



BASIC ABDOMINAL ULTRASOUND

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ABDOMINAL ULTRASOUND

PART I

- References
- Basic ultrasound physics
- Overview of equipment and technology
- Ultrasound artifacts
- Scanning techniques
- Terminology



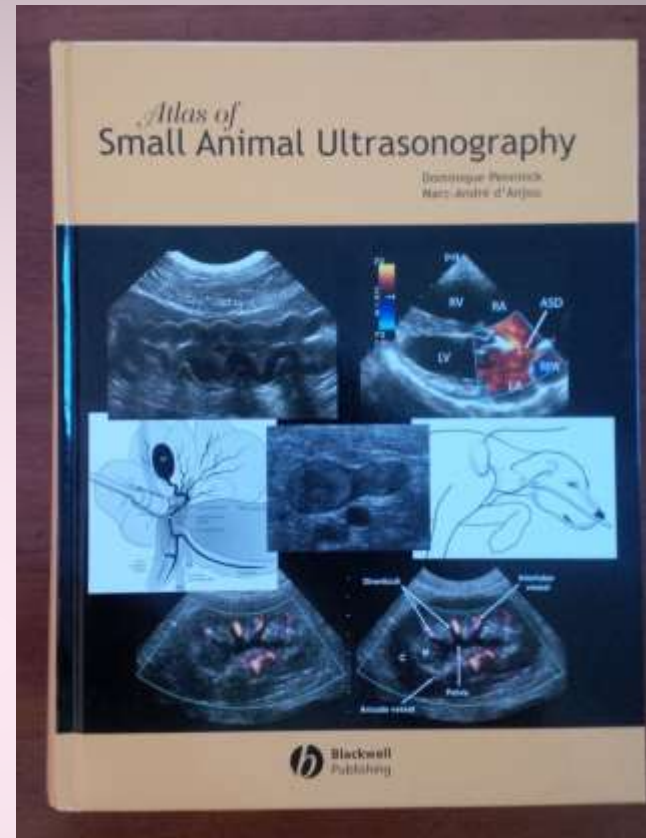
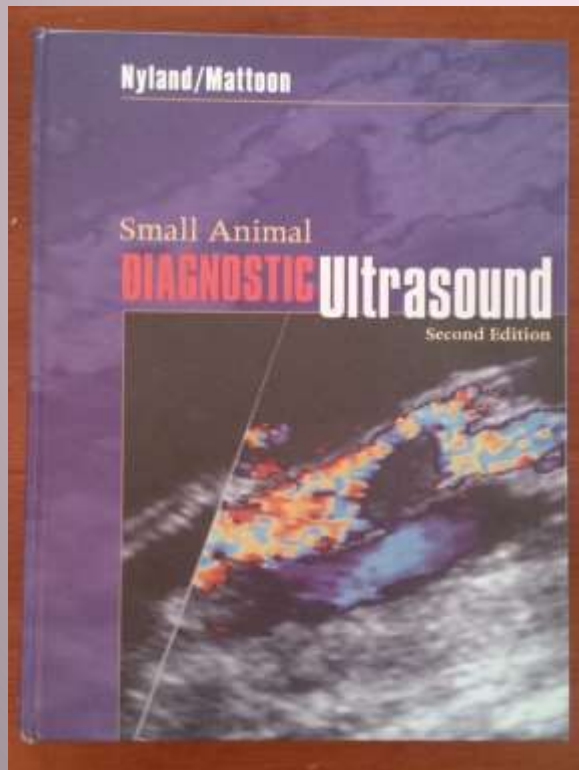
ABDOMINAL ULTRASOUND

PART II

- ◉ Indications
- ◉ Advantages and Disadvantages
- ◉ Systematic approach
- ◉ Relative organ echogenicity
- ◉ NORMAL vs. ABNORMAL

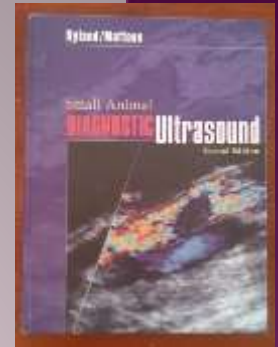
REFERENCES: BEFORE YOU START

Nyland and Mattoon:
*Diagnostic Small Animal
Ultrasound, 2nd edition.*



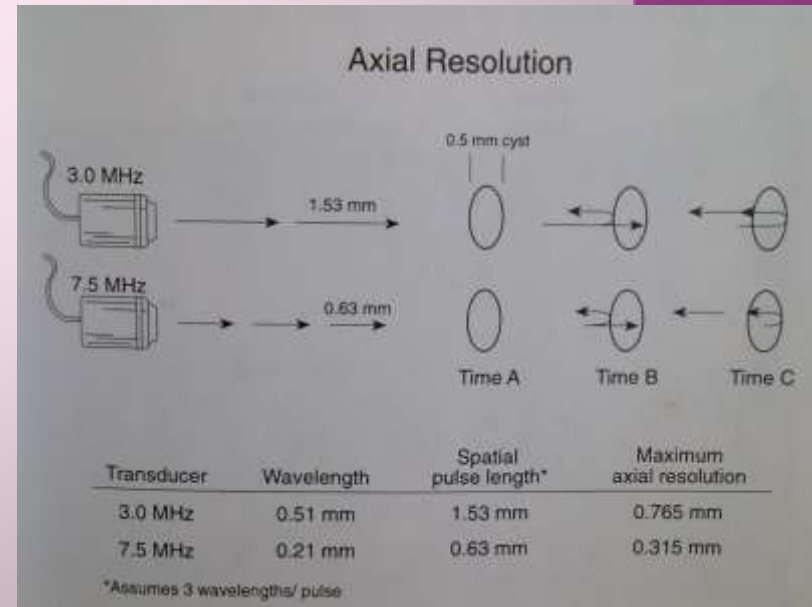
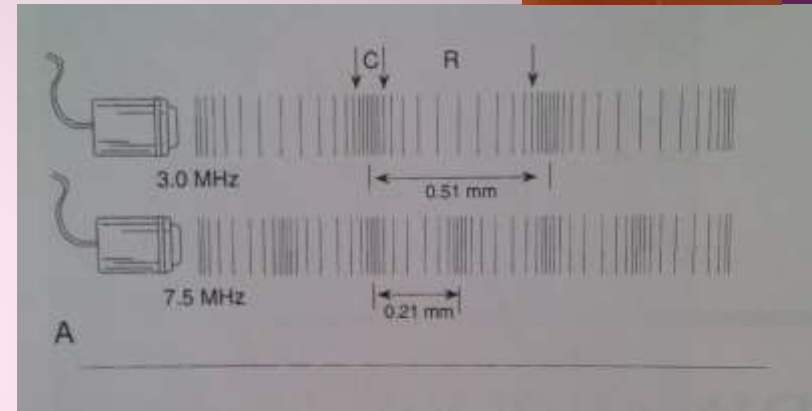
Pennick and D'Anjou
*Atlas of Small Animal
Ultrasonography*

BASIC ULTRASOUND PHYSICS



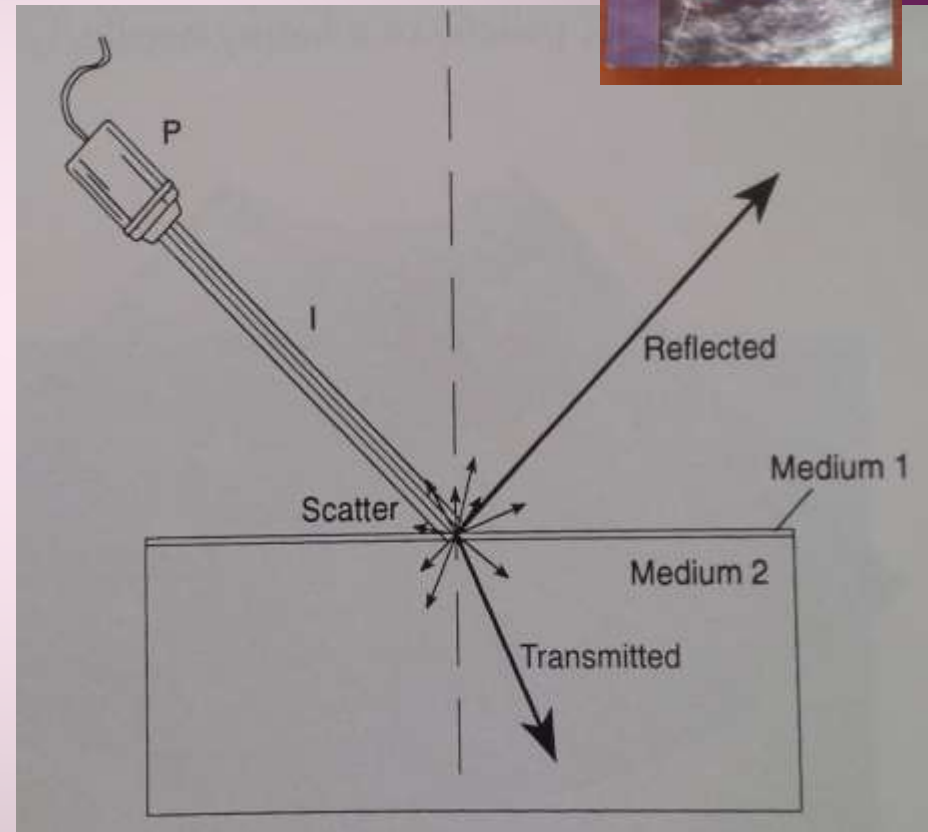
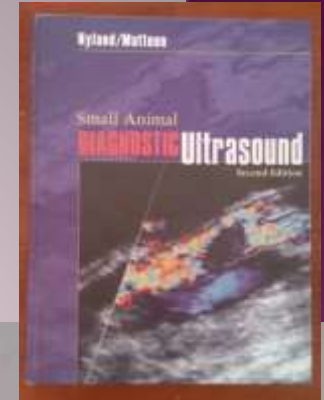
○ What is ultrasound?

- Sound waves at higher frequency than human hearing (>20 kHz)
 - Diagnostic ultrasound uses 2-15 MHz
- Frequency inverse related to depth
 - High frequency, low penetration
 - High frequency, higher attenuated
 - Absorbed energy is lost as HEAT
- Frequency direct related to resolution
 - High frequency, high resolution
 - axial resolution 7.5 MHz ~ 0.3 mm



SOUND INTERACTIONS WITH TISSUE

- TRANSMISSION: sound passes through
- ATTENUATION: sound energy lost
 - REFLECTION
 - Is the basis of u/s image
 - Acoustic impedance of tissue
 - Velocity x density
 - Tissue interfaces
 - SCATTER
 - Tiny uneven interfaces within tissue
 - Creates parenchymal “echotexture”



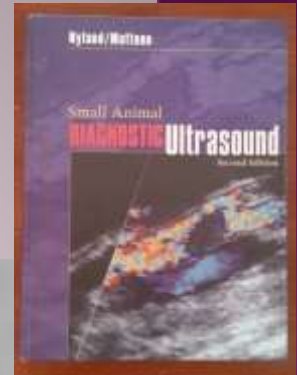
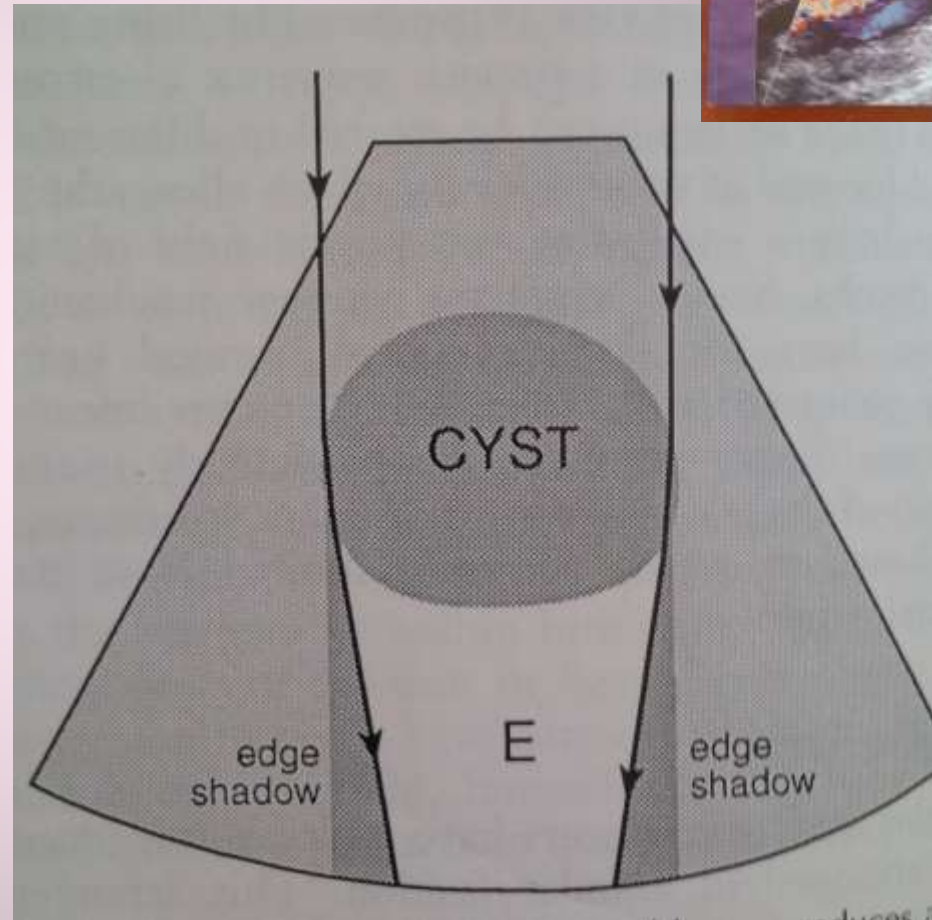
TISSUE INTERACTIONS CONT...

○ REFRACTION

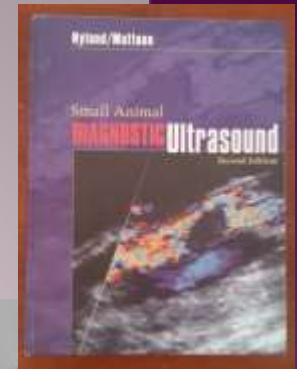
- “BENDING” of sound beam as passes through tissues of different velocities
 - at curved interface

○ ABSORPTION

- Energy lost and converted to heat
- Safety considerations
 - High frequency: greater absorption: greater heat

