Urology

Volume - 1

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IMAGING IN UROLOGY

----- Active space -----

Radiation management

00:00:44

Terminologies :

- Radiation exposure :
  - Charge per unit mass of air caused by passage of radiation through tissue.
  - measured in coulombs (C)/kg.
- Absorbed dose :
  - Energy absorbed from radiation exposure.
  - measured in gray (Gy).
- Equivalent dose :
  - Conversion factor applied to absorbeds dose to measure different interaction of radiation with different type of tissue.
  - measured in Sievert (Sv).
  - Conversion factor for diagnostic x rays = 1.
- Effective dose :
  - Denotes radiation risk to a population of patients from an imaging study.
  - measured in Sievert (Sv).
  - Estimation of range of effective doses for various imaging modalities allows assignment of relative.

Radiation quantity	Traditional unit	SI unit	Conversion	Clinical relevance
Exposure	roentgen (R)	coulomb 1 C/kg = 3876 R Charge per unit mass	1 C/kg = 3876 R	Charge per unit mass
Absorbed dose	rad	Gray (Gy)	1 Gy = 100 rad	Energy absorbed by tissue
Equivalent dose	rem	Sievert (Sv)	1 Sv = 100 rem	Absorbed energy based on tissue type
Effective dose	rem	Sievert (Sv)		Biologic risk associated with absorbed energy

----- Active space -----

- Radiation level :

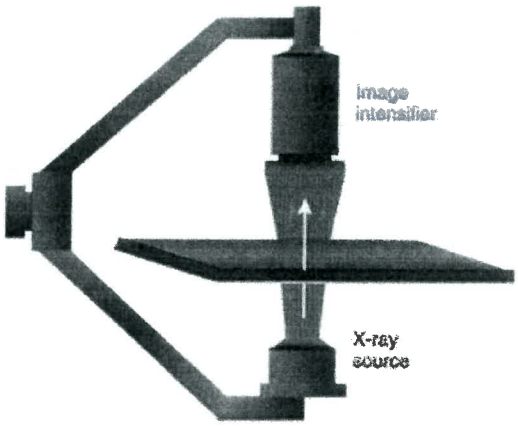
Relative radiation level (RRL)	Effective dose estimated range	Example examinations
None	0	Ultrasound, MRI
Minimal	<0.1 mSv	Chest radiographs
Low	0.1–1.0 mSv	Lumbar spine radiographs, pelvic radiographs
Medium	1–10 mSv	Abdomen CT without contrast, nuclear medicine, bone scan, mic-DMSA renal scan, IVP, retrograde pyelograms, KUB, chest CT with contrast
High	10–100 mSv	Abdomen CT without and with contrast, whole-bod PET

Radiation protection :

- Recommended occupational exposure : 50 mSv/yr.
- No safe dose of radiation (Linear no threshold model).
- Greater risk to eyes and gonads.

Reduction in radiation exposure :

- Limiting time of exposure :
  - Use short bursts.
  - Last image hold.
- Maximizing distance from radiation source :
  - Exposure diminishes as square of distance from radiation source.
  - Positioning image intensifier close to patient reduces scatter radiation.



Positioning of the radiation source

- Shielding :
  - Radiation resistant eye protection, leaded gloves.
  - Collimate to minimum required visual fluoroscopy field.

Contrast media :

Allergy-like reactions :

- Idiosyncratic, anaphylactoid, not dose dependent.
- Differ immunologically from true allergic reactions.
- Antigen antibody response rarely identified, no true IgE reaction.
- Mechanism of action : Combination of systemic effects :
  - Release of vasoactive substances like histamine.

----- Active space -----

- Activation of physiologic cascades : Complement, Kinin, coagulation, fibrinolytic systems.
- Inhibition of enzymes like cholinesterase leads to prolonged vagal stimulation.
- Patient anxiety and fear of actual procedure.

Physiologic reactions :

- Not allergy-like, dose and concentration dependent.
- Physiologic response to contrast medium molecular properties creating chemotoxicity.
- Effects can be due to hyperosmolality.
- Can also be due to binding of specific contrast molecules to activators.

