**A NEET SS (SURGERY) PREPARATION COURSE BY MARROW, WITH A TEAM OF SELECTED SUPER-SPECIALITY FACULTY**

# SURGERY NEET SS

## UROLOGY

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# NEET SS SURGERY

# UROLOGY

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CONTENT

# INTRODUCTION

# IMAGING IN UROLOGY

## Radiation management

00:00:44

- Radiation exposure : Charge per unit mass of air cause 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 level :

| RADIATION QUANTITY | TRADITIONAL UNIT | SI UNIT | CONVERSION | CLINICAL RELEVANCE |
|---|---|---|---|---|
| Exposure | roentgen (R) | coulomb (C)/kg | 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 |

| 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, $^{99m}$Tc-DMSA renal scan, IVP, retrograde pyelograms, KUB, chest CT with contrast |
| High | 10–100 mSv | Abdomen CT without and with contrast, whole-body PET |

Radiation protection :

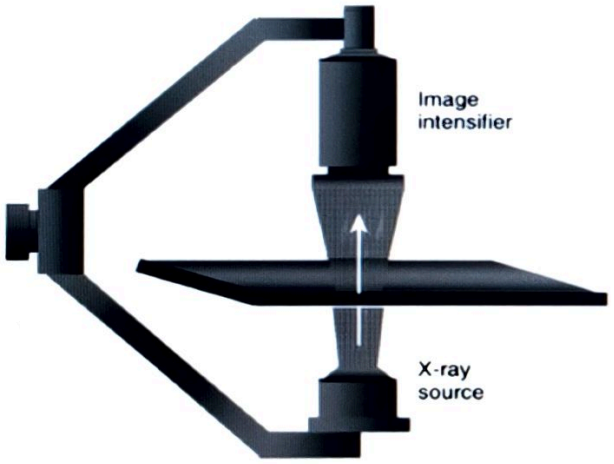
Recommended occupational exposure : 50 msv/yr.

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.




Shielding :

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

Contrast media :

1. Allergic 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.
- 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.

2. Physiologic reactions :
   - Not allergic 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 :

1. Mild :
   - Observation, reassurance.
   - Diphenhydramine, chlorpheniramine, diazepam.
   - Bronchospasm management.

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

- Emergency treatment :
  - Rapid administration of epinephrine is the treatment of choice.
  - 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.

1. 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
2. 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 :

- 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 : Occurance within 48 hrs :
  1. Increase in creatinine of > 0.3 mg/dl.
  2. Increase in creatinine from baseline > 50%.
  3. U/O < 0.5 ml/kg/hr for at least 6 hrs.
  - 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 :

1. DM.
2. Dehydration.
3. CV disease.
4. Diuretic use.
5. Advanced age.
6. multiple myeloma.
7. HTN.
8. Hyperuricemia.
9. Repeated contrast injections.
10. Low PCV.
11. EF < 40%.
12. Renal tumor/transplant/single kidney.

13. HOCM, increased contrast viscosity.
14. ESRD with no natural renal function is no longer at risk for CIN.

Prevention :

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

Frusemide increases risk for CIN.

Metformin use :

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

## MRI contrast agents 00:16:56

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 effect :

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.

IVU :

- Clear liquids 12 to 24 hr and enema 2 hr before procedure.
- Scout film.
- 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 :

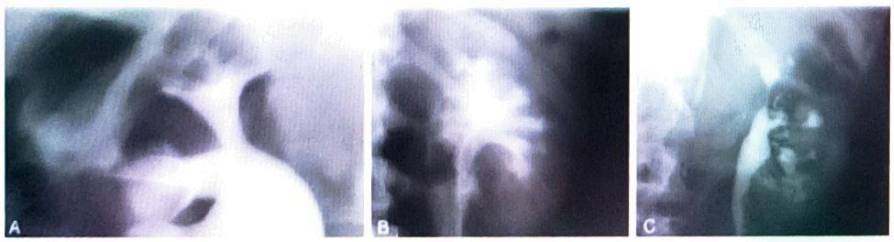
- Supine position.