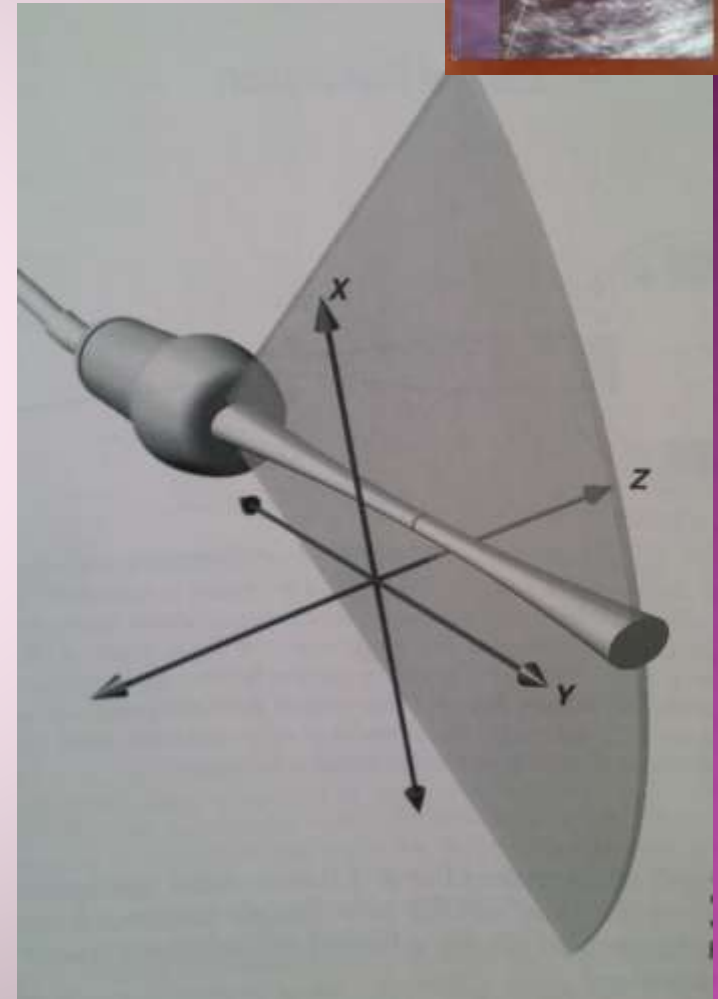


ULTRASOUND EQUIPMENT



○ Transducer

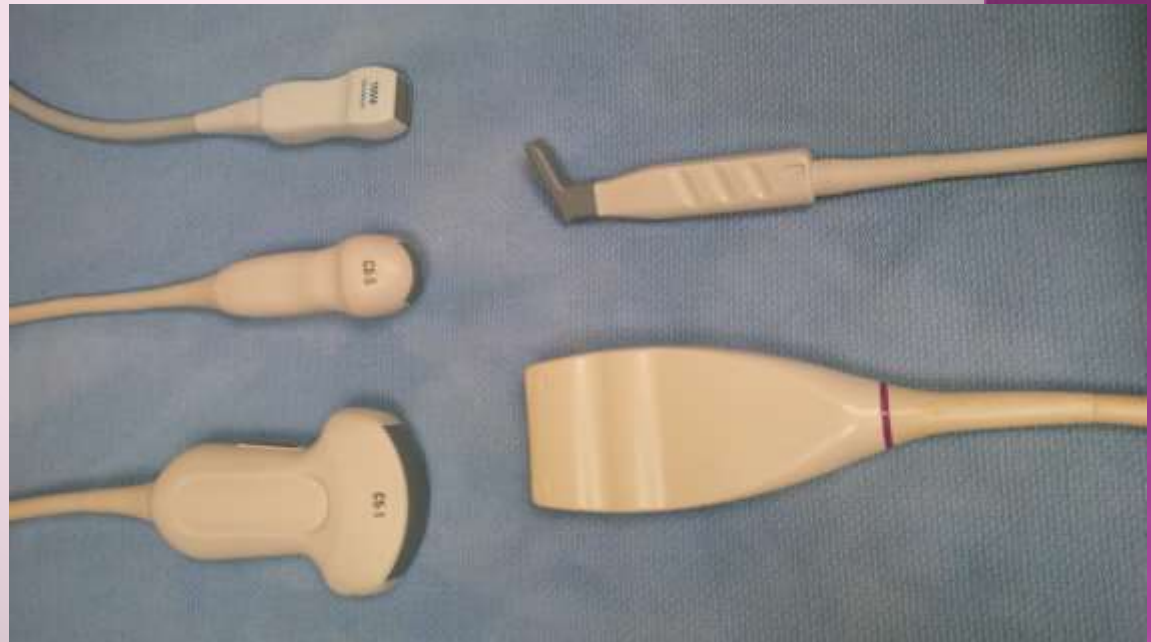
- Wave forms created by transducer
 - Vibrations of piezoelectric crystals when electricity applied or sound received
 - Transducer is “emitting” < 1 %, “listening” >99% of time
- Sound Beam
 - 3-D, thin slice
 - creates artifacts
 - Focal zone
 - Narrowest beam, best resolution



ULTRASOUND EQUIPMENT

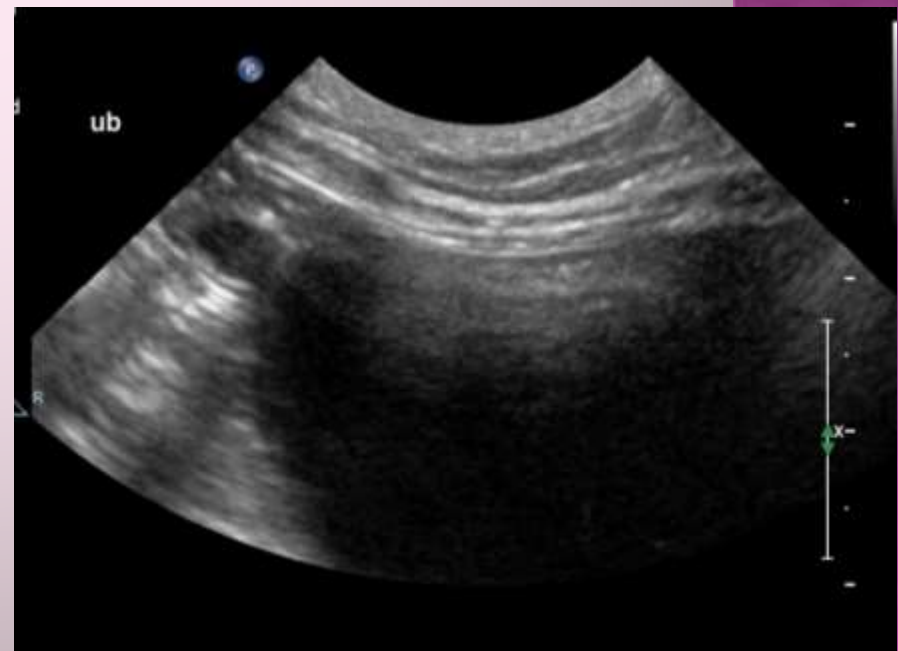
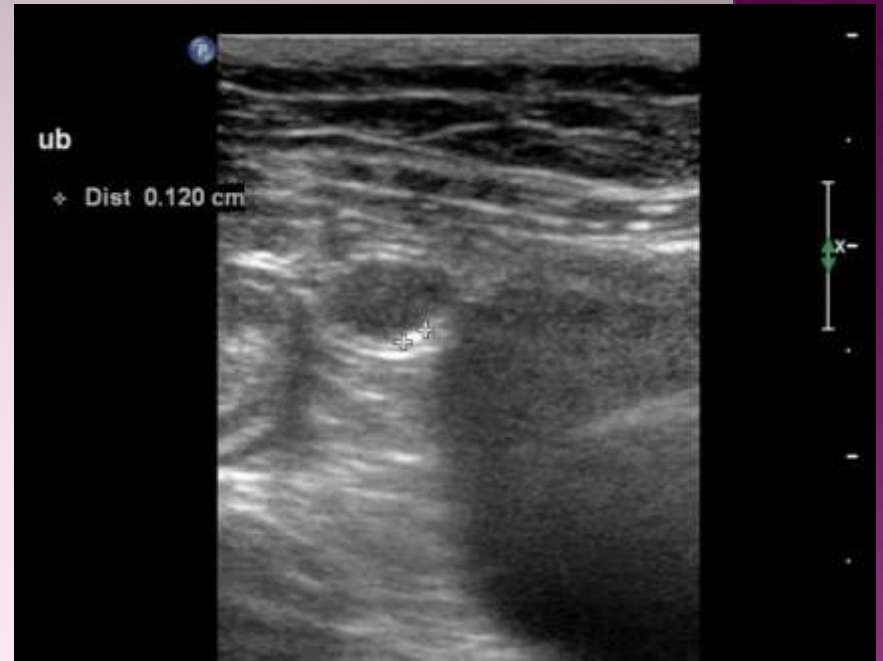
◉ Sector Transducers (real time B-mode)

- Electronic
 - Curvilinear array
 - Phased array
 - Linear array
- Mechanical
 - Annular array



TRANSDUCER

- Pick the highest frequency for best resolution for depth of penetration needed
- Pick the “footprint” best suited for body part imaged



ULTRASOUND EQUIPMENT

- Scanner Computer- magic happens
 - Image generated from returning echoes
 - Time to return of echo = depth of pixel (y axis)
 - Intensity of echoes = brightness and grayscale
 - Direction of returned echo = location in image (x axis)
 - Assume returning echoes traveled at 1540 m/s
 - Avg velocity of sound in fluid/soft tissue is 1540 m/s
 - Velocity actually variable across tissues encountered
 - Air 331 m/s, fat 1450 m/s, bone 4080 m/s
 - Velocity depends on density and physical stiffness
 - Differing velocities cause acoustic impedance
 - Responsible for creation of some artifacts



KNOBOLOGY: BASIC CONTROLS

- ◉ Depth
 - Always set to be able to see the deepest margin of organ being imaged
- ◉ Focus
 - Set within region of most interest
 - Set where measurements are taken
- ◉ Overall gain
 - Often left alone
 - May need to change if poor contact (increase) or if abdominal fluid (decrease)
- ◉ TGC
 - near and far fields
 - Slides set to (b)right for deeper structures



ULTRASOUND ARTIFACTS

○ Helpful

- Acoustic enhancement
- Acoustic shadowing
 - Dirty shadow
 - Clean shadow

○ Not helpful

- Reverberation
- Mirror Image
- Side-Lobe
- Slice thickness
- Edge shadowing
- Electrical interference

ARTIFACTS: HELPFUL

- Acoustic enhancement
 - “through transmission”
 - Structure fluid filled
 - Low attenuation: increases intensity of returned echoes
 - Adjust far field gain



ARTIFACTS: HELPFUL?

○ Acoustic Shadowing

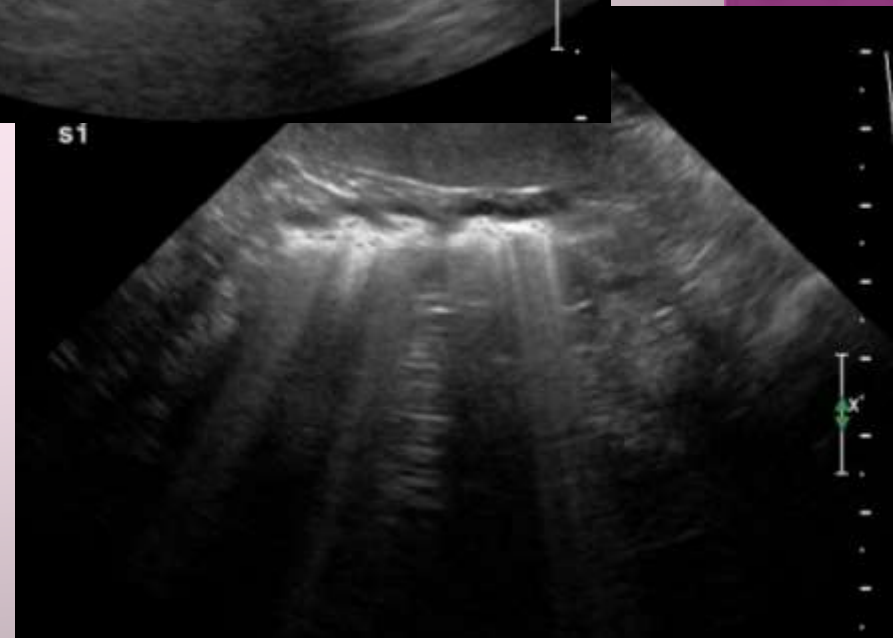
- Clean shadow
 - Sharp edge, pure black
 - solid or high reflective structure (bone, foreign body, solid feces, barium or pure gas)
- Dirty shadow
 - Mixed echogenicity with fuzzy edges
 - inhomogenous structures that contain gas and semisolid material (cloth, soft feces, food in stomach)
- Both can “hide” deeper structure



ARTIFACTS: NOT HELPFUL

○ Reverberation

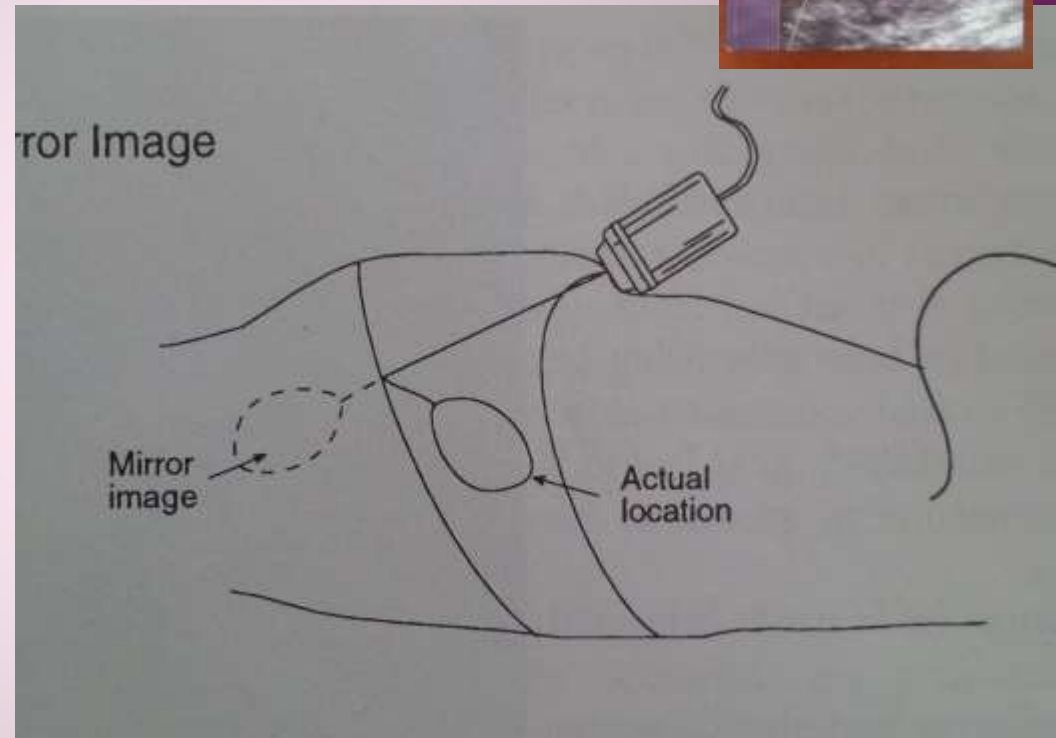
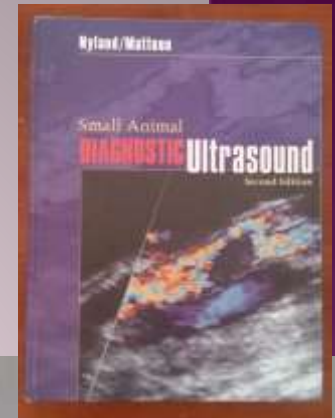
- Common artifact
- Occurs at highly reflective interface: gas, metal
- Sound bounces back and forth between reflective surfaces and probe
- “Comet tails”



ARTIFACTS: NOT HELPFUL

○ Mirror image

- At reflective interfaces- especially diaphragm/ lung
- “mismaps” location based on travel time
- Mistake thoracic pathology



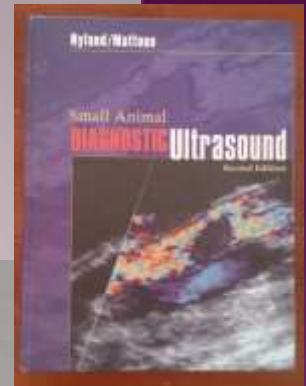
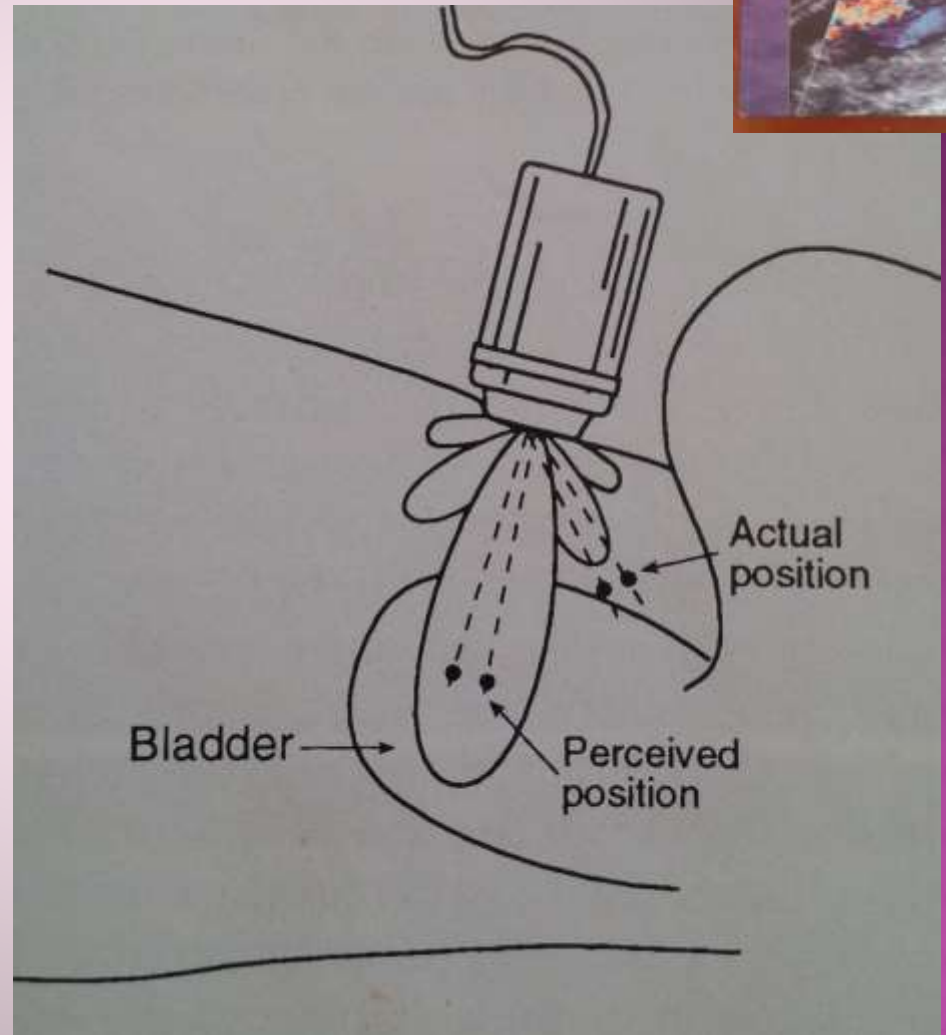
MIRROR IMAGE