MILD REACTIONS	
Self-limiting signs or symptoms	
Allergic-Like	**Physiologic**
Limited urticaria/pruritus	Limited nausea/emesis
Limited edema	Transient flushing/warm/chills
Limited throat irritation	Headache/dizziness/anxiety/altered taste
Nasal congestion	Mild hypertension
Sneezing, eye irritation, rhinorrhea	Vasovagal but resolves spontaneously
MODERATE REACTIONS	
Commonly require medical management and may become severe if not treated	
Allergic-Like	**Physiologic**
Diffuse urticaria/pruritus	Protracted nausea/emesis
Diffuse erythema	Hypertension
Facial edema	Chest pain
Throat tightness	Vasovagal responds to treatment
Wheezing/bronchospasm mild	

SEVERE REACTIONS	
Life-threatening, may result in morbidity or mortality if not treated. Cardiac arrest may occur from allergic-like as well as physiologic adverse reactions	
Allergic-Like	**Physiologic**
Diffuse edema/facial edema/shortness of breath	Vasovagal reaction resists treatment
Diffuse erythema and hypotension	Arrhythmia
Laryngeal edema with hypoxia	Seizures
Wheezing/bronchospasm with hypoxia	Hypertensive emergency
Anaphylactic shock/hypotension/tachycardia	

Treatment of contrast reactions :

Mild :

- Observation, reassurance.
- Diphenhydramine, chlorpheniramine, diazepam.
- Bronchospasm management.

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Moderate :

- Incidence : 0.5 to 2 %.
- Close observation.
- Hydrocortisone, salbutamol, oxygen.

Severe :

Emergency treatment :

- Rapid administration of epinephrine (TOC).
- IV 0.1 ml/kg of 1:10000 dilution (0.01 mg/kg) slowly into running saline infusion, repeated every 5 to 15 min, maximum single dose 1 ml (0.1 mg), total dose 1 mg.
  - IM 0.01 mg/kg of 1:1000 dilution (0.01 ml/kg) to maximum 0.15 mg of 1:1000 if < 30 kg (0.3 mg if weight > 30 kg) in lateral thigh, repeated every 5 to 15 min up to 1 ml (1 mg).
- Vasopressors : Most effective vasopressor : Dopamine (2 to 10 mcg/kg/min).

Premedication :

- No known strategy to eliminate risk of severe adverse reaction to contrast media.
- Low osmolar contrast media is preferred in patients with known history of allergy.
- AR may happen after extravascular procedures too (RGP).
- Corticosteroid premedication lowers likelihood of ALR.
- Adverse effect of premedication : Leukocytosis, asymptomatic hyperglycemia, possible infection risk.
- Oral steroids preferable.
- Steroids required at least 6 hrs before contrast media injection.
- Administration within 3 hrs not useful.
- Accelerated IV premedication only used when no alternatives present.

- Prednisone : 50 mg by mouth at 13 hours, 7 hours, and 1 hour before contrast media injection.
- Plus diphenhydramine (Benadryl) 50 mg intravenously, intramuscularly, or by mouth 1 hour before contrast medium injection.
- Methylprednisolone (medrol) : 32 mg by mouth 12 hours and 2 hours before contrast media injection.
- Plus diphenhydramine (Benadryl) : 50 mg intravenously, intramuscularly, or by mouth 1 hour before contrast medium injection.

Delayed contrast reactions :

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- Occur from 3 hrs to 7 days after contrast.
- m/c allergic like and cutaneous reactions.
- Typically resolve spontaneously.