- AP exposure.
- Level of diaphragm to inferior pubic ramus.
- Cost effective to monitor residual stone burden after treatment.

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



Loopography :

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


Retrograde urethrography :

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


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).
- Postdrainage film required
- As sensitive as CT cystography in detecting bladder rupture.


Voiding cystography :

1. Evaluates posterior urethra.
2. VUR.
3. Supine or semi upright position.
4. B/l oblique views useful.

## CT

00:31:06

- 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 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.

MRI :

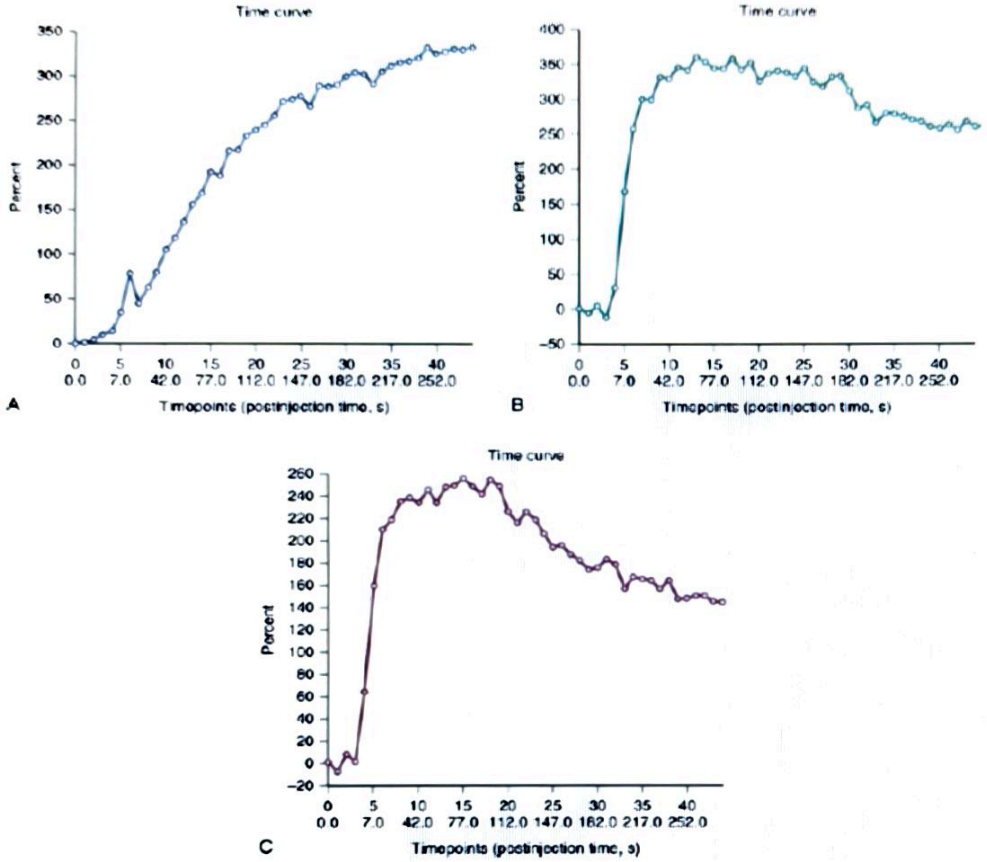
- Excellent signal contrast resolution of soft tissue.
- Free proton orient along magnetic Z axis.
- RF antenna or coil placed over area of interest.
- Coil transmits RF pulses through patient.
- Protons release energy on stopping RF pulse.
- TI weighted images generated by time to return to
- equilibrium 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 :