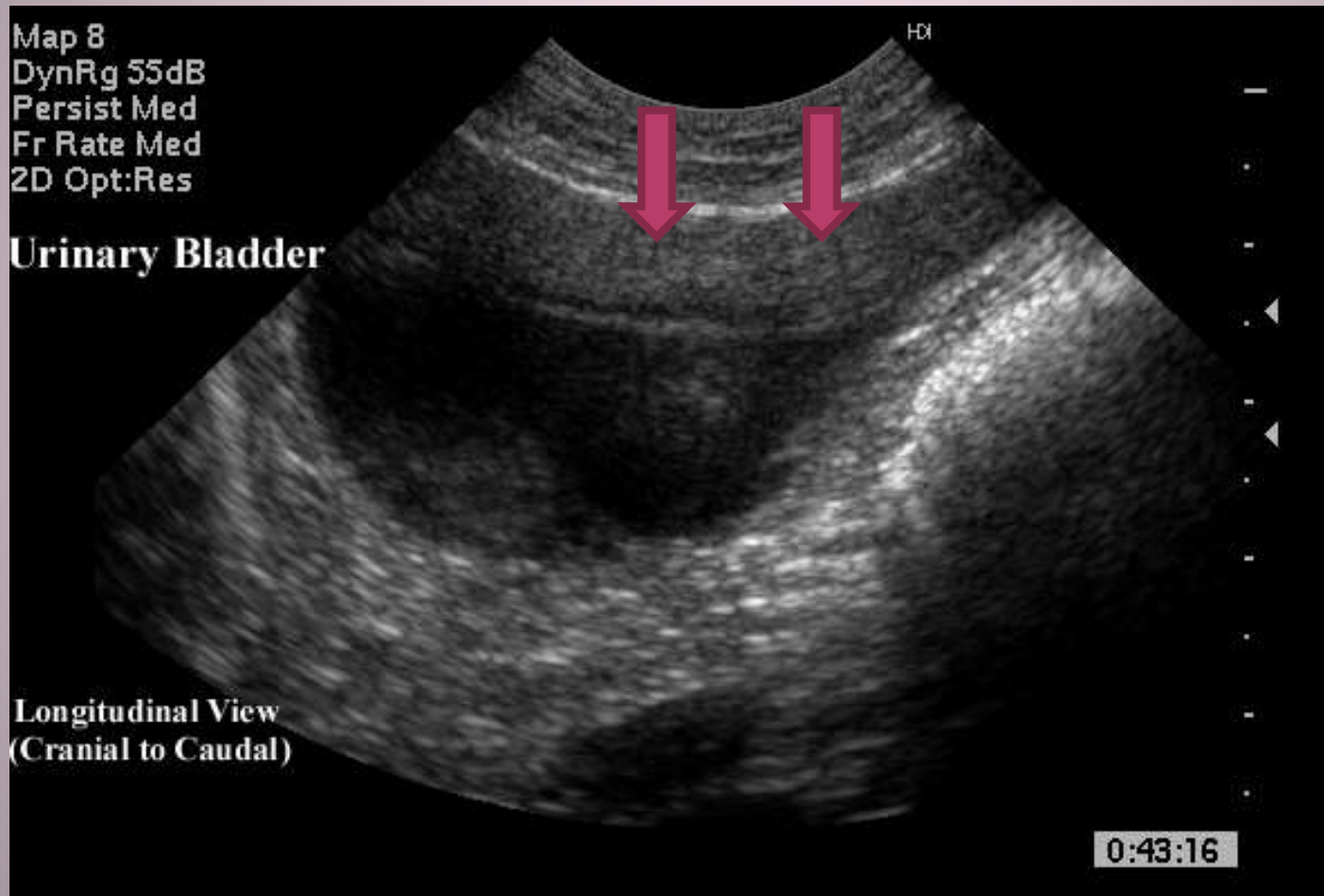
ARTIFACTS: NOT HELPFUL

○ Side lobe artifact

- Intense echoes from lateral lobes are mismatched as being within main lobe
 - Occurs with high reflective interfaces lateral to anechoic object in main beam
- Correct by lower gain, lower frequency, change orientation or deeper focus



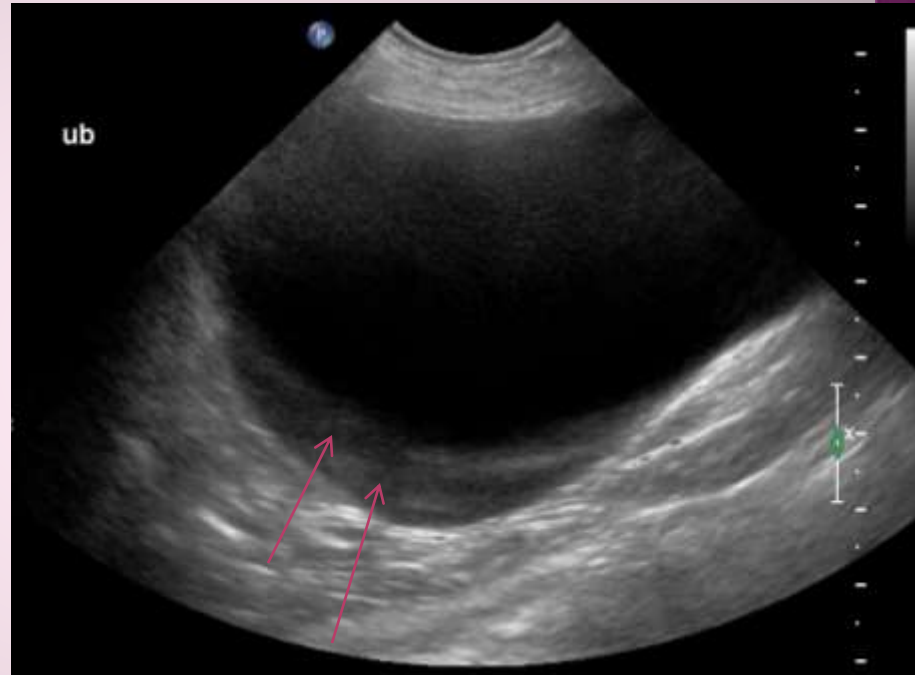
SIDE LOBE ARTIFACT



ARTIFACTS: NOT HELPFUL

○ Slice thickness

- High reflective structure within “slice” along with anechoic structure
- “pseudo-sludge” in UB/GB
 - Look for “curved” surface of sludge
- Change position of probe, reposition animal



ARTIFACTS: NOT HELPFUL

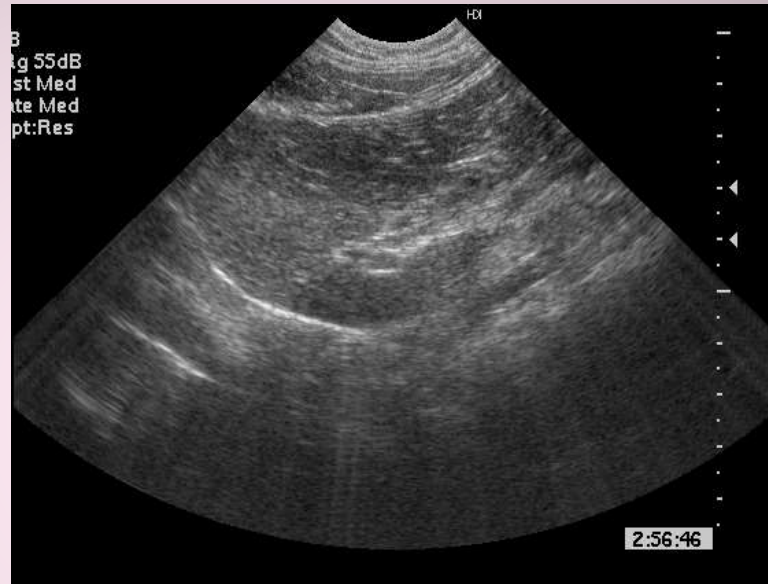


○ Edge Shadowing

- At edge of curved structures
- Cystic structures or structures of different acoustic impedance
- Refraction- sound redirected and not returned to probe
 - “Loss” of thin wall structure mimic rupture bladder
- Change angle of insonation?

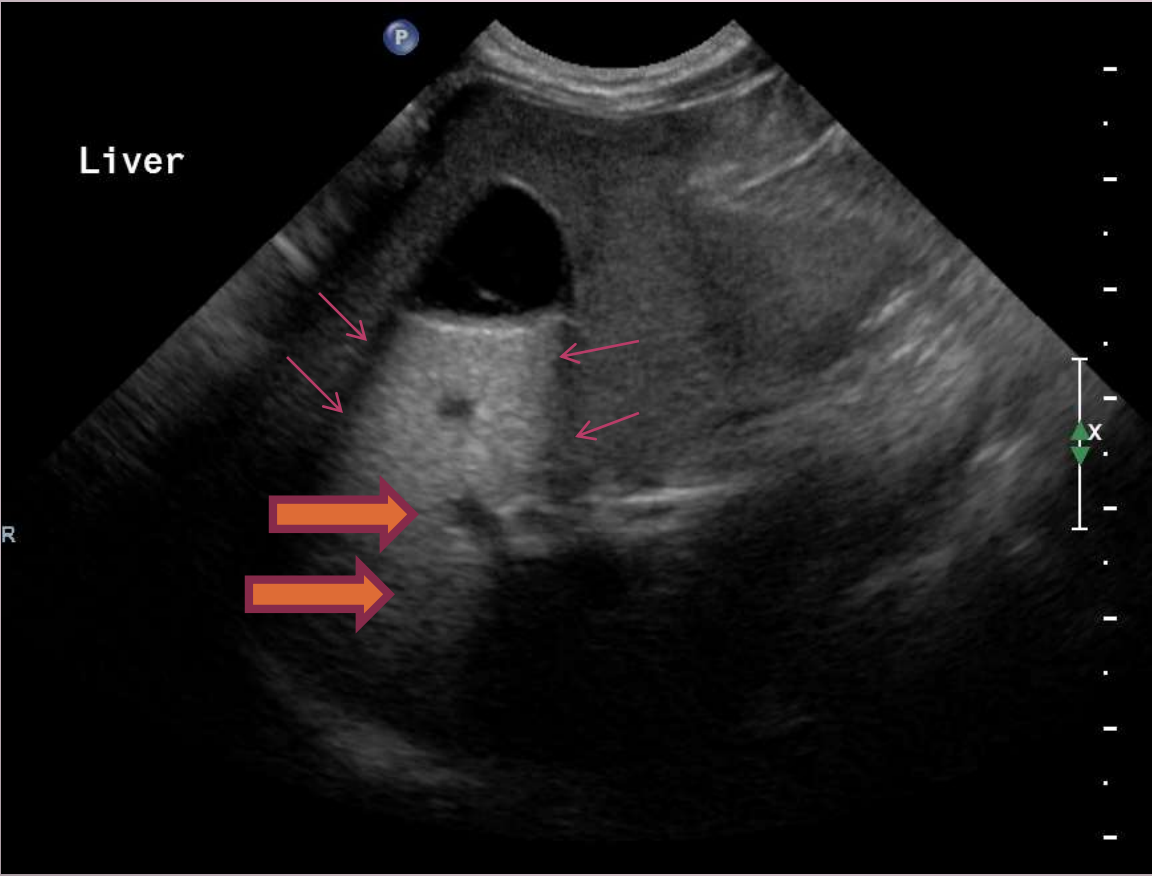
ARTIFACTS: NOT HELPFUL

- Electrical interference
 - Clippers, radiowaves, centrifuge, fluorescent lights, other equipment



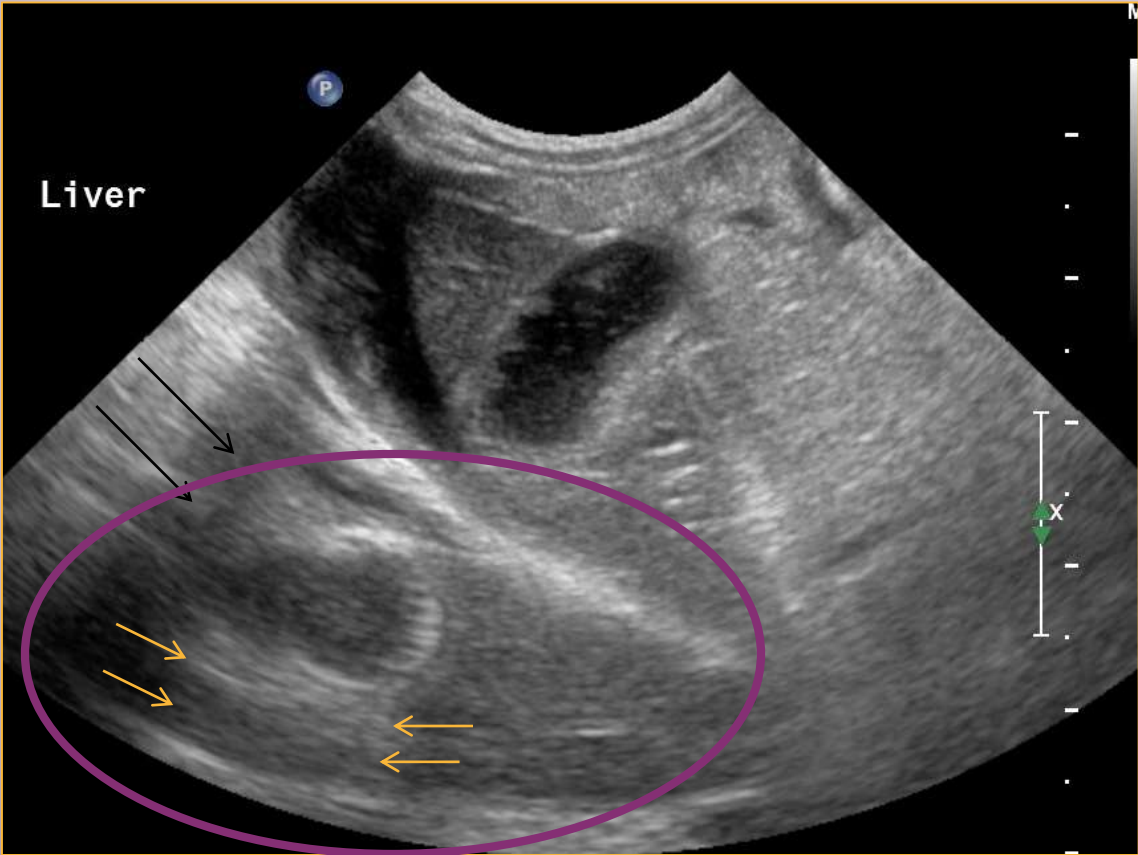
ARTIFACTS: QUIZ

CAN YOU NAME TWO?



ARTIFACTS: QUIZ

CAN YOU NAME THREE?