Specific contrast considerations :

- Allergic patients (unrelated to contrast) 2 to 3 times more likely to have contrast reaction.
- Reaction to 1 class doesn't increase risk of reaction to another type of contrast medium.
- Contrast reactions more common in patients with anxiety.
- Asthma increases chance of ALR (Premedication not recommended).
- Beta blockers can lower threshold for contrast reactions (Cessation not recommended).
- Premedication not recommended solely on cardiac status.
- Hyperthyroid patients may develop thyrotoxicosis with contrast (Rare).
- Washout of 3 to 6 wks recommended after contrast study before radioiodine therapy.
- Premedication not recommended for myasthenia gravis/pheochromocytoma/ sickle cell trait.
- Large volume extravasation of contrast :
  - Swelling, edema, erythema, pain, cellulitis, compartment syndrome.
  - Maximum symptoms in 24 to 48 hrs.
  - Primary mechanism : Hyperosmolality of contrast.
- Rx : Manual massage, plastic surgery consult.

Post contrast AKI (Nonspecific term) : Acute, sudden deterioration in kidney function within 48 hrs.

CIN :

- Specific for sudden decrease in kidney function by IV administration of iodinated contrast medium.
- Pathophysiology : Vasoconstriction, direct tubular toxicity, osmotic mechanisms, chemotoxic mechanisms.
- Diagnosis of CIN → Occurence within 48 hrs :
  - Increase in creatinine of > 0.3 mg/dl.
  - Increase in creatinine from baseline > 50%.
  - u/o < 0.5 ml/kg/hr for at least 6 hrs.

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- Risk factors :
  - GFR at least 45 ml/min/1.73 m^2 not independent risk factor for CIN.
  - IV contrast risk factor for CIN with GFR < 30 ml/min/1.73 m^2.
  - Incidence : 2 to 5 %.
  - Most important risk factor for CIN is pre-existing severe renal insufficiency.

Other risk factors for CIN :

- DM.
- Dehydration.
- CV disease.
- Diuretic use.
- Advanced age.
- Multiple myeloma.
- HTN.
- Hyperuricemia.
- Repeated contrast injections.
- Low PCV.
- EF < 40%.
- Renal tumor/transplant/single kidney.
- HOCM, increased contrast viscosity.

Prevention :

- Hydration.
- Sodium bicarbonate : Doubtful role.
- N acetyl cysteine : Controversial.

Metformin use :

- Advised discontinuation 48 hrs prior in patients withrenal insufficiency.
- Fatal in 50 % cases.
- Rare with normal renal function.
- Discontinuation not required before Gd MRI.

Note :

- Furesemide increases risk for CIN.
- ESRD with no natural renal function is no longer at risk for CIN.

Gadolinium :

- Paramagnetic metal ion.
- 7 unpaired electrons.
- Reduces T1 and T2 relaxation times.
- Increases tissue signal intensity on T1 weighted images.
- Can interfere with assay for Ca (False hypocalcemia for 24 hrs), iron, magnesium, iron binding capacity and zinc.

Adverse effects :

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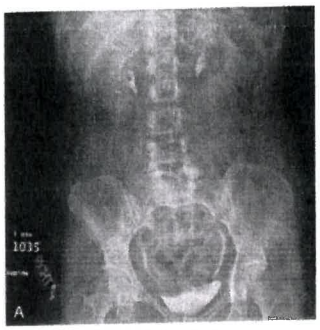
Nephrogenic systemic fibrosis :

- Fibrosing disease of skin, subcutaneous tissue, lungs, esophagus, heart and skeletal muscles.
- Initial features are skin thickening and pruritis.
- Later : Contractures and joint immobility, death due to visceral involvement.
- Strong association with advanced renal disease.
- Onset : 2 days to 3 months.
- Patients with GFR < 30 not on chronic dialysis, most difficult patient population, IV contrast is contraindicated, Gd may cause NSF.
- NSF risk greatest with GFR < 15 (1 to 7 % incidence).
- In high risk patients, use minimal dose, consider macrocyclic agents, avoid gadodiamide.
- mechanism : Gd dissociates from chelates in patients with poor renal clearance → Free Gd binds phosphate and other anions → Forms insoluble precipitate → Deposited in tissues with subsequent fibrotic reaction.

Plain imaging modalities

00:20:01

IVU :



IVU

- Clear liquids 12 to 24 hr and enema 2 hr before procedure.
- Scout film : Non contrast image to see the location of stones.
- 50 to 100 ml contrast bolus.
- Nephrogenic phase immediately after injection.
- Next film at 5 minutes and every 5 minutes.
- Abdominal compression : Visualization of ureters.
- Upright films possible for renal ptosis.
- Postvoid films taken.