1. T2 weighted sequence.
2. DWI.
3. DCE.
4. MRS.

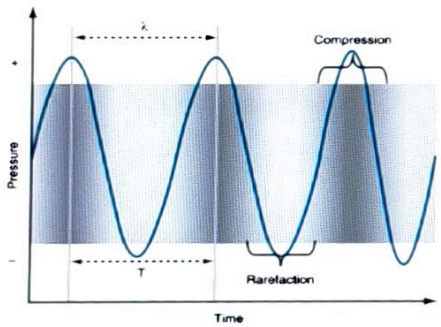

Time curve
Percent
Timepoints (postinjection time, s)
A
Time curve
Percent
Timepoints (postinjection time, s)
B
Time curve
Percent
Timepoints (postinjection time, s)
C

# ULTRASONOGRAPHY AND NUCLEAR IMAGING

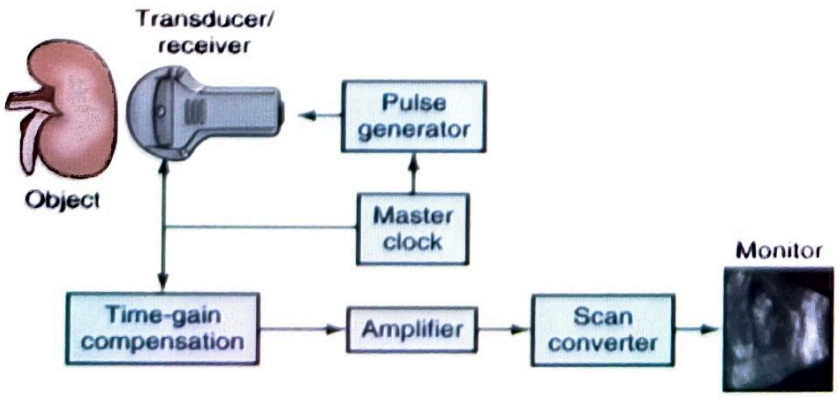
## Ultrasonography 00:00:40

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.

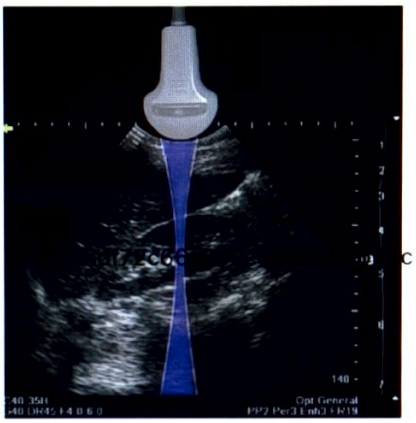



- Longitudinal waves produced (graphically sine wave).
- Reflected component of wave received by transducer.
- Amplitude : Maximum excursion in positive or negative direction from baseline (higher amplitude = brighter pixel).
- Wavelength : Distance between 2 peaks.
- Cycle : Complete path of wave between 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.

1. 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.



2. Lateral resolution :
    - 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.

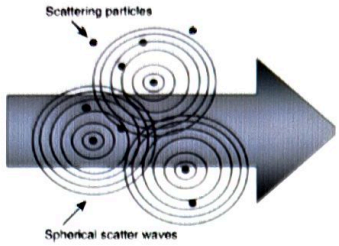
High frequency transducers (7-18 MHz) : Less depth, better resolution (more absorption → less reflection → less depth).
Low frequency transducers (3-5 MHz) : more depth, less resolution.

Mechanisms of attenuation :

1. Reflection :
    - Wave strikes an object, surface or boundary (interface) between unlike tissues.
    - Affected by impedance of tissues.

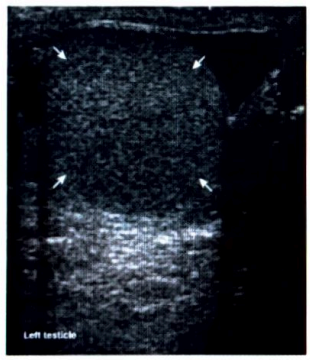
2. Scattering :

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




3. Interference :

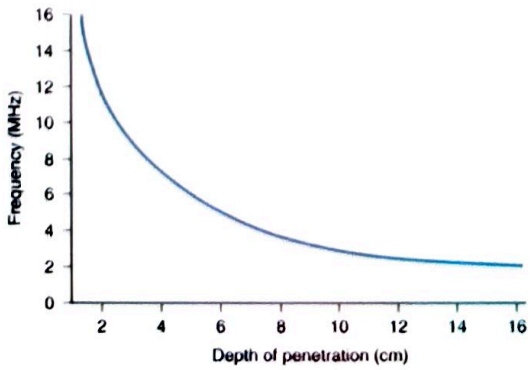
- Scatter waves collide in or out of phase.
- Pattern of interference responsible for echo architecture or texture of organs.
- 'Speckling' seen in organs with fine, internal histology (testis).




4. 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.

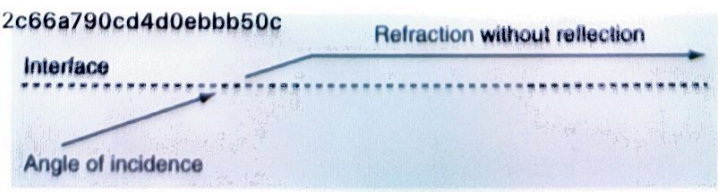


## Artifacts in Ultrasound :

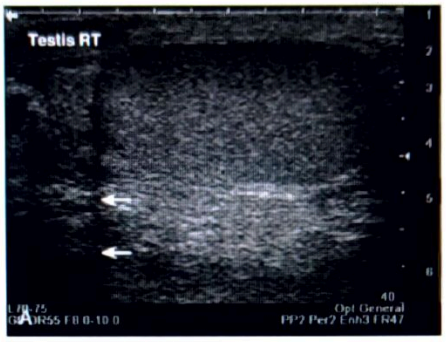
1. Acoustic shadowing :
   - Significant attenuation or reflection of sound waves at tissue interface.
   - Echo information posterior to interface obscured.
   - 3D objects appear cresenteric, difficult to get accurate measurements.
   - Mitigated by changing angle of insonation, frequency of transducer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


2. 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.

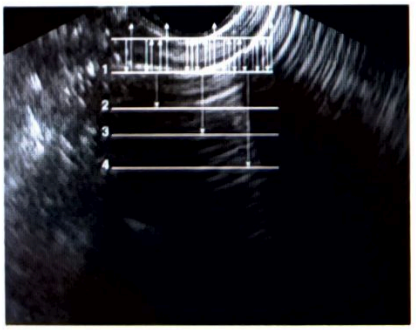

3. Edging artifact :



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


4. 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.
    - Eg : gas fluid mixture in small bowel.
    - Comet tail artifact : Blackish line beyond the edging artifact.



## Modes of USG 00:14:40

1. Grey scale :
    - B mode mc employed.
    - Real time 2D images in shades of grey.
    - Position of pixel determined by duration of round trip of sound wave.

2. Doppler :

- Principle : Frequency shift when sound waves strike a moving object.
- Allows characterization of motion (blood, urine).

3. Color doppler :

- Evaluates velocity and direction of motion.
- Brighter the color, greater the velocity.

4. Color flow with spectral display :

- Allows interrogation of particular areas within USG field for flow.
- Displays the flow as continuous wave form.
- Evaluates pattern and velocity of blood flow in intrarenal or penile vasculature.
- Provides information about peripheral vascular resistance in tissues (Resistive index).
- RI = PSV-EDV/PSV.

5. Power doppler :

- Assigns amplitude of frequency change to color map.
- Does not permit evaluation of velocity or direction of flow.
- Less affected by back scattered waves.
- more sensitive mode for detecting blood flow.
- Less angle dependent than color doppler, 3 to 5 times more sensitive as color doppler for detecting flow.
- Useful for evaluating testicular torsion.

6. Harmonic scanning :

- makes use of aberrations related to non linear propagation of sound waves within tissue.
- Has less noise → less artifact and greater resolution.

7. Sonoelastography : Ability to evaluate elasticity (compressibility and displacement) of biologic tissues.

8. Real time elastography (RTE) :
   - External, non quantifiable mechanically produced compression wave travels in tissue (1540 m/s).
   - These waves successively compress tissue layers.
   - Deformation induced my manually pressing on anatomy with transducer.
   - Qualitative technique, highly user dependent.
   - Cannot measure absolute tissue stiffness.
   - Benefits : High spatial resolution, real time and doesn't require modifications to conventional USG hardware.

9. Shear wave elastography (SWE) : measurable shear wave, travelling slowly (1-10 m/s) ; propagated by tangential sliding force between tissue layers.
   Limitations :
   - Shear waves weak , only few mm of propagation.
   - Detection of shear wave propagation requires very rapid acquisition speeds, may limit area of detection.

10. 3D scanning :
    - Produces composite of images.
    - Important on procedural planning and precise volumetric assessments.

11. Multiparametric USG (mpUSG) : Combines different modalities of USG.

| Attribute | Ultrasound | MRI |
|---|---|---|
| Anatomic resolution | 2.3 mm (7.5 mHz). | 1 mm. |
| Vascularity | • Microbubbles.<br>• No problem with renal insufficiency. | • Gadolinium.<br>• NSF. |
| Tissue structure | Elastography :<br>1. Strain.<br>2. Shear. | $H_2O$ diffusion / ADC. |
| Chemical characteristics | | Choline/spectroscopy. |
| Access for biopsy | • Real time.<br>• Infinite flexibility. | • Fusion techniques.<br>• In bore. |

Contrast agents in USG :

- Contain microbubbles.
- Enhance echogenicity of blood and tissue.
- Targeting ligands attached to microbubble allow it to selectively accumulate in diseased or abnormal tissues.
- Bubbles rapidly degraded by interaction with sound waves.
- Good safety profile.

Patient safety measures :

- Mechanical effects :
  - Torque and streaming.
  - Cavitation → small gas → filled bubbles form and collapse → liberate large amount of energy → may damage tissue in certain circumstances.
  - most likely to be observed around gas containing structures like lung and bowel.
  - mechanical index (MI) : Probability that cavitation may occur.
  - Lung and intestine : MI < 0.7 safe.
  - Adjacent structures : Limit scanning time if MI > 0.4.
- Thermal effects :
  - Due to tissue heating by absorption of energy.
  - Influenced by beam focusing, transducer frequency, exposure time, scanning mode and tissue density.
  - Thermal index (TI) : Probability that tissue temperature within sonographic field will be increased by 1 degree celsius.
  - Elevations up to 6 degree celsius safe unless exposure time < 60 seconds.

## Clinical Uses of USG

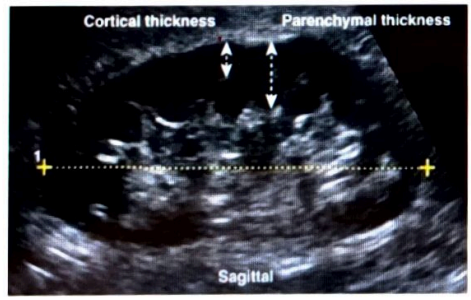
00:27:27

Renal USG :

- 3.5-5 MHz, higher for children.
- Intraop/lap USG : 6-10 MHz.

- LK slightly higher than RK, bowel gas problematic on left, LK lacks liver as acoustic window.


- LP 15 degrees lateral to UP, Kidney rotated 30 degrees posterior to coronal plane, LP slightly anterior to UP.
- Normal Kidneys : Hypoechoic to liver; infant Kidneys hyperechoic.
- Central hyperechoic band : Renal hilar adipose tissue, blood vessels and PCS.
- Renal cortical thickness > 7 mm and renal parenchymal thickness > 15 mm normal.




Transabdominal pelvic USG :

- 3.5 to 5 MHz, higher for children.
- Up to 10 minutes observation required to verify absence of ureteral jets.