ULTRASOUND TECHNIQUES

○ Patient prep

- Fasting 12 hours
- Shaved, clean skin
- Gel or alcohol

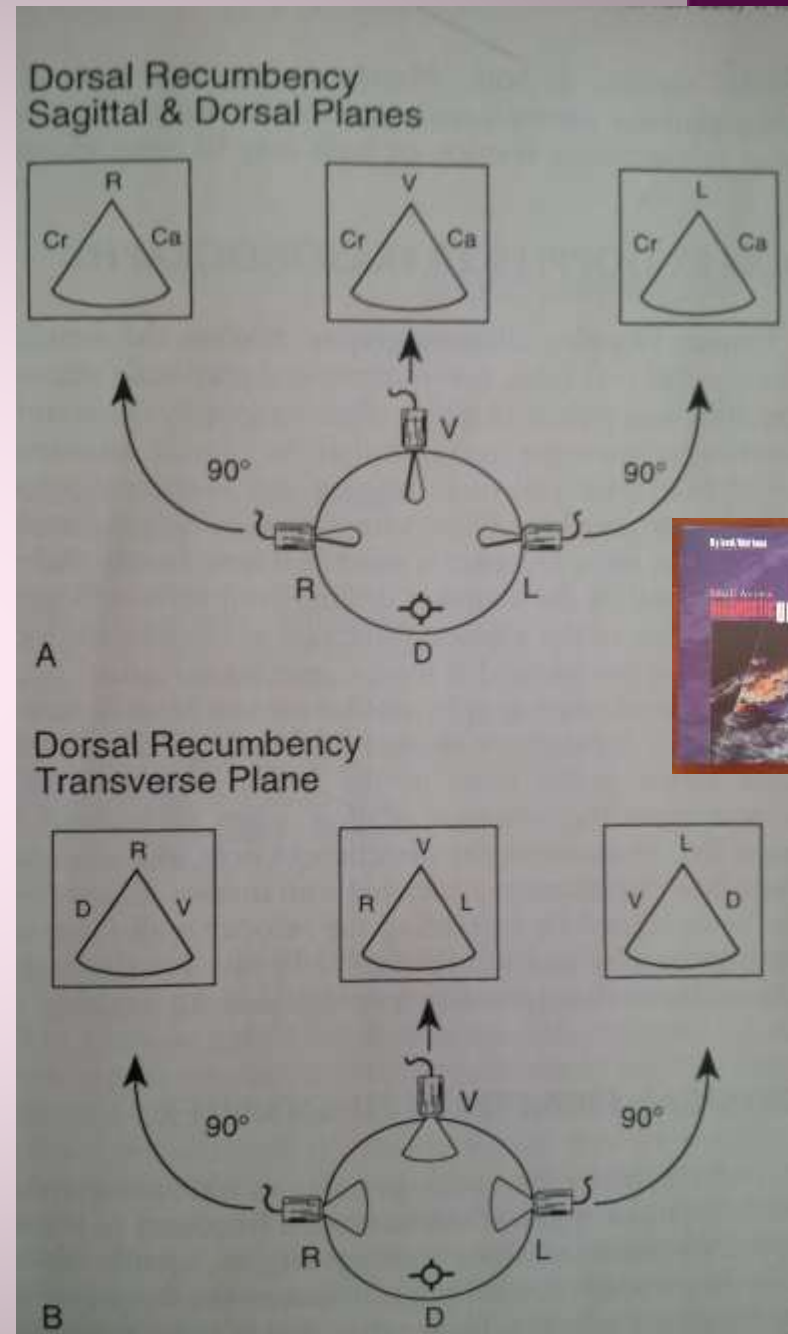
○ Patient position

- Dorsal recumbency
 - Use troughs
 - Sedation if needed
- Change positions
 - Left lateral: right liver/ kidney
 - Standing: bladder, GB



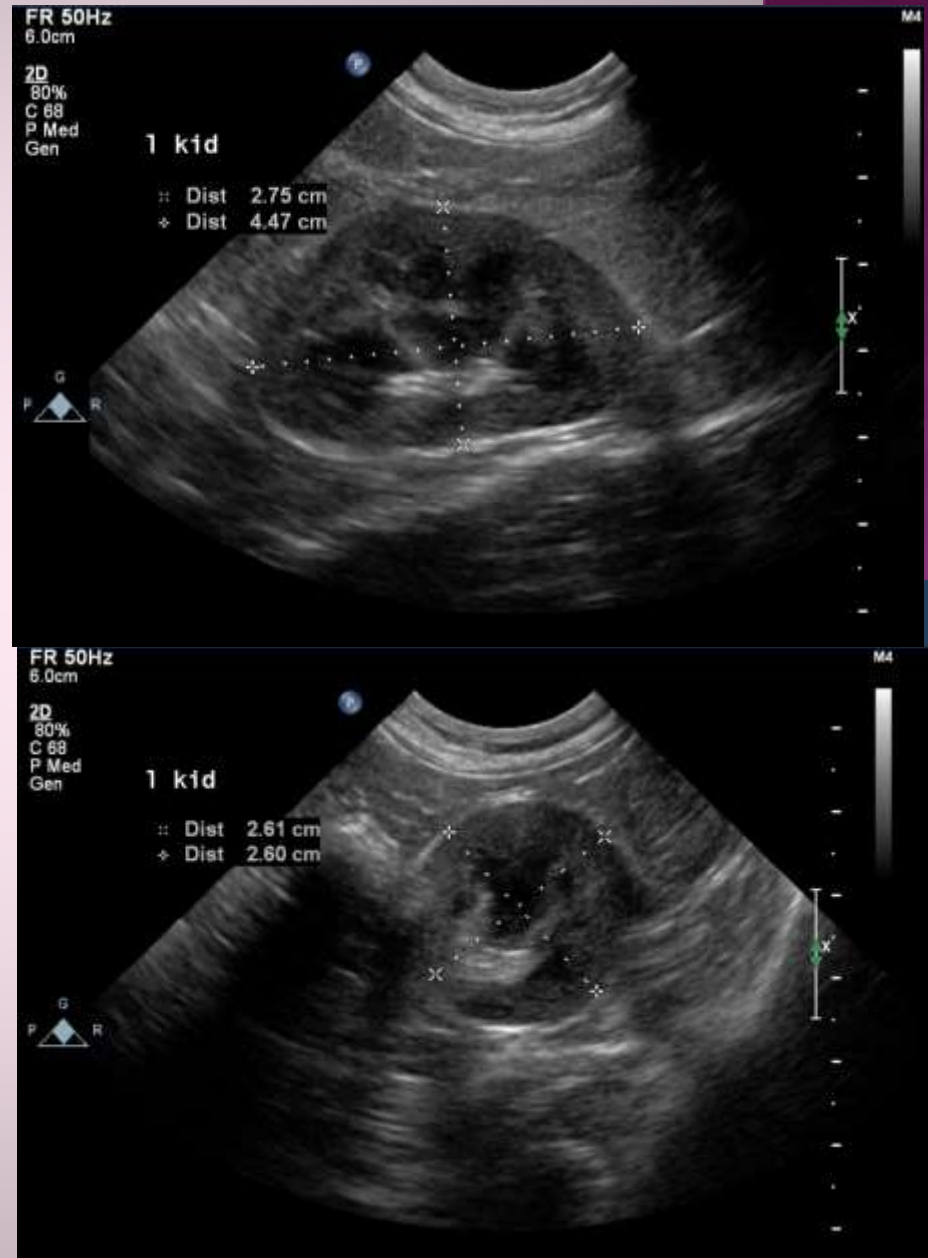
TECHNIQUES

- Standard orientation of images
 - Sagittal/ dorsal plane view: cranial patient to left of image
 - Transverse ventral view: right side of patient to left
 - Right intercostal view: dorsal to left
 - Left intercostal: ventral to left



TECHNIQUES

- Follow systematic approach
 - Organ to organ in clockwise fashion
 - Two Views!
 - At least two planes of imaging for each organ
- Label and ARCHIVE images!!!
 - Video best for external review



DESCRIPTIVE TERMINOLOGY: ECHOTEXTURE

○ Echogenicity

- Hypoechoic- darker
- Hyperechoic- brighter
- Anechoic- no echoes, black
- Normoechoic- expected
- Isoechoic- equal to
- Mixed

○ Texture

- Coarse or fine
- Patchy or mottled
- Nodular
- Complex (cavitary)



DESCRIPTIVE TERMINOLOGY: SONOGRAPHIC SIGNS

○ Echotexture

- See previous slide

○ Shape

- Asymmetric
- Irregular
- Round, flat, triangular

○ Margins

- Irregular vs smooth
- Bumpy
- Ill-defined

○ Size

- Enlarged, small
- MEASURE organ!

○ Location

- The left kidney is located more caudal than normal...
- In right cranial abdomen, there is...

○ Function

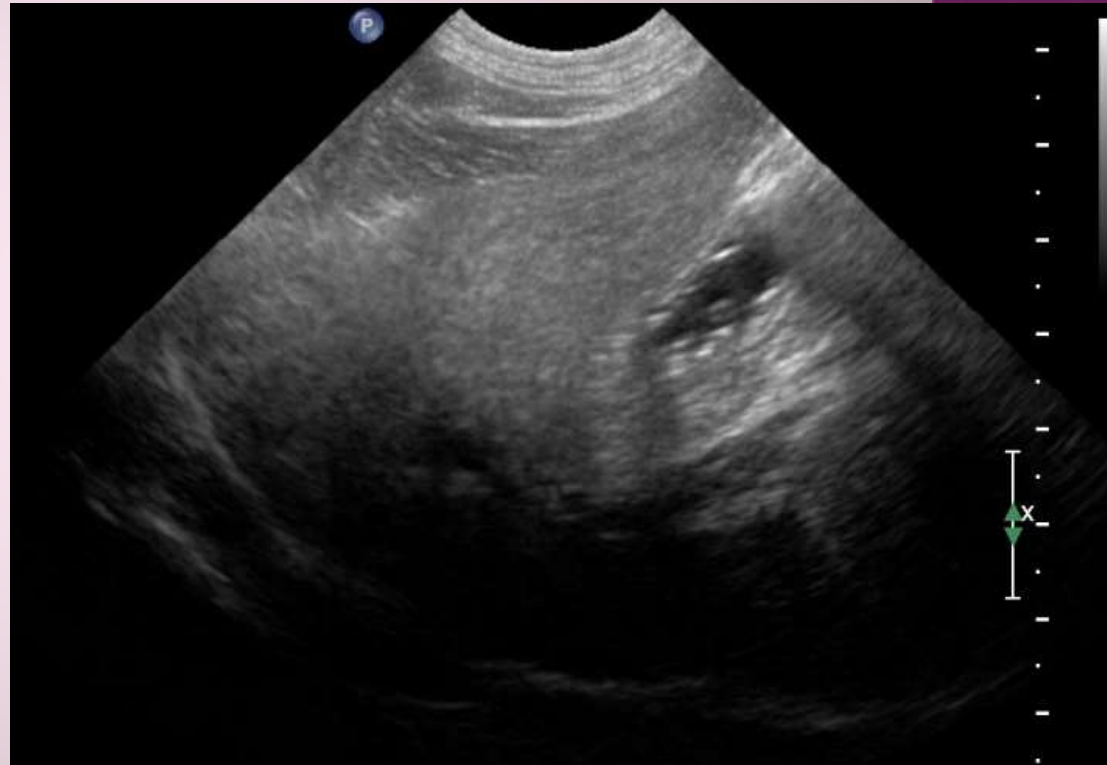
- Motility- hyper or hypo
- Urine “jets”
- hypovascular

○ Contrast enhancement

- Not commonly done in routine studies

PATTERN RECOGNITION

- Combinations of sonographic signs will help prioritize differential diagnoses list
 - ie: enlarged, hyperechoic liver w/ normal GB in anorexic jaundiced cat = lipidosis





BASIC ABDOMINAL ULTRASOUND PART II

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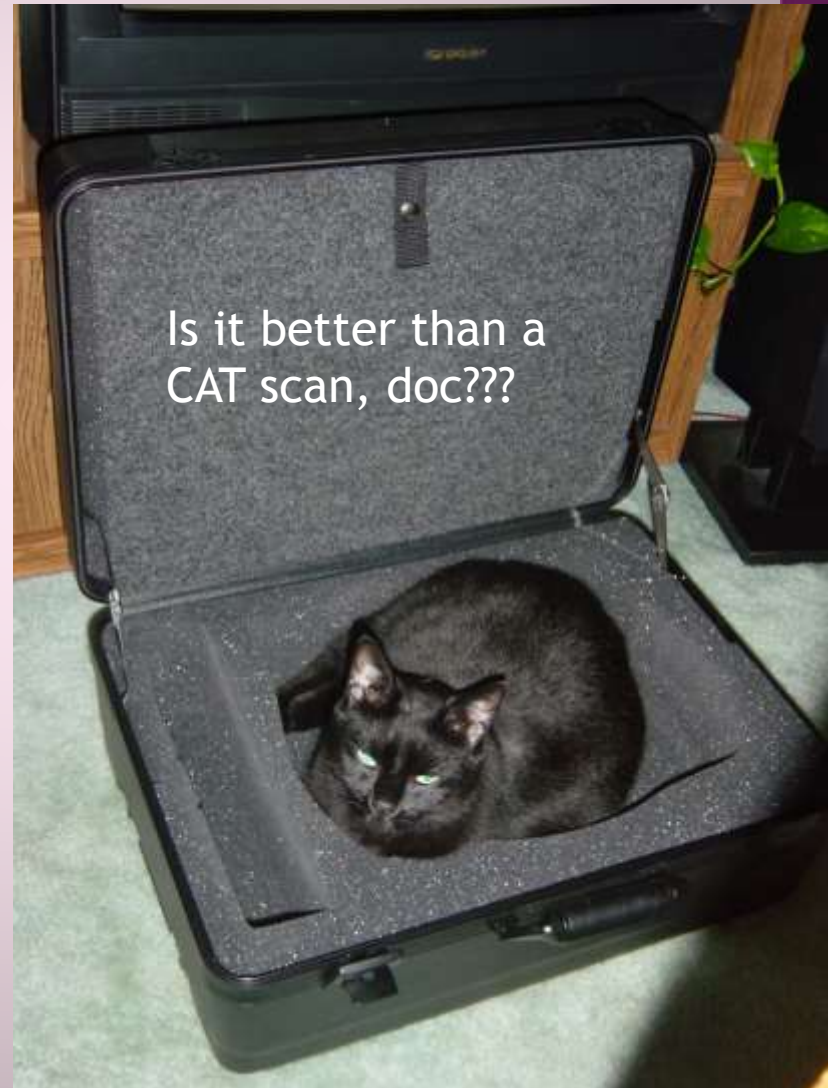
ABDOMINAL ULTRASOUND

○ Advantages

- Non- invasive
- Most often does NOT require anesthesia
- CAN see inside of organs
- CAN see thru abdominal fluid

○ Disadvantages

- Relative costly test
- Costly equipment
- Highly user dependent
- Takes time to perform
- CANT see thru air or barium

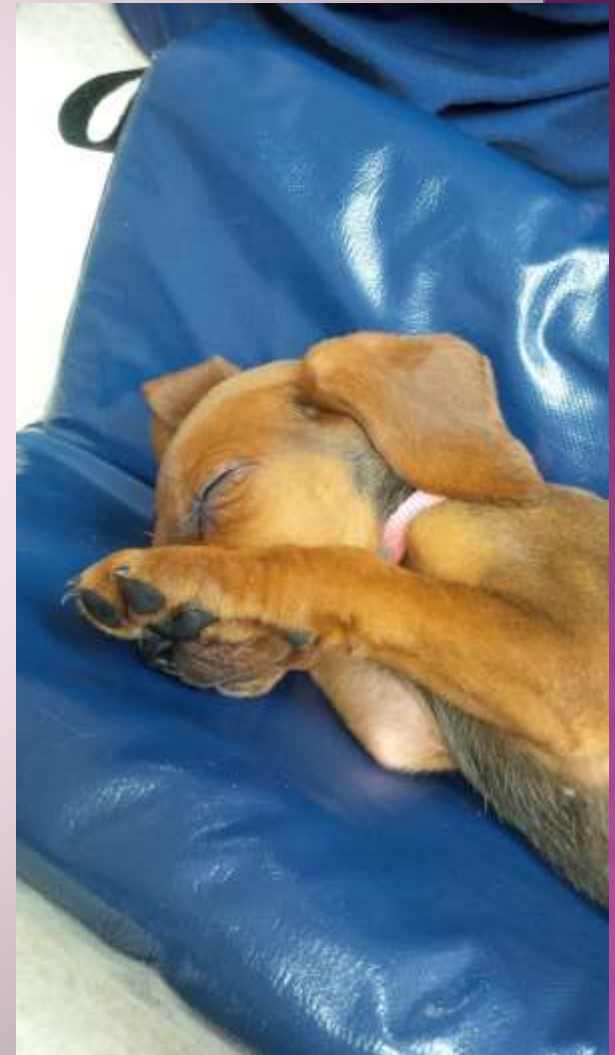


ABDOMINAL ULTRASOUND

- **Diagnostic test: know indications**
 - Abnormal organ function/ enzymes
 - Abdominal fluid or loss of detail on rads
 - Palpable mass/ mass on rads
 - Abdominal pain
 - Vomiting/ diarrhea
 - Hematuria/ stranguria, Cushings disease, cancer staging, hypercalcemia, IMHA, VPCs/ arrhythmia, anal sac tumor, GI foreign body, etc
 - Guide cystocentesis, aspirate/ biopsy, injections

ABDOMINAL ULTRASOUND:

- Systematic approach
 - Same for every scan
 - Know anatomy!
 - PRACTICE
- Learn NORMALS
 - Variants-age, breed, sex, fat vs thin
 - Species differences
- Recognize abnormal
 - Changes in sonographic signs



ABDOMINAL ULTRASOUND: ORGAN RELATIVE ECHOGENICITY

Table 1-5. Order of Increasing Echogenicity of Body Tissues and Substances

Bile, urine
Renal medulla
Muscle
Renal cortex
Liver
Storage fat
Spleen
Prostate
Renal sinus
Structural fat, vessel walls
Bone, gas, organ boundaries



○ SiLK

- Spleen > liver > kidney cortex

○ New normals?