Plain abdominal radiography :


Plain abdominal radiography

- Supine position.
- AP exposure.
- Level of diaphragm to inferior pubic ramus.
- Structures to look in plain abdominal radiograph :
  - Look for fractures of pelvis,hip and sacroiliac joint.
  - Renal shadow lying L1-L5.
  - Any foreign body and kidney stones can be visualised.
  - Psoas can be identified.
- Cost effective to monitor residual stone burden after treatment.

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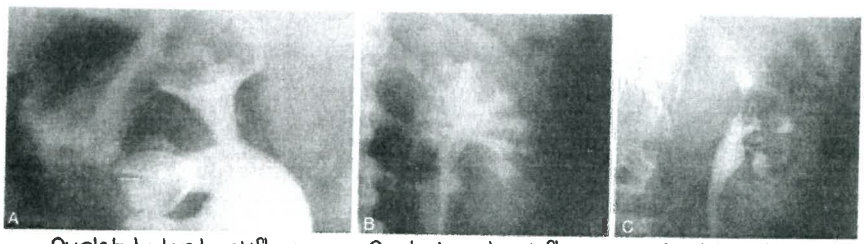
Retrograde pyelography :

- Sterilize urine before study.
- Can determine ureteral normalcy distal to obstruction.
- Dilute contrast medium (50 % or less) to prevent subtle filling defects getting obscured.
- Evacuate air bubbles from syringe before instillation.
- 5 to 8 cc contrast usually required in normal syst.

Complications :

- Pyelotubular backflow : Opacification of medullary pyramids.
- Pyelosinus backflow : Tear in calyceal fornix leading to contrast leak in renal sinus.
- Pyelolymphatic backflow : Opacification of renal lymphatic channels.
- Pyelovenous backflow : Contrast entering venous system.



Pyelotubular backflow | Pyelosinus backflow | Pyelolymphatic backflow

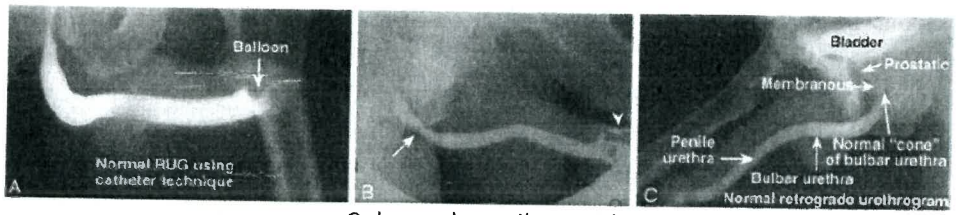
Loopography :

- Advance catheter just proximal to abdominal wall fascia.
- Balloon inflated with 5 to 10 ml water.
- Oblique films useful.
- Drainage film useful.

Loopography

Retrograde urethrography :

- Measures total length of urethral stricture.
- Anatomy of urethra distal to stricture visualised.



Retrograde urethrography

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Static cystography :

Static cystography

- Visualizes structural integrity of bladder.
- Shape and contour of bladder.
- Supine position.
- Bladder filled under gravity with 200 to 400 ml contrast.
- Oblique films useful (Diverticulae, fistulae).
- Post-drainage film required.
- As sensitive as CT cystography in detecting bladder rupture.

Voiding cystography :

- Evaluates posterior urethra.
- VUR.
- Supine or semi upright position.
- B/l oblique views useful.

CT 00:31:02

Features :

- Attenuation of X ray photons passing through patient.
- Computer based reconstruction of cross sectional images.
- Amount of transmitted radiation measured by detector on opposite side of X ray beam.
- Helical (multidetector CT) : Patient moves through continuously rotating gantry.
- Current CT : 64 to 320 rows of detectors.
- Gray scale of each pixel of CT image depends on amount of radiation absorbed at that point → Attenuation value.
- Attenuation value is expressed in HU.
- Air HU = −1000, bone HU = +1000, water HU = 0.

