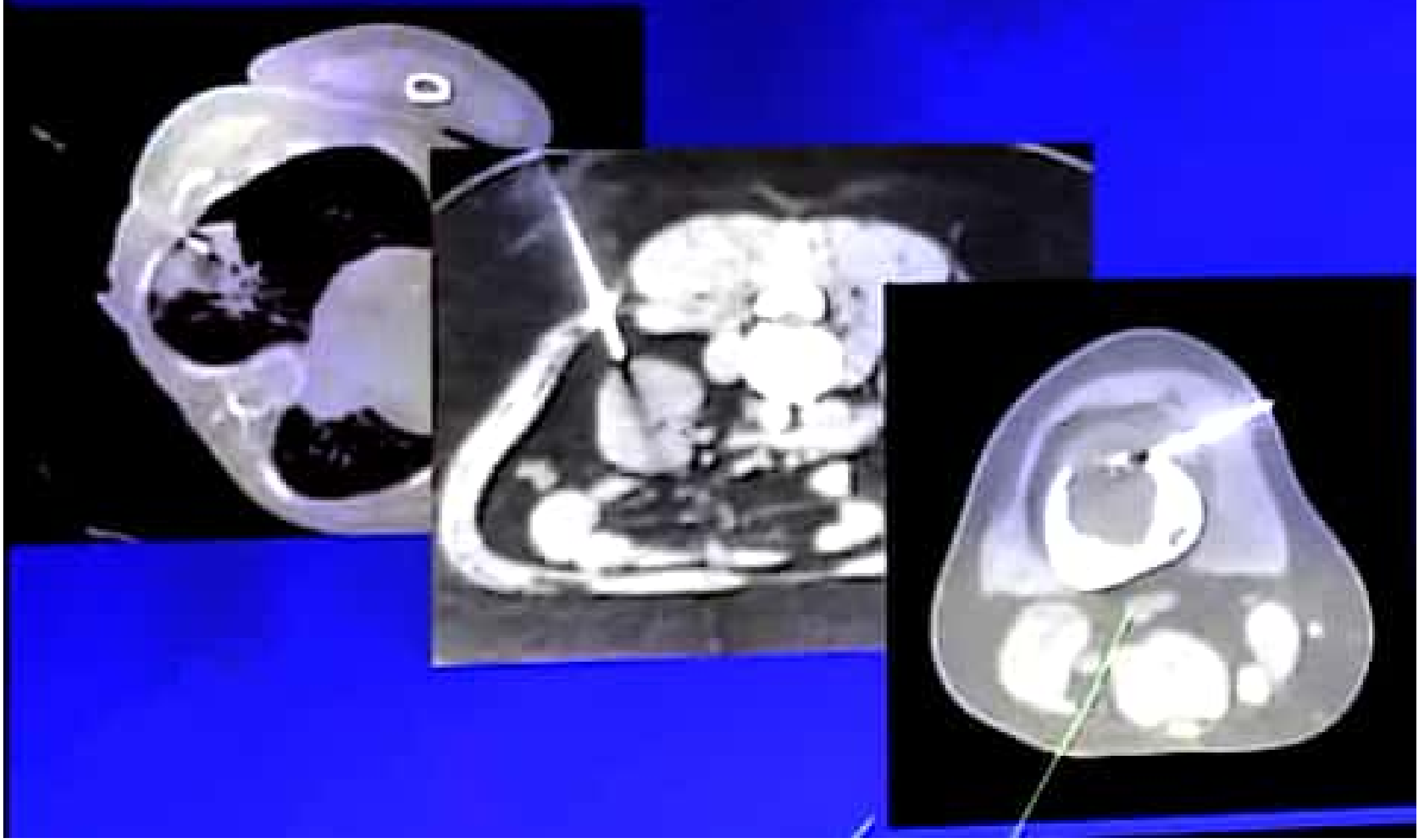
NORMAL BONE SCAN

ABNORMAL BONE SCAN

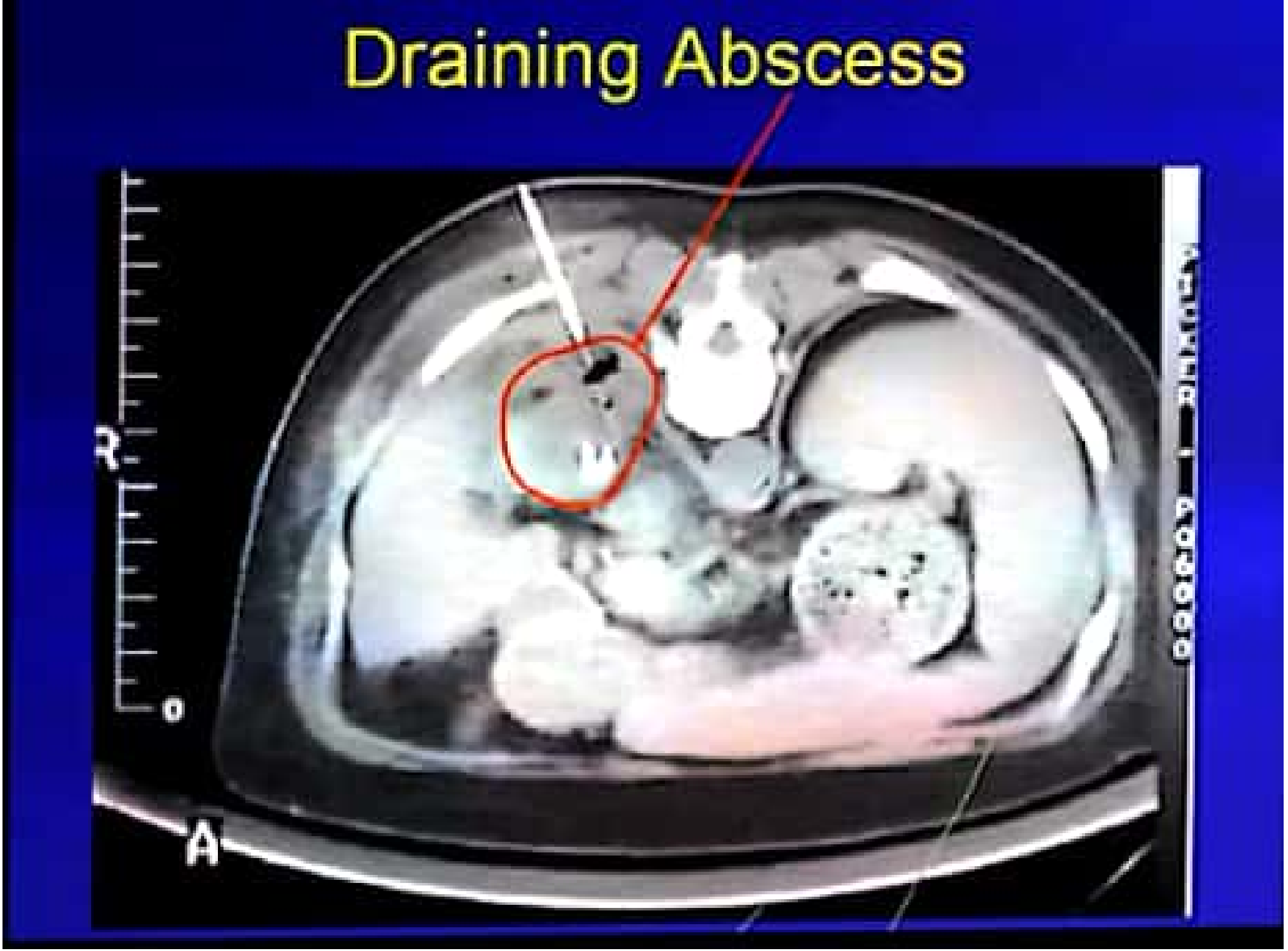
Interventional Radiology

- Radiologists do invasive procedures guided by images for either diagnosis or treatment
- Basically anything that breaks the skin
  - Needles for biopsy or fluid removal
  - Catheters to make angiograms
  - Catheters with balloons to open blood vessels
  - Stents to hold blood vessels open
  - Coils and material to block blood vessels
  - Catheters to drain abscesses
  - Tubes for feeding
  - etc etc