- Cats: renal cortex hyper to liver
- Dogs: renal cortex iso to liver

○ Liver always hypo to spleen

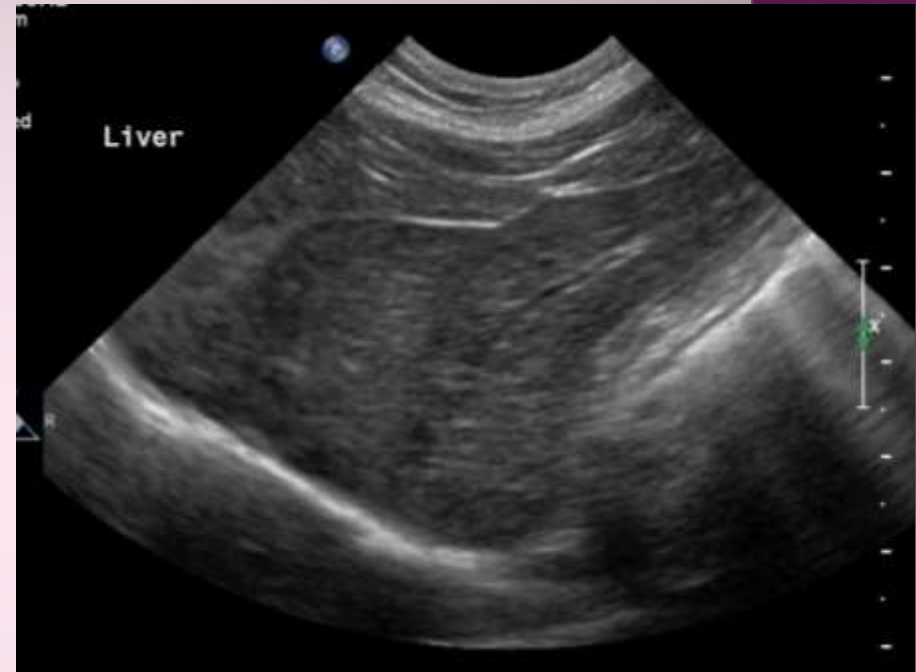
○ Lymph nodes = spleen

ABDOMINAL ULTRASOUND: MY SYSTEMATIC APPROACH

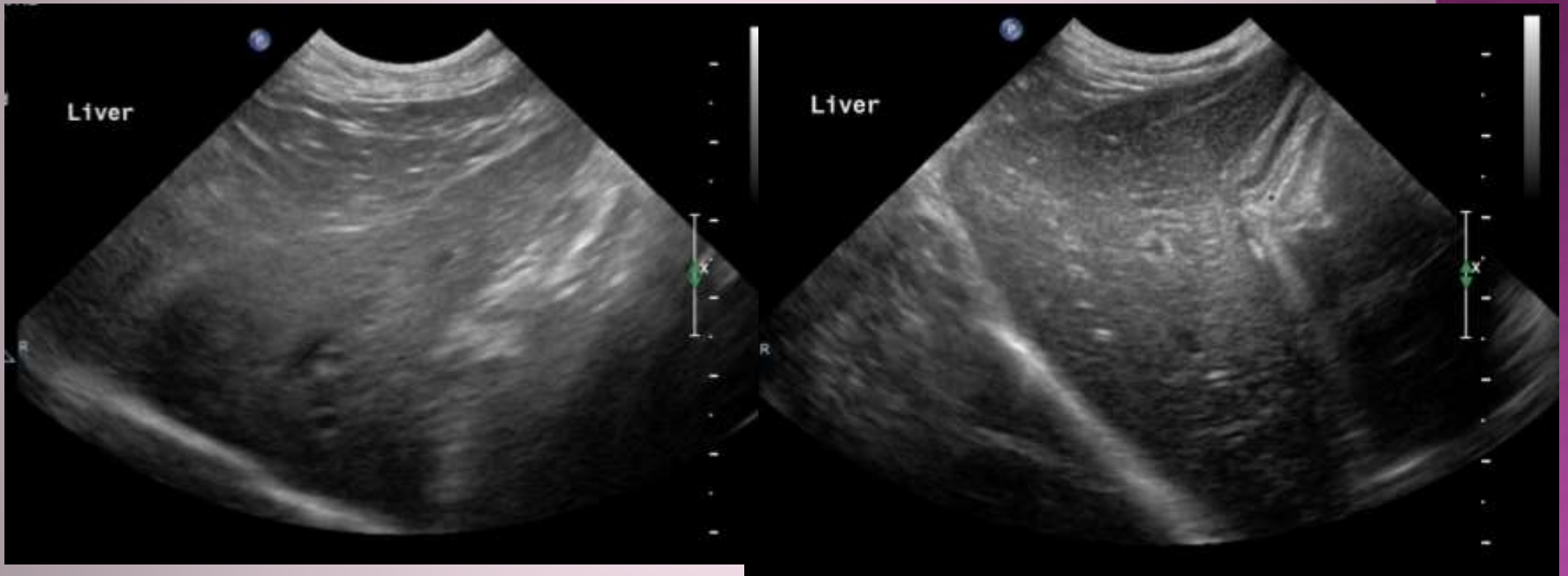
- Liver
- Gallbladder
- Stomach
- Pancreas- left limb
- Spleen
- Left kidney
- Left adrenal gland
- Urinary bladder
- Urethra/ prostate
- Medial iliac nodes
- Intestine
- Mesenteric nodes
- Right kidney
- Right adrenal gland
- Right dorsal liver
- Porta hepatis
- Duodenum/ papilla
- Pancreas- right limb

NORMAL LIVER

- Largest abd organ
 - Lobation: differentiate lobes with fluid
 - intercostal views for caudate lobe, deep chest, small liver or porta hepatis
 - Vessels- PV wall hyper to HV, HA not seen w/o doppler
- Size: subjective
 - Left liver to caudal edge of stomach
 - Tapered, sharp tips
- Echotexture
 - Medium echo- hypo to spleen, iso to falciform
 - Coarse, uniform parenchyma



NORMAL LIVER



Normal cat

Normal dog

NORMAL LIVER

- Right dorsal intercostal view
 - Caudate lobe
 - Porta hepatis- CVC, PV, Ao
 - Hepatic nodes

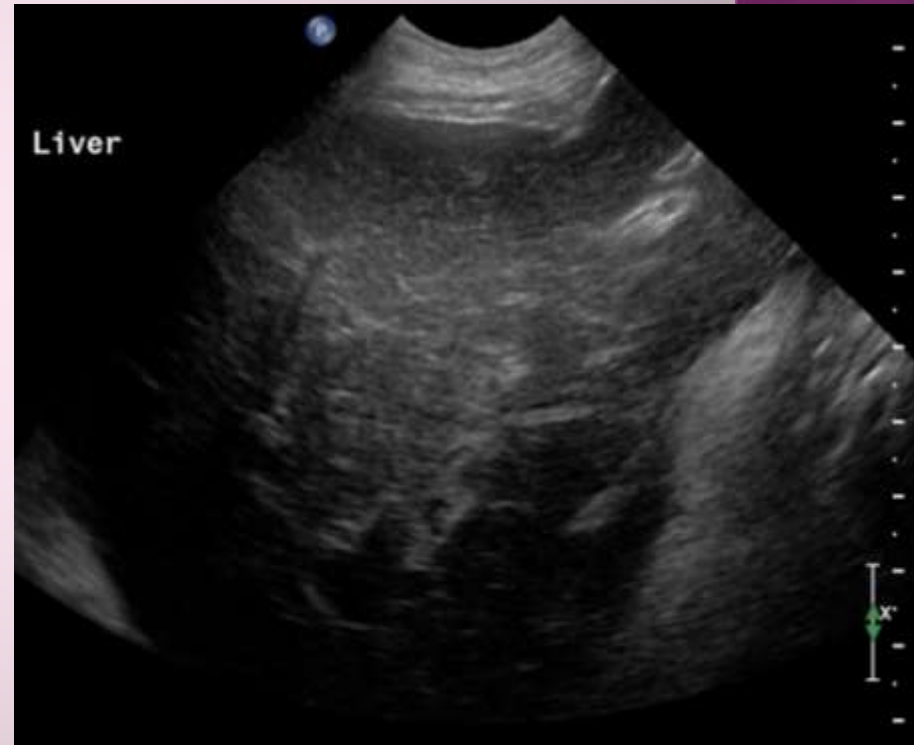


NORMAL GALLBLADDER: CAT BILOBED SHAPE



DIFFUSE HEPATIC DISEASE: PATTERNS OF ABNORMAL

- Enlarged, Hypoechoic
- DDX:
 - Infection (bacterial, viral)
 - Inflammation (immune mediated hepatitis, systemic inflammation)
 - Amyloidosis
 - Infiltrative neoplasia (lymphoma, mast cell)
 - “reactive” processes (EMH, congestion, drugs/toxin)



DIFFUSE HEPATIC DISEASE: PATTERNS OF ABNORMAL

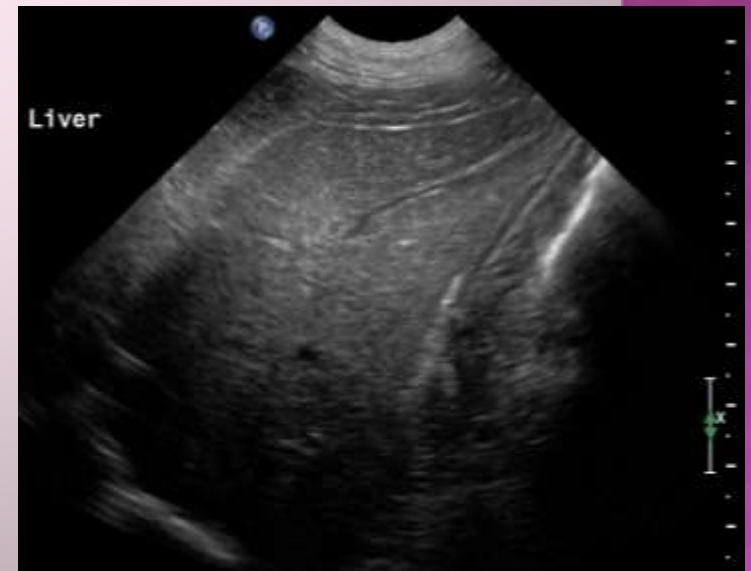
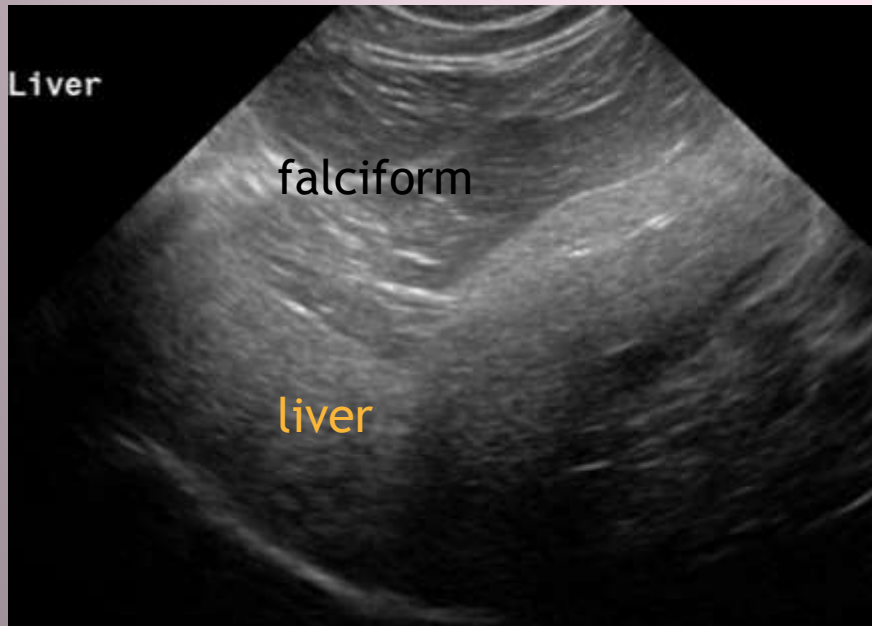
○ Enlarged, Hyperechoic

■ DDX CAT

- Hepatic lipidosis
- Endocrinopathy (diabetes)
- Lymphoma, mast cell (rarely)

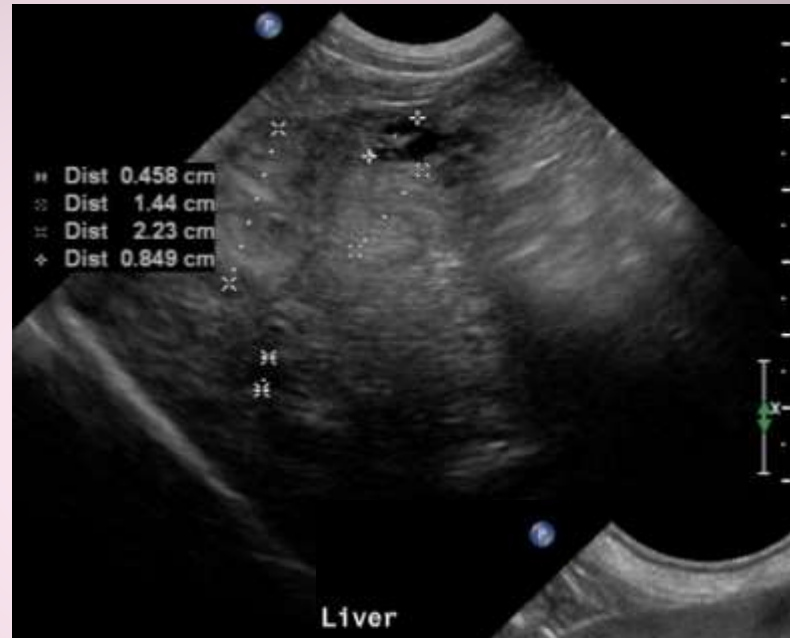
■ DDX DOG

- Vacuolar hepatopathy-
endocrine or primary
- Medication- corticosteroids
- Chronic inflammation
w/fibrosis
- Copper?



DIFFUSE HEPATIC DISEASE: PATTERNS OF ABNORMAL

- Enlarged, Nodular
 - Benign- vacuolar hepatopathy with hyperplastic nodules
 - Neoplasia- lymphoma, histiocytic sarcoma, metastatic neoplasia
 - Fungal disease
 - Hepatocutaneous syndrome



DIFFUSE HEPATIC DISEASE: PATTERNS OF ABNORMAL

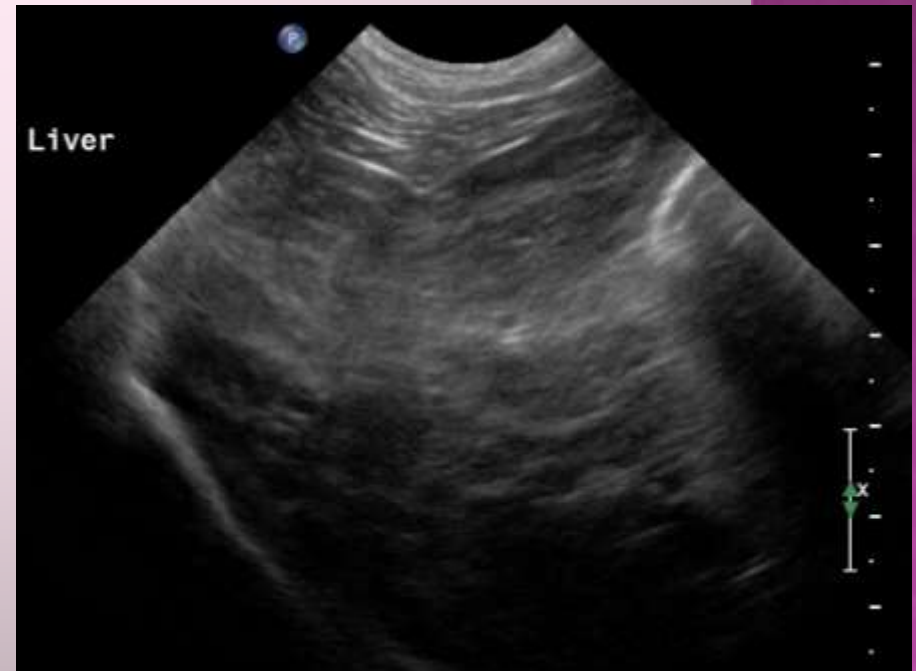
○ Small, irregular, nodular

- Cirrhosis w/ nodular regeneration
 - Often ascites
 - Portal hypertension



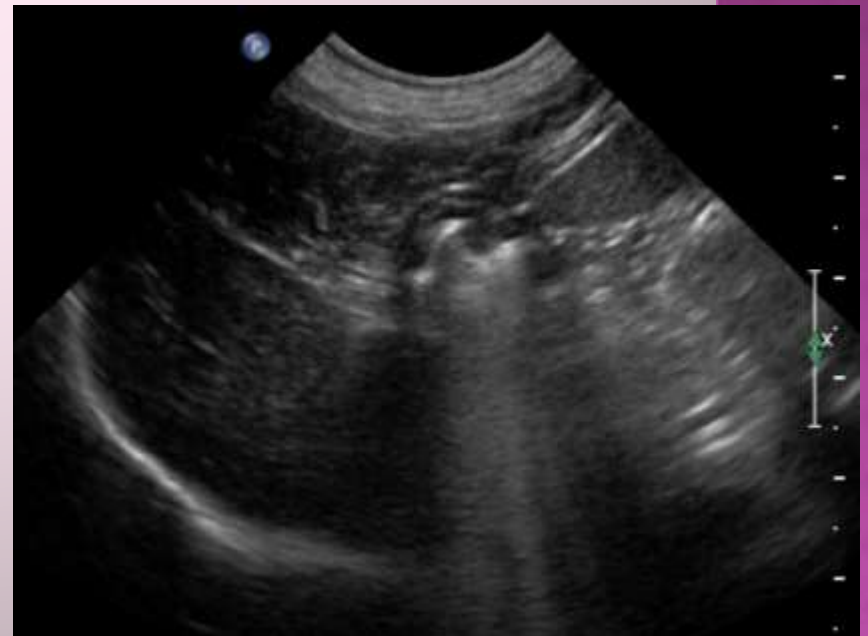
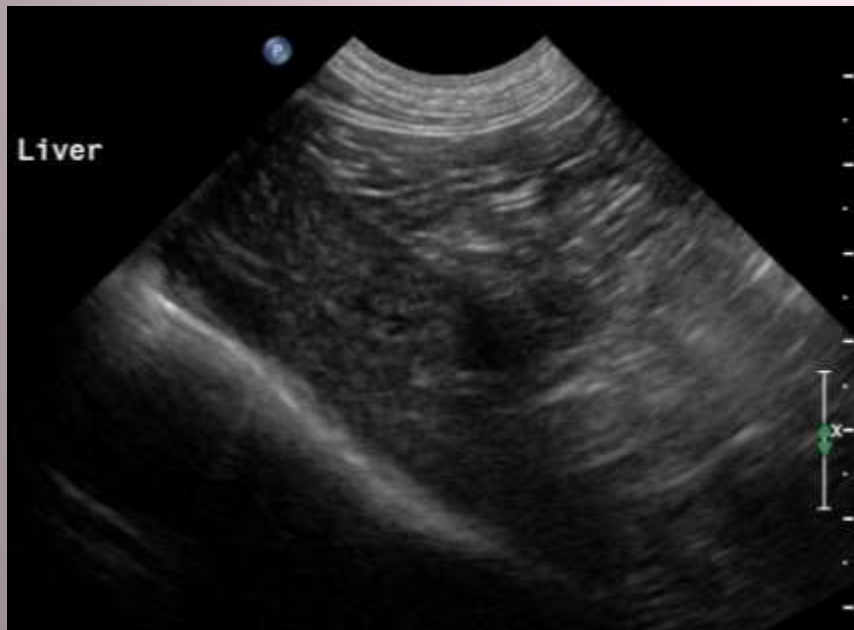
○ Normal size, nodular

- Benign hyperplasia
- Active hepatitis with nodular regeneration



DIFFUSE HEPATIC DISEASE: PATTERNS OF ABNORMAL

- Small liver, normal architecture
 - NORMAL variant-dog
 - Microvascular dysplasia
 - Atrophy from chronic low-grade disease
 - Portosystemic shunt



HEPATIC DISEASE: FOCAL

○ Mass

- Neoplasm- primary (carcinoma, HSA, lymphoma)
- Abscess/ granuloma
- Hematoma
- Cysts-hereditary?

○ Area of altered echotexture

- Hypoechoic- infarct, necrosis, inflammation
- Hyperechoic- poorly defined neoplasm, fibrosis



NORMAL GALLBLADDER

- Thin wall
 - 1-2 mm
- Anechoic bile
 - Some sludge normal esp fasting dogs
- Size- subjective
 - Contracts w/ meal
 - Appears to take up 1/3 to 1/2 of right liver
 - Cat 2.5 to 4 cm
 - Dog 3-6 cm
- Shape- tear drop
 - Cystic duct-tapered end



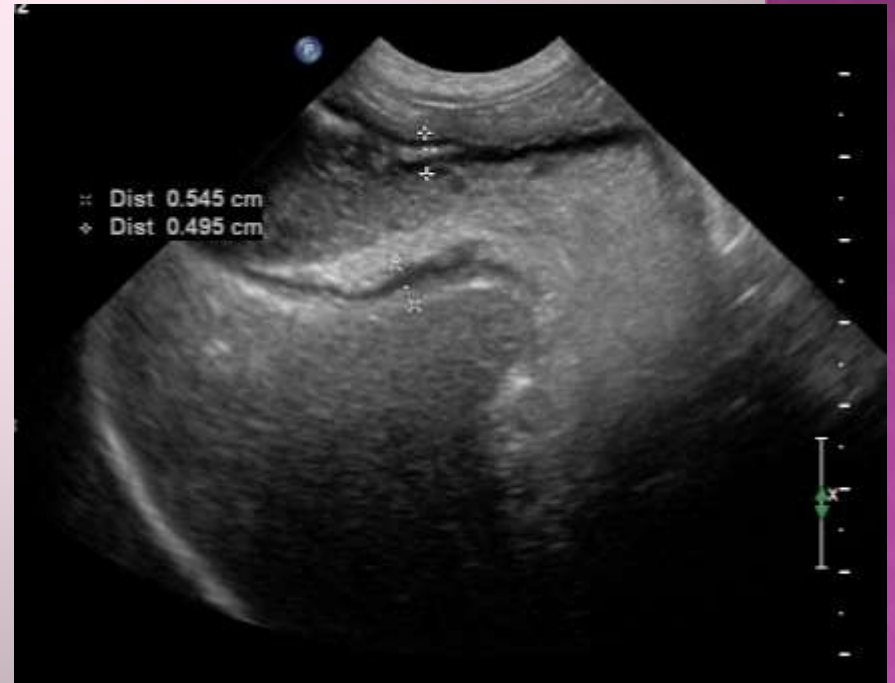
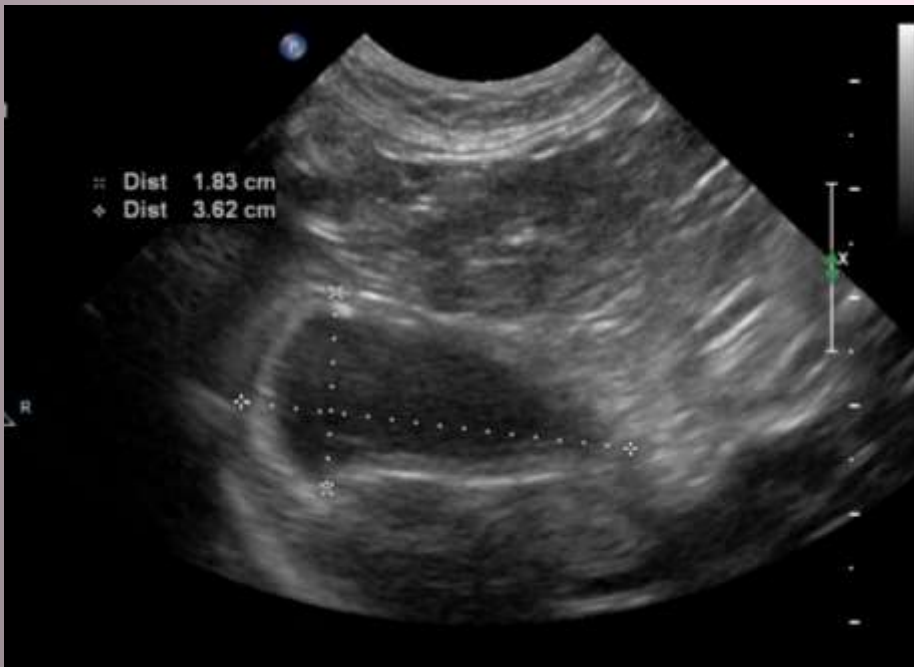
GALLBLADDER DISEASE: CHOLECYSTITIS

○ CAT

- Bacterial
- Immune mediated
- Viral- FIP?

○ DOG

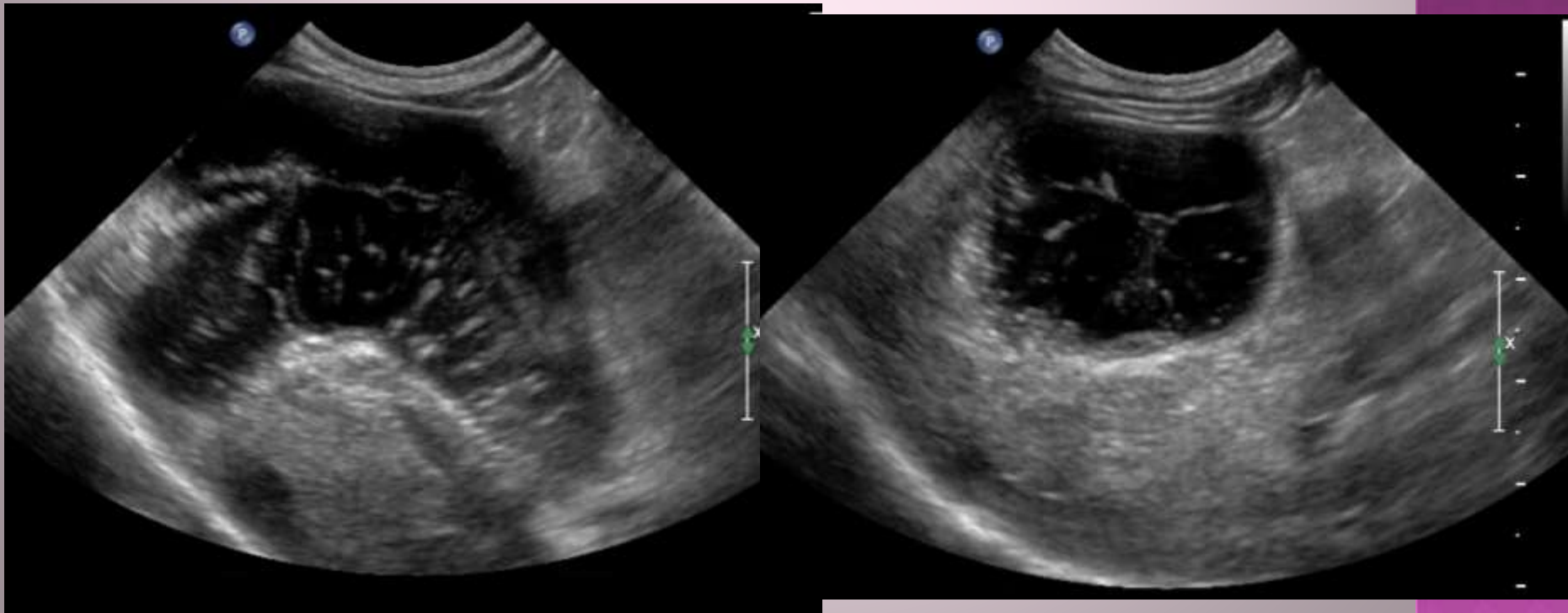
- Bacterial
- Immune mediated?



GALLBLADDER DISEASE: MUCOCOELE

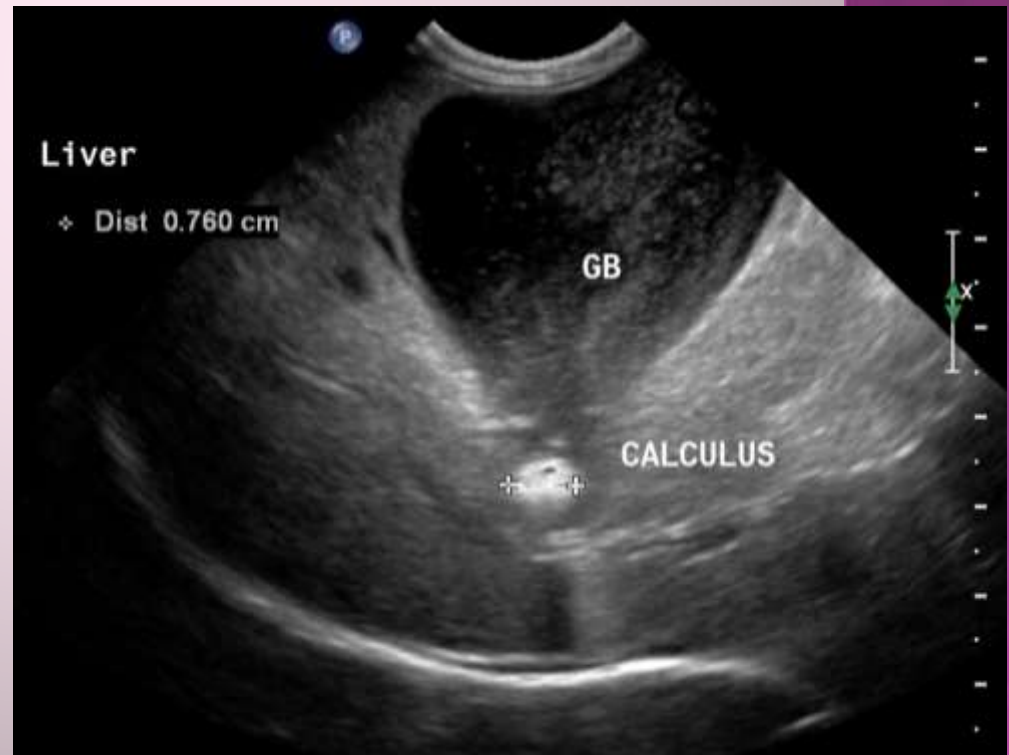
○ Mucocoele

- Most often associated with endocrine disease
 - Hypo- to anechoic, hyper strands/ striations, ENLARGED, “Stellate”, “kiwi”



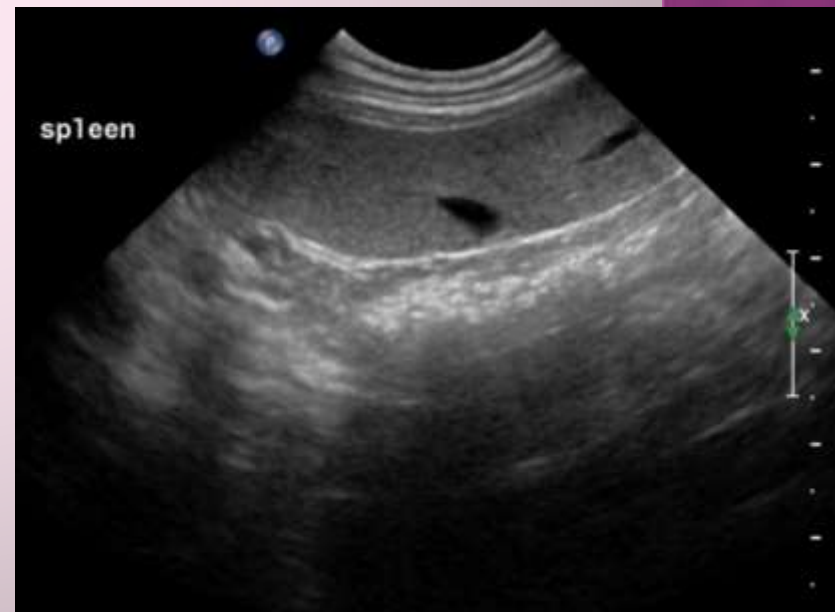
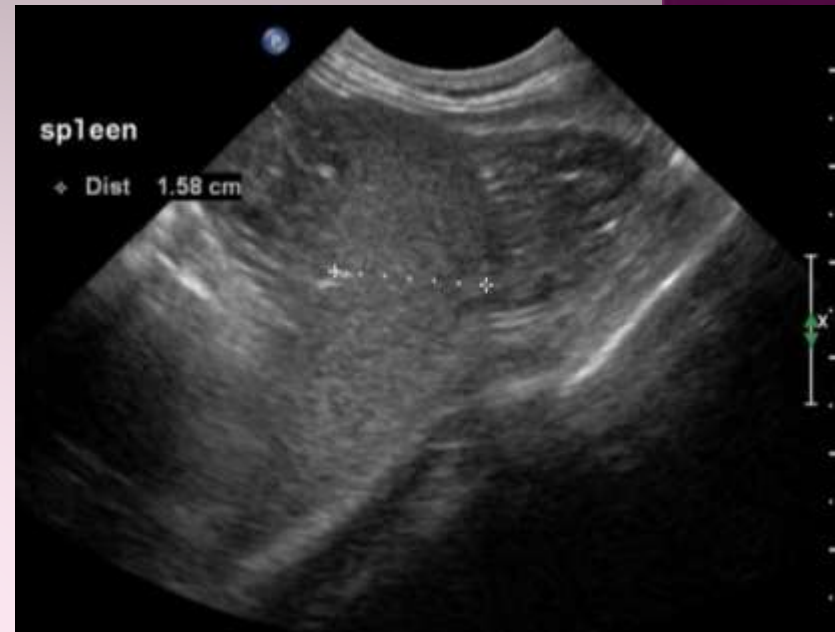
GALLBLADDER DISEASE: GALLSTONES

- Cholesterol/ bile salts
 - Associated with endocrine disease
 - Obstructive
 - - GB enlarged
 - - stone doesn't move
 - Non-obstructive
 - Gravity dependent
 - "sand"



NORMAL SPLEEN

- Head, body, tail
 - Head: transverse left intercostal view
 - Tail movable
- Echotexture
 - hyperechoic
 - Finely granular
 - Splenic v > a, anechoic
- Size: variable
 - Cat <1 cm thick at hilus
 - Dog 1-2.5 cm thick



NORMAL SPLEEN: CAT



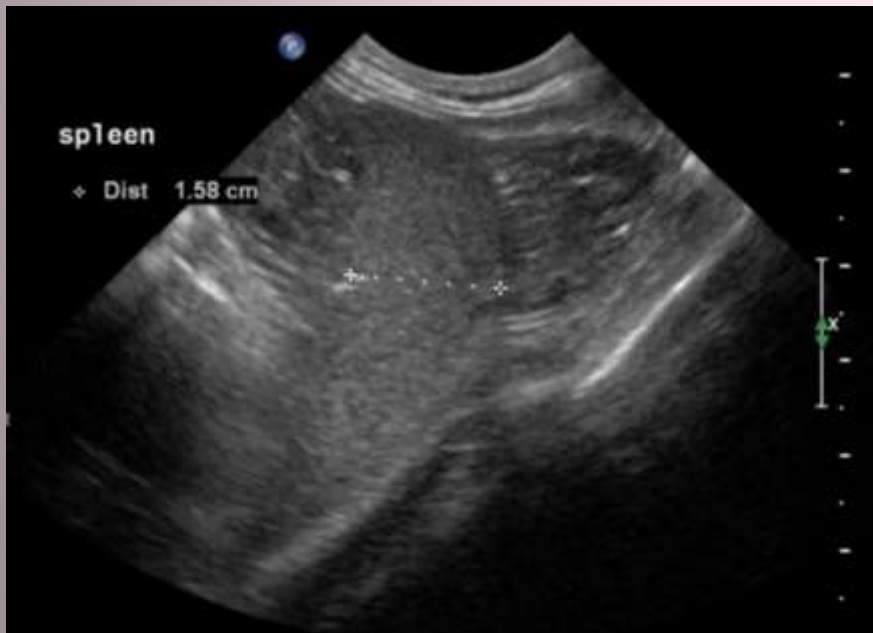
ABNORMAL SPLEEN: DIFFUSE DISEASES

○ Enlarged, normoechoic

- Drugs (ace, barbiturates)
- EMH
- Infiltrative neoplasia
- Normal?

○ Enlarged, hypoechoic

- Infiltrative neoplasia
- Splenitis
- Congestion/ Torsion- “lacey”

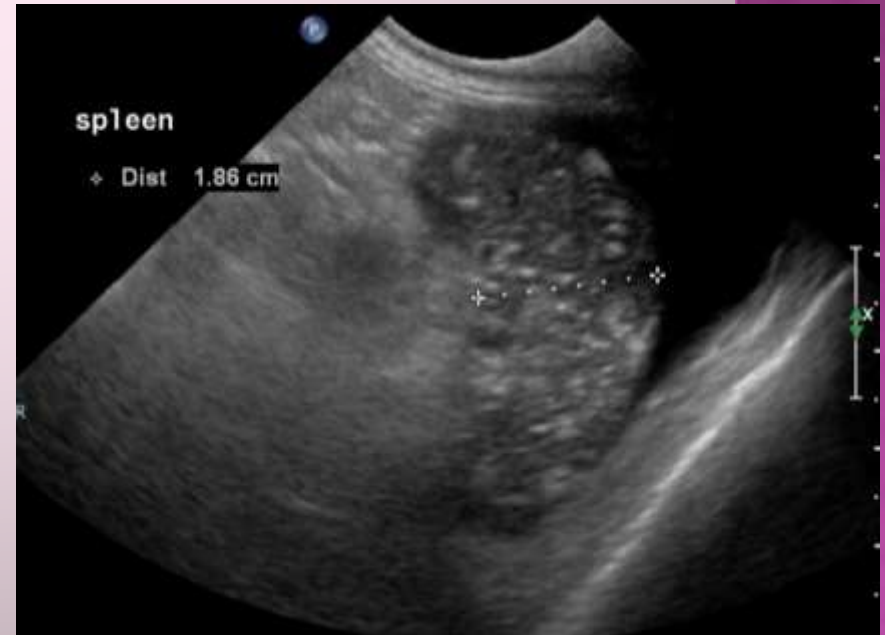
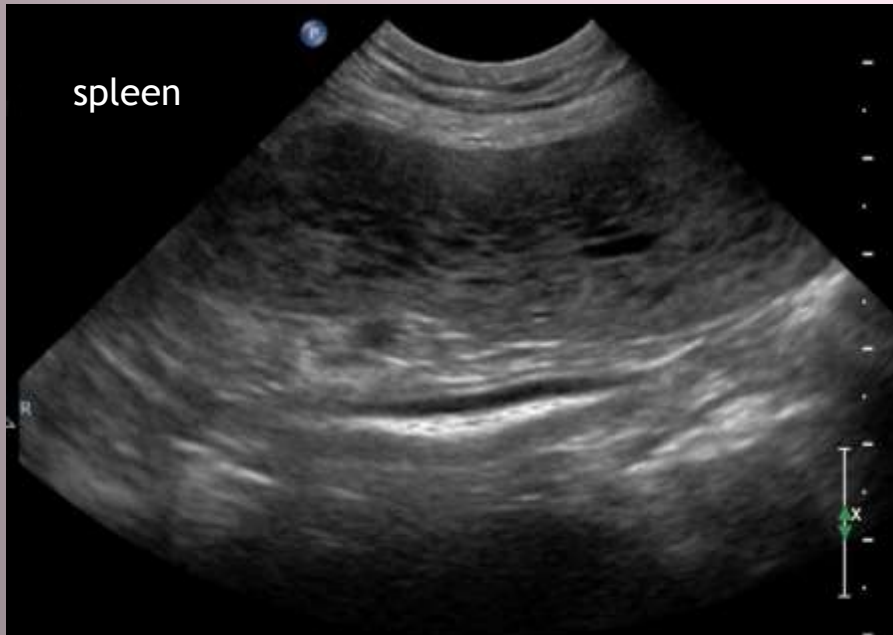


ABNORMAL SPLEEN: DIFFUSE DISEASES

○ Enlarged, multi-nodular

■ Neoplasia

- Round, hypoechoic nodules- histiocytic, lymphoma
- Miliary nodular- lymphoma, mast cell
- Abscess/ granulomas
- Round, often complex nodules



ABNORMAL SPLEEN: FOCAL DISEASE

○ Masses

- Hypoechoic- benign, round cell, HSA
- Hyperechoic- benign, round cell, leioSA, myelolipoma
- Mixed echoic- old hematoma, HSA round cell, leiomyo
- Complex/ cavitary-HSA, hematoma

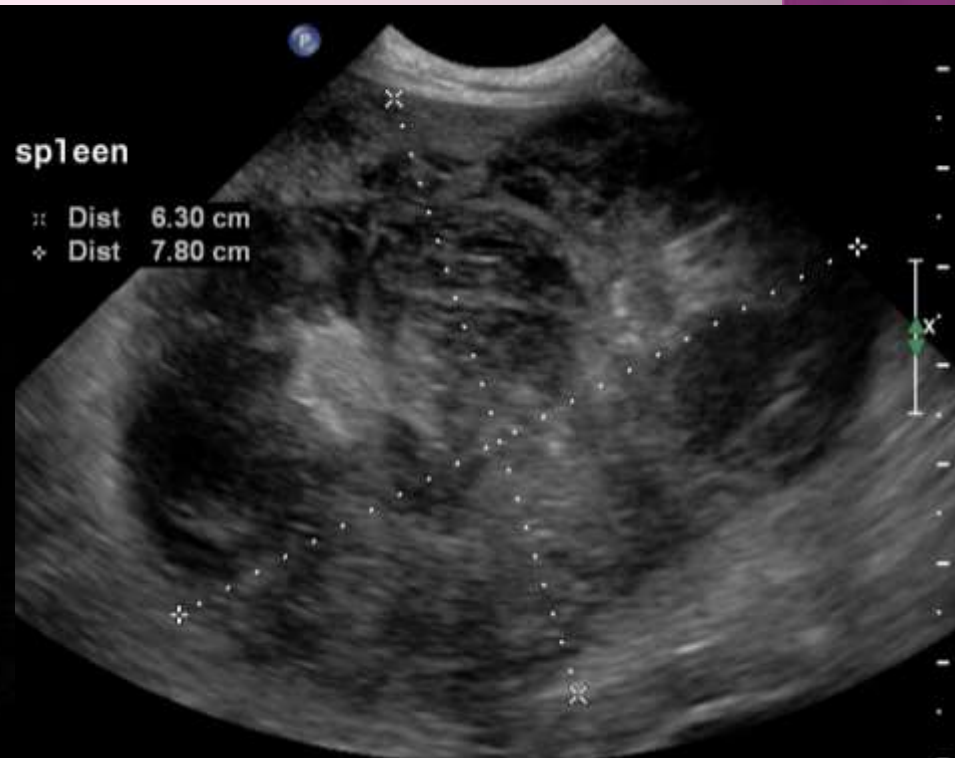
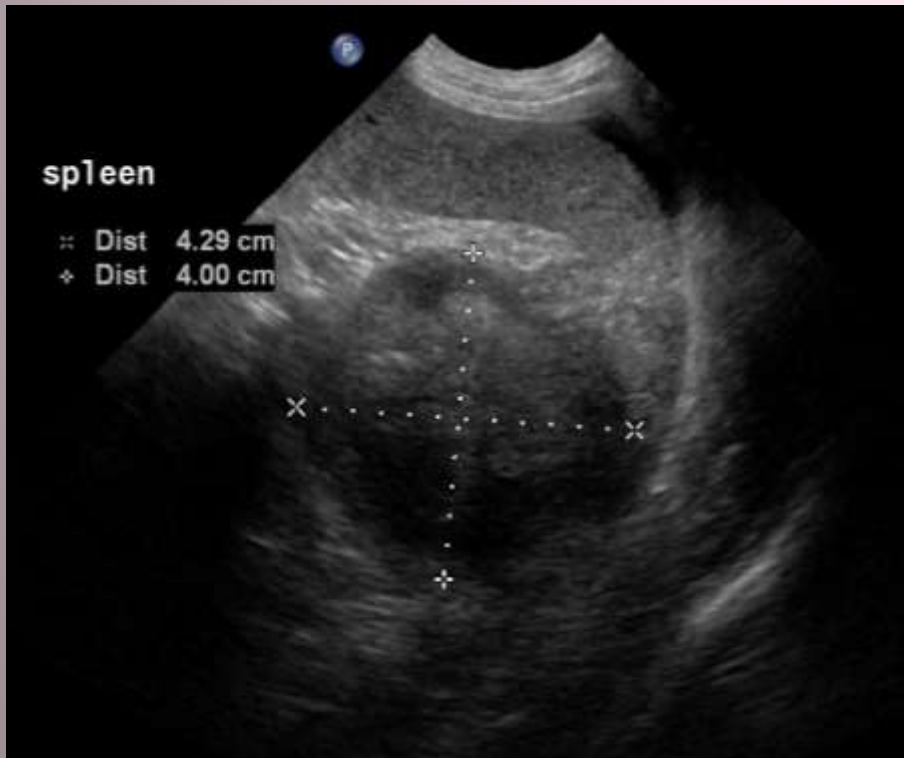
○ Area of abnormal echotecture

- Infarct
- Contusion
- Necrosis
- Neoplasia



ABNORMAL SPLEEN: MASSES

- Hemangiosarcoma-
 - Single or multiple
 - ANY APPEARANCE but often complex
 - free fluid
 - Metastatic disease



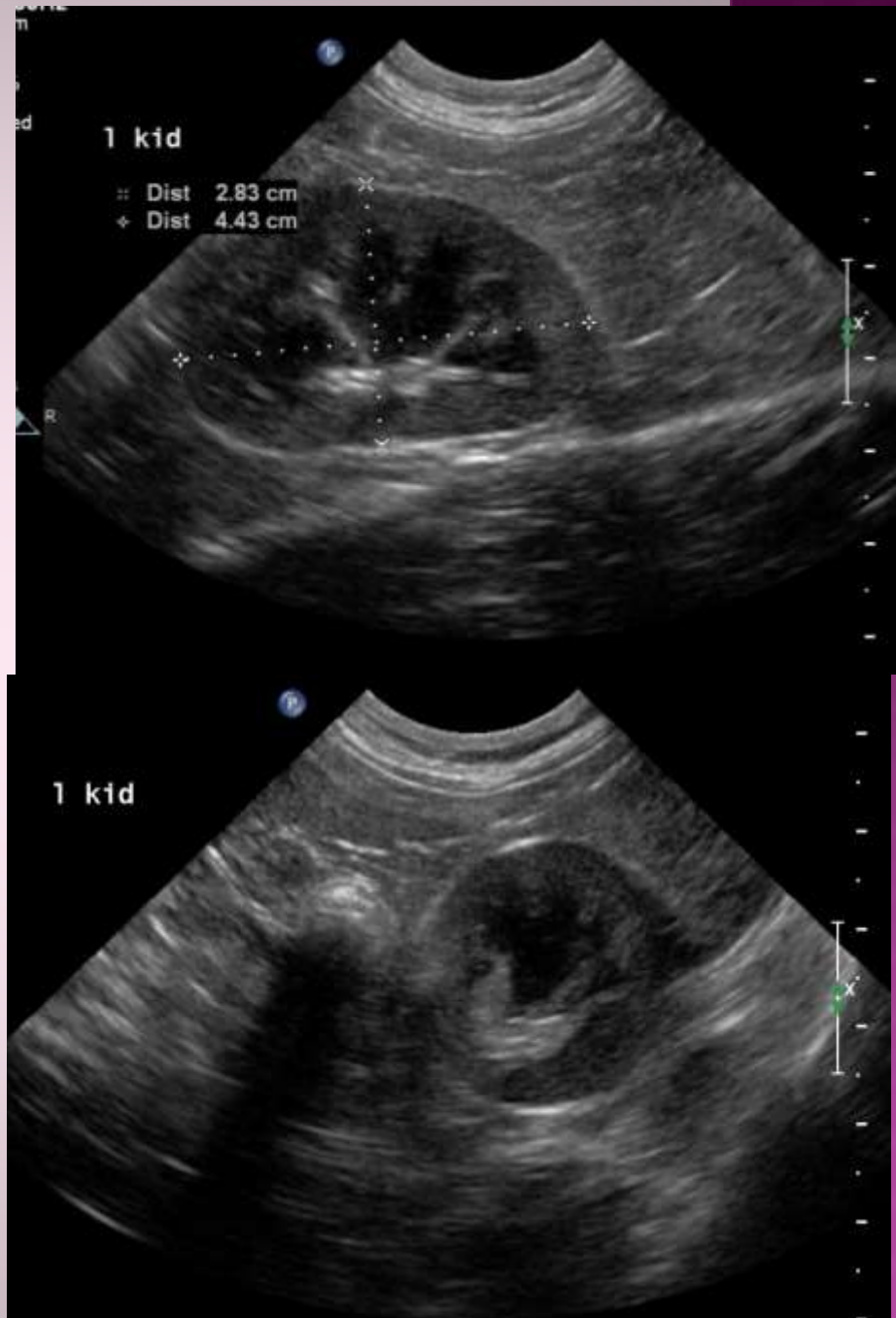
NORMAL KIDNEYS

○ Anatomy:

- Cortex, medulla, diverticulae, pyramids, pelvis, sinus
- Cortex hyper to Medulla
- Sharp definition between C/M
- Right kidney intercostal

○ Size

- Cats/small dogs 3.5-4.5 cm
- 50 lb = 5 cm, then 10 lbs per cm up to max about 9 cm
- If >10 cm, too big



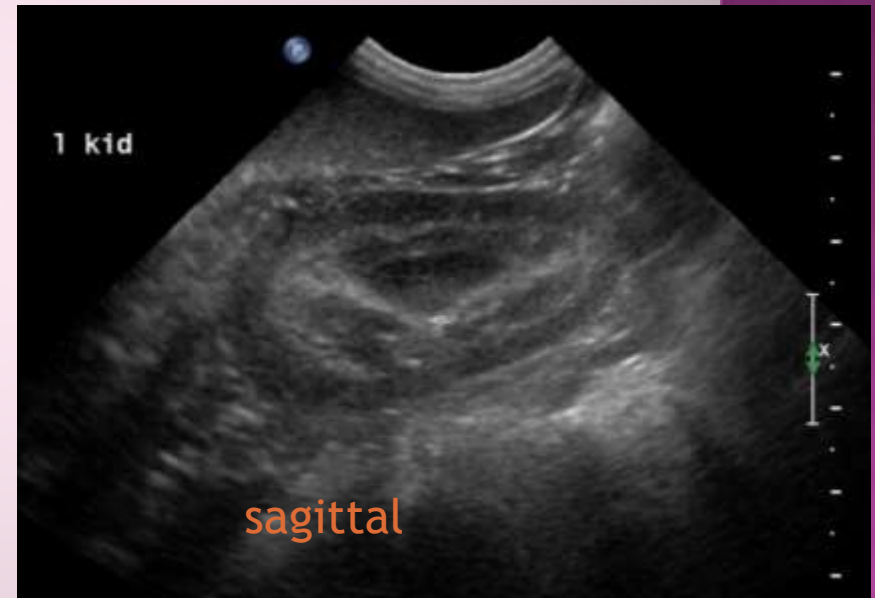
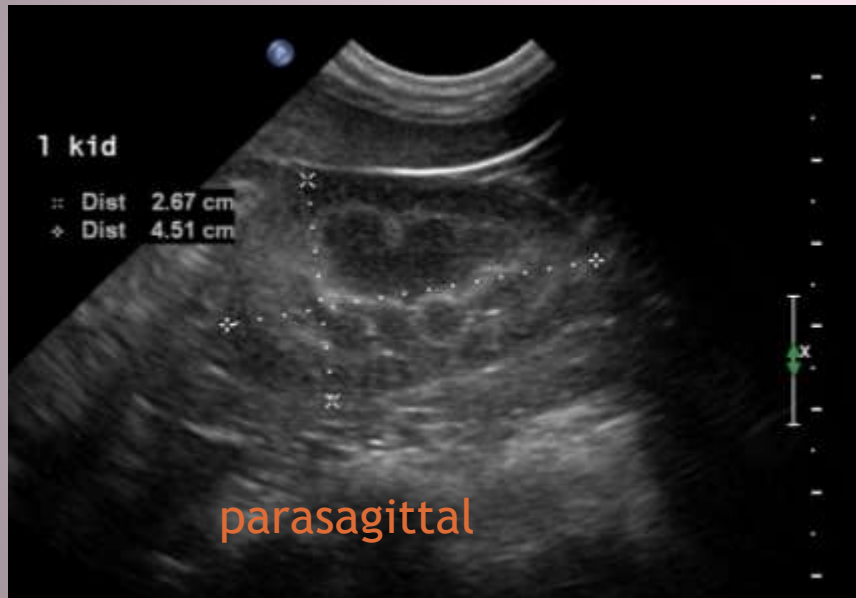
NORMAL KIDNEYS

- Right kidney- longitudinal ventral vs intercostal view



NORMAL KIDNEYS:

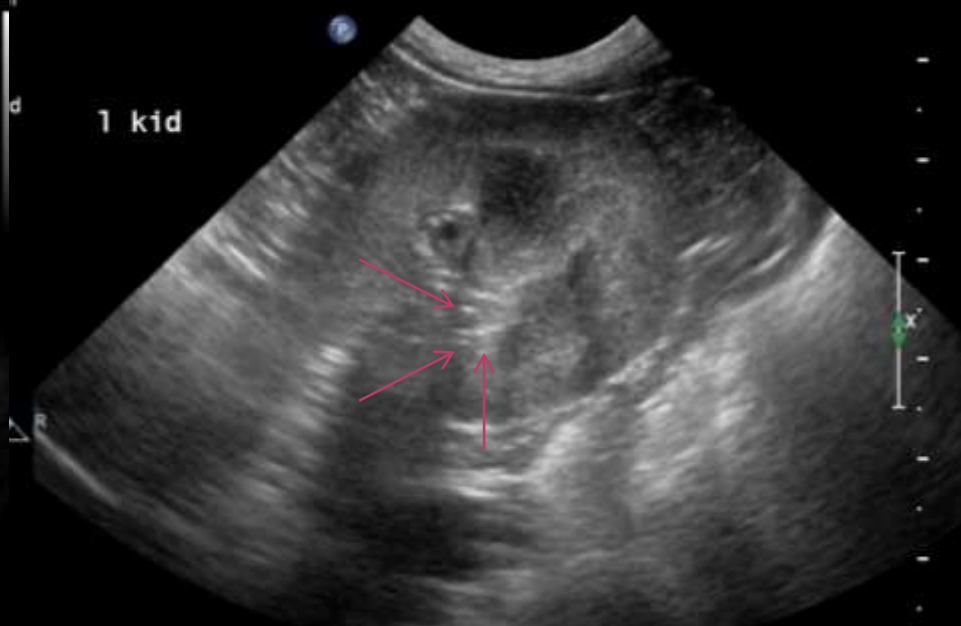
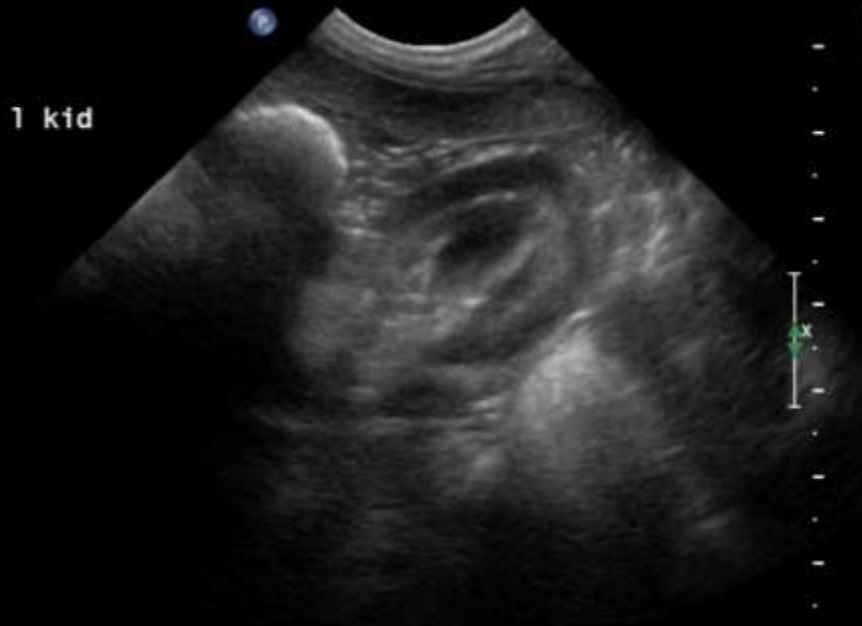
- Plane of imaging



NORMAL KIDNEYS

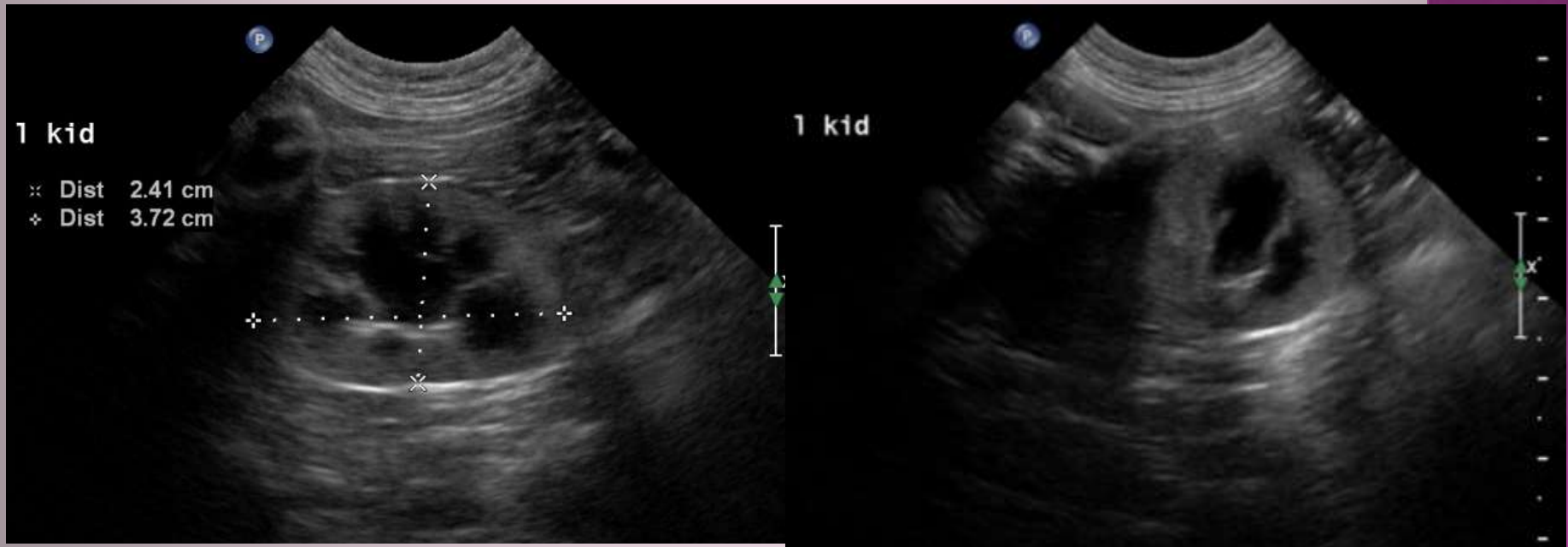
- Renal pelvis

- Best seen in transverse image when mild



NORMAL KIDNEYS: CAT

- Hyperechoic renal cortices
 - Overweight males



KIDNEYS: PATTERNS OF ABNORMAL

- Enlarged, smooth contour, retained architecture
 - Nephritis
 - Infectious- viral (cat), bacterial
 - immune mediated and amyloidosis
 - Toxin
 - Neoplasia-lymphoma
 - Portosystemic shunt
 - Unaltered animal- normal
 - Compensatory hypertrophy

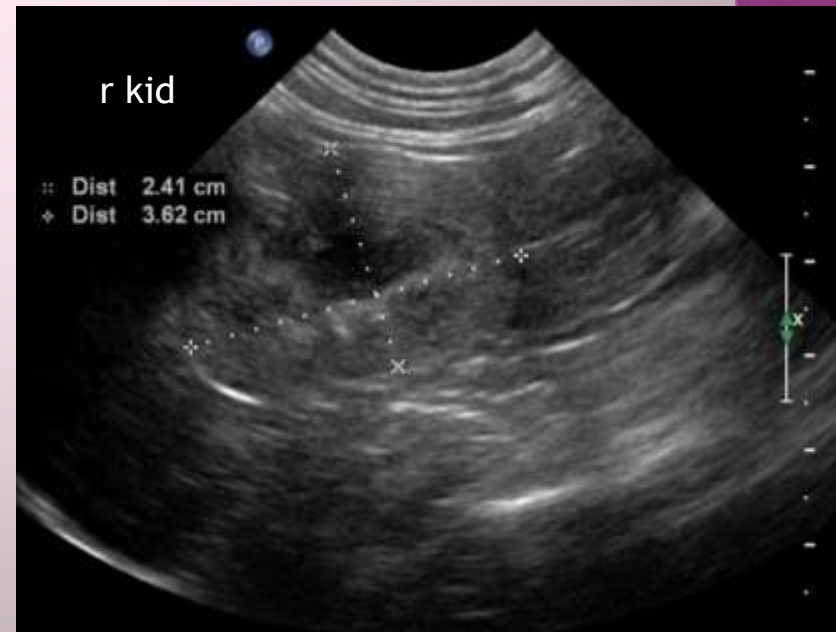
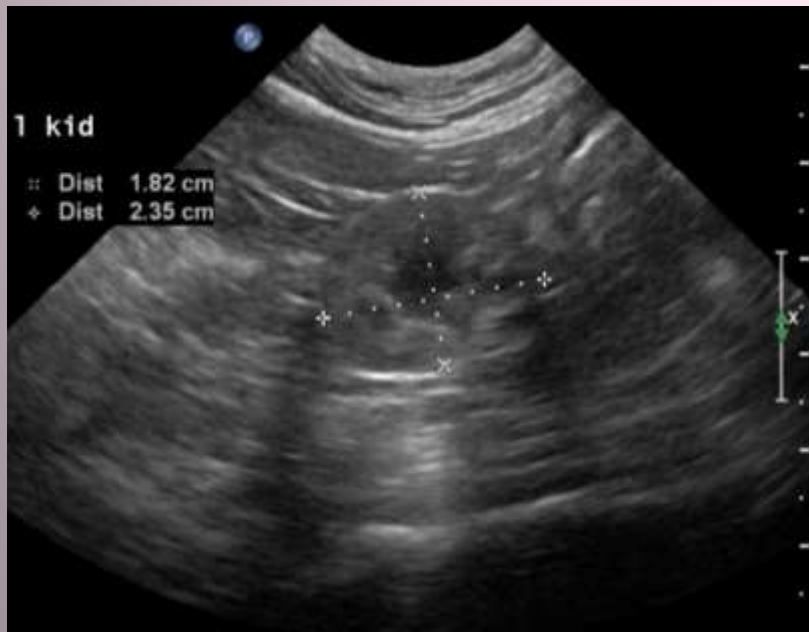


KIDNEYS: PATTERNS OF ABNORMAL

- Enlarged, lumpy, distorted architecture
 - Neoplasia
 - Lymphoma
 - Renal carcinoma
 - Metastatic- hemangiosarcoma
 - Abscess/ granulomas
 - Ascending/ sepsis
 - Fungal granulomas
 - ‘Acute on chronic’ disease
 - Renal lymphoma in CRF cat

KIDNEYS: PATTERNS OF ABNORMAL

- Small, irregular, distorted architecture
 - Chronic renal disease
 - Immune/toxin/unknown
 - Chronic pyelonephritis
 - Chronic congenital disease (dysplasia)
 - Renal cortical infarcts



ABNORMAL KIDNEYS

○ Renal cortical infarcts