Phases of CECT :

- Unenhanced CT : 1st phase.
- Corticomedullary phase : 30 to 70 seconds, defines vasculature and perfusion.
- Nephrogenic phase : 90 to 180 seconds, allows sensitive detection and characterization of renal masses.
- Excretory phase : 3 to 5 minutes, visualization of PCS and ureter.

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MRI

00:33:52

Features :

- Excellent signal contrast resolution of soft tissue.
- Free proton orient along magnetic Z axis.
- RF antenna or coil placed over area of interest.
- Coil transmits RF pulses through patient.
- Protons release energy on stopping RF pulse.
- T1 weighted images generated by time to return to equilibrium in Z axis, T2 weighted images in XY axis.
- T2 images : Water appears bright.
- Cortex brighter than medulla.

Fat imaging :

- Inversion recovery imaging.
- Chemical shift imaging (m.c.).
  - In phase and out of phase images taken.
  - Loss of signal on OP imaging s/o intracytoplasmic fat.
- Fat saturation imaging.
- Spectral presaturation with inversion recovery (SPIR).
- Spectral presaturation attenuated inversion recovery (SPAIR).

Multiparametric MRI :

- T2 weighted sequence.
- DWI : Texture of the organs.
- DCE :
  - Contrast enhancement.
  - Different curves are seen.
  - Type 1 curve → Straight upright curve.
  - Type 3 curve → Malignancy.
- MRS : Depends on the level of choline, citrate and creatine.

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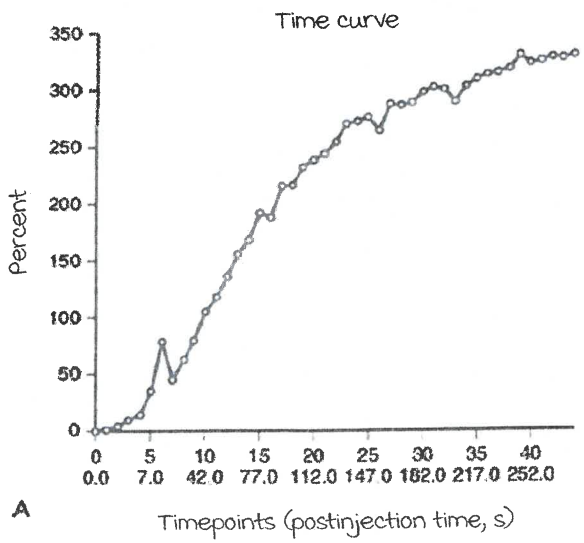

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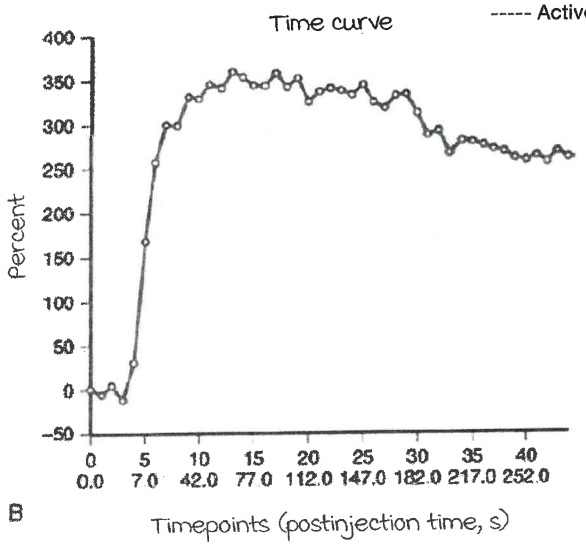

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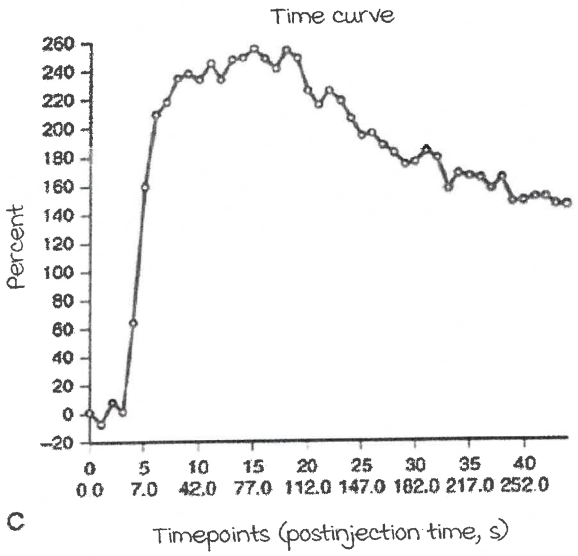

C

Curves in DCE

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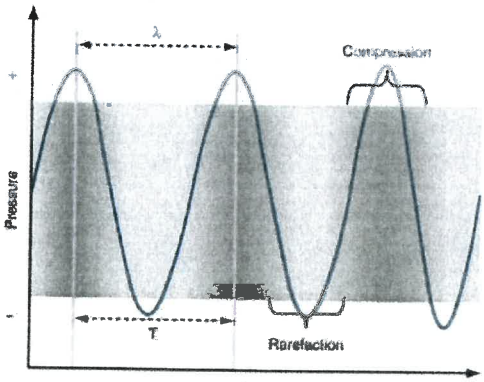
ULTRASONOGRAPHY AND NUCLEAR MEDICINE

Ultrasonography

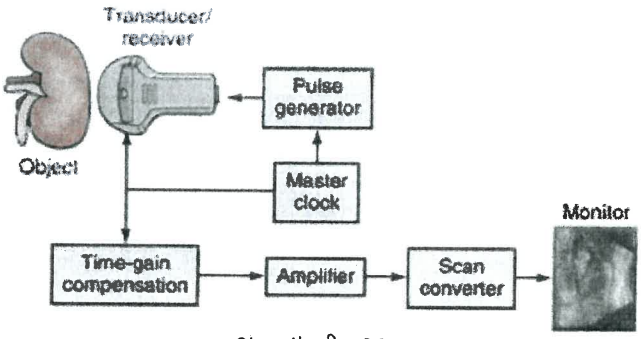
00:00:20

Physical principles :

- USG waves produced by applying short bursts of alternating electrical current to series of crystals housed in transducer.
- Alternating expansion and contraction of crystals via piezoelectric ~~effect~~ creates mechanical wave.



Waves in USG

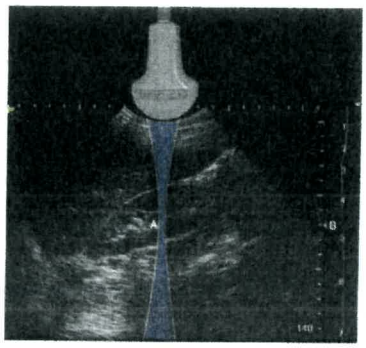


Circuit of USG

- Longitudinal waves produced (Graphically sine wave).
- Reflected component of wave received by transducer.
- Amplitude : Maximum excursion in positive or negative direction from baseline (Higher amplitude = brighter pixel).
- Wavelength : Distance between 2 peaks.
- Cycle : Complete path of wave between 2 peaks.
- 1 Hertz : 1 cycle/sec.
- Average velocity of sound in human tissues : 1540 m/s.

Resolution :

Ability to discriminate between 2 objects close to each other.



Resolution

Axial resolution :

- Ability to identify as separate 2 objects in direction of travelling wave.
- Dependent on frequency of sound waves.
- Higher frequency : Better axial resolution.

Lateral resolution :

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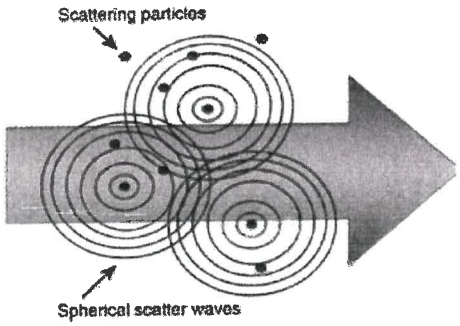
- Ability to identify separately objects equidistant from transducer.
- Function of focused width of USG beam.
- Characteristic of transducer.
- Location of narrowest beam adjustable by user.
- More focused beam : Better lateral resolution at that location.
- Image quality enhanced by locating narrowest beam width (focus) at depth of object or tissue of interest.