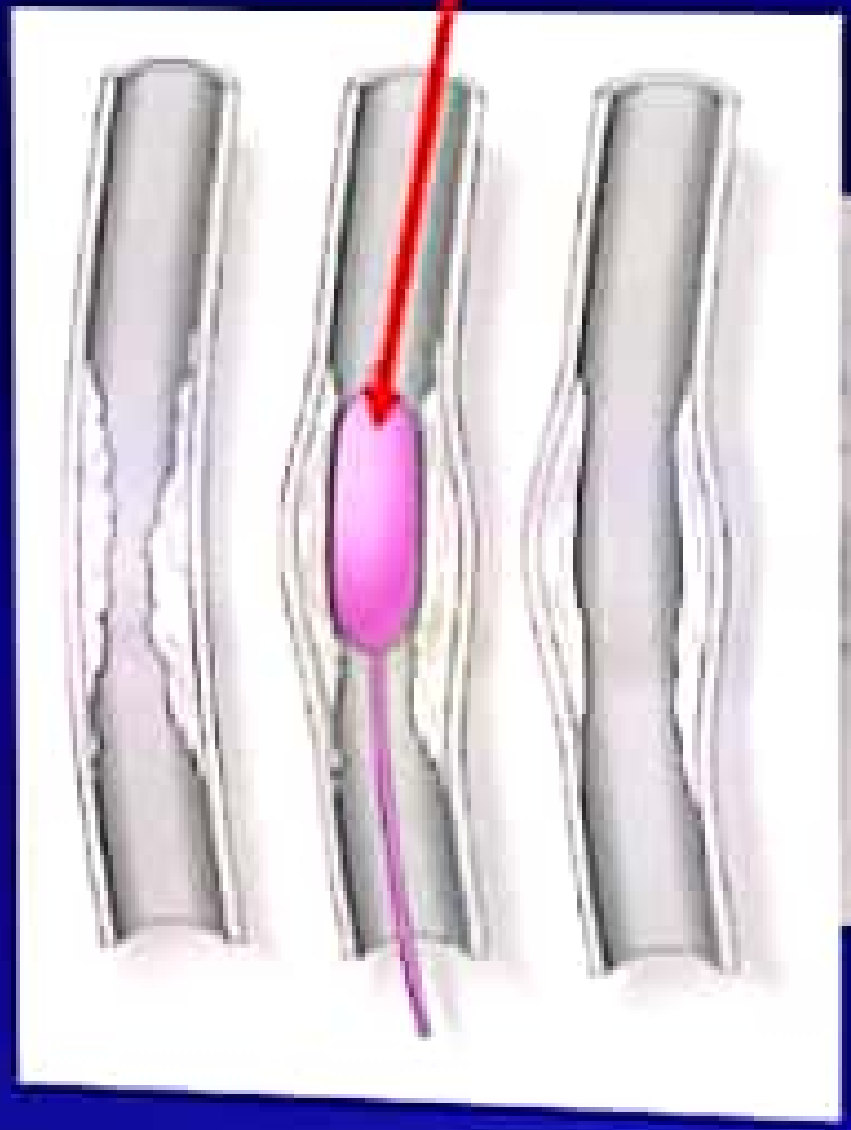
Non Surgical Biopsy

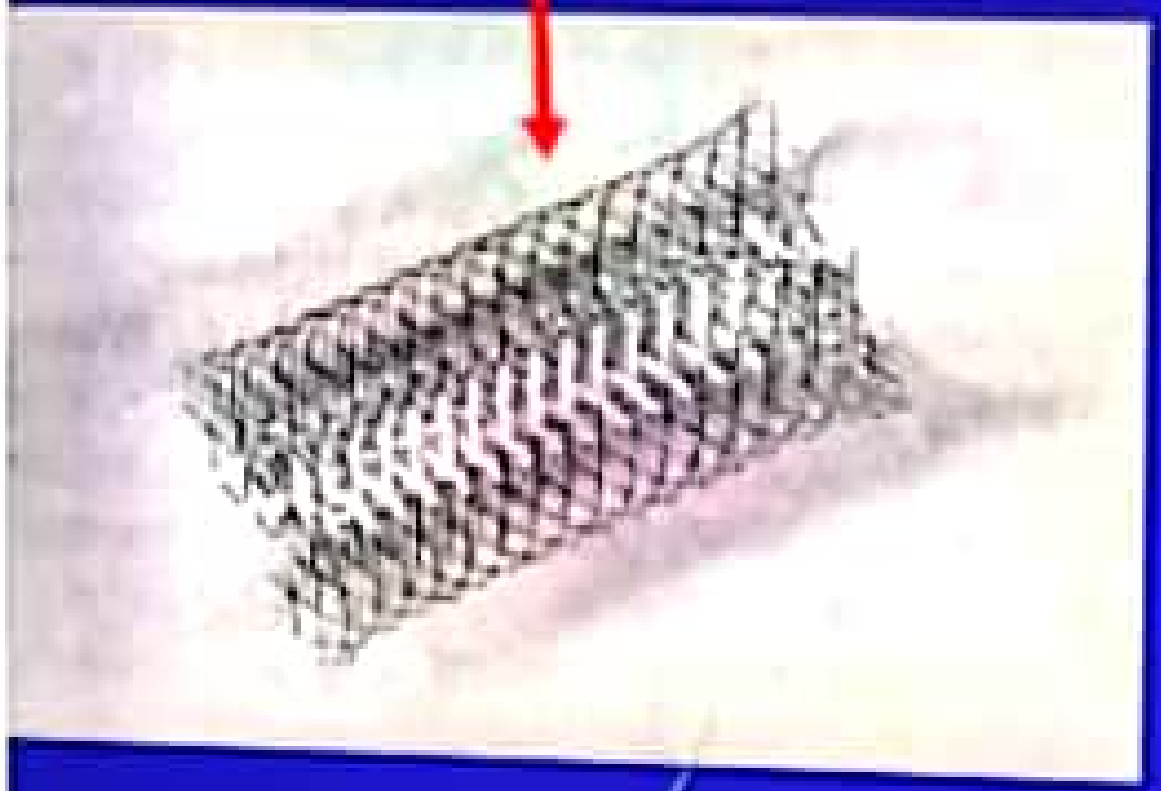


Draining Abscess

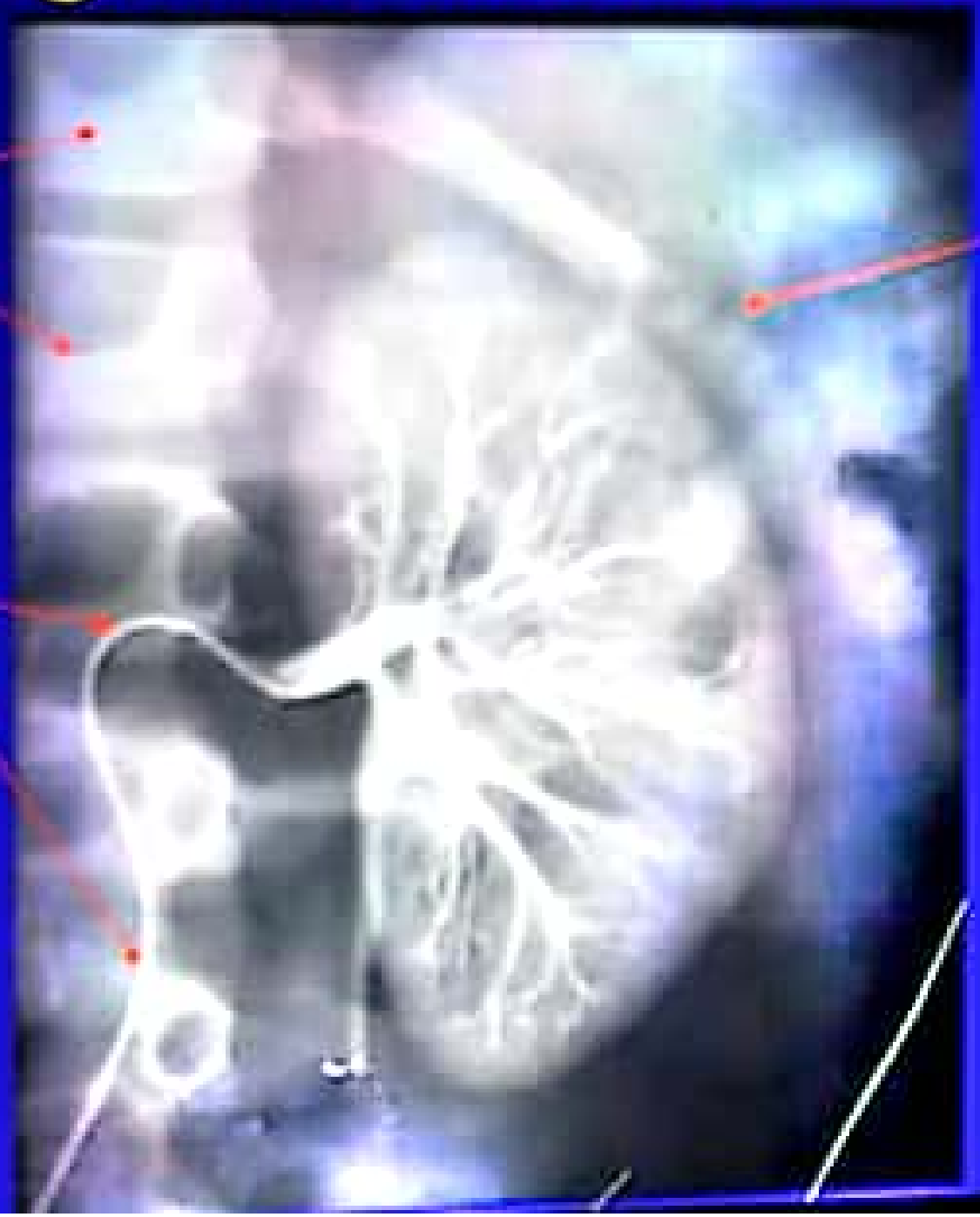