High freauency transducers (7-18 MHz) : Less depth, better resolution (more absorption → Less reflection → Less depth).
Low frequency transducers (3-5 MHz) : more depth, less resolution.

Mechanisms of attenuation :

Reflection :

- Wave strikes an object, surface or boundary (Interface) between unlike tissues.
- Affected by impedance of tissues.



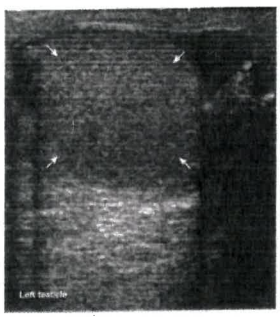
Scattering

Scattering :

- Sound waves strike small or irregular object.
- Produce spherical scatter waves.

Interference :

- Scatter waves collide in or out of phase.
- Pattern of interference responsible for echo architecture/texture of organs.
- 'Speckling' seen in organs with fine, internal histology (Testis).


Speckling

Absorption :

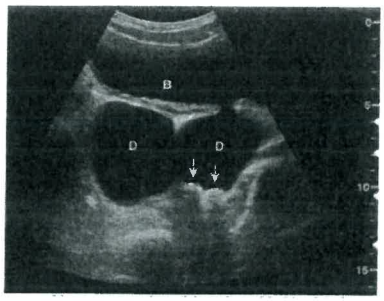
- Mechanical energy converted to heat.
- Absorption directly proportional to frequency.
- Higher frequency → Rapidly attenuated → Limited depth of penetrance.
- As frequency goes up, depth of penetration decreases.

----- Active space -----

Artifacts in ultrasound :

Acoustic shadowing :

- Significant attenuation or reflection of sound waves at tissue interface.
- Echo information posterior to interface obscured.
- 3D objects appear cresenteric, difficult to get accurate measurements.
- Mitigated by changing angle of insonation, frequency of transducer or focal zone of transducer.



Acoustic shadowing

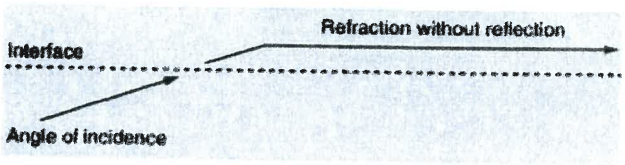
Increased through transmission

Increased through transmission :

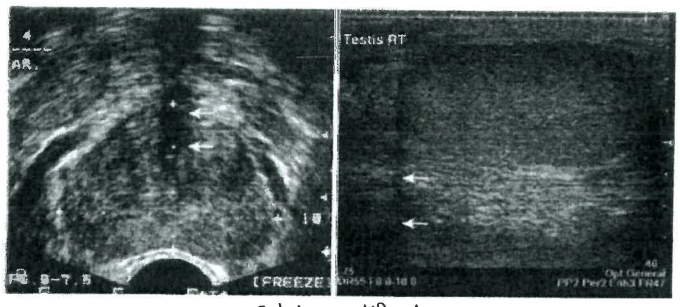
- Less attenuation of waves while passing through an object.
- Waves passing through object (Simple cyst) has more energy.
- Reflected wave has more energy.
- Tissue posterior to cyst appears brighter.
- Mitigated by changing angle of insonation or adjusting time gain compensation settings.

Edging artifact :

- Waves strike a curved surface or interface at incident angle : Refraction of wave along plane of interface.
- Overcome by changing angle of insonation.



Mechanism of edging artifact



Edging artifact

Reverberation artifact :

- Large differences in impedance between 2 adjacent tissues.
- Strong reflection of incident wave.
- USG wave bounces back and forth b/w reflective interfaces.