Angioplasty Balloon
Vascular Stent

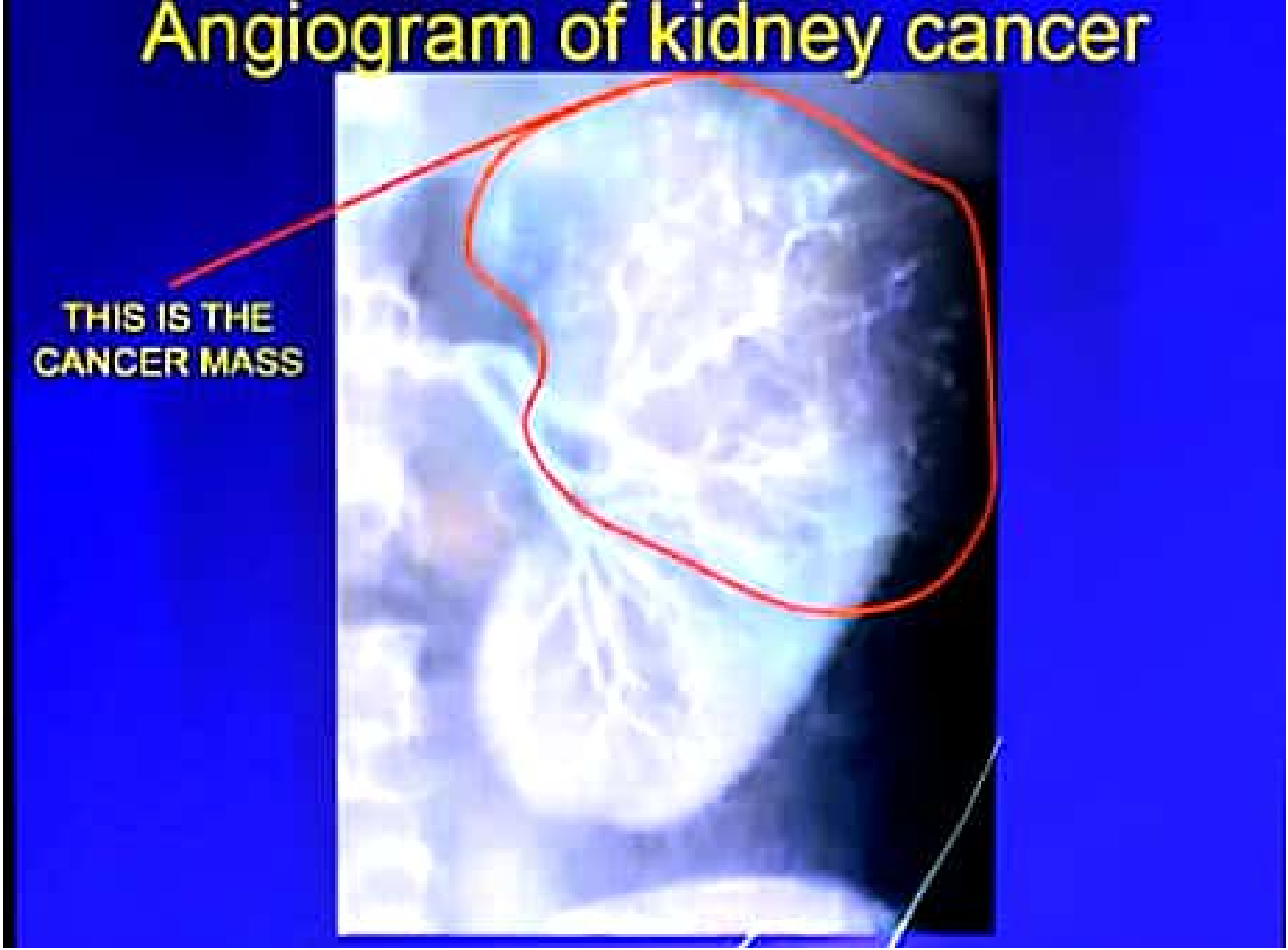




Angiogram of normal kidney



Angiogram of kidney cancer



Angiogram after embolization

NO BLOOD FLOW TO THE MASS NOW IT CAN BE REMOVED WITHOUT EXCESSIVE BLEEDING

Advancements in imaging technologies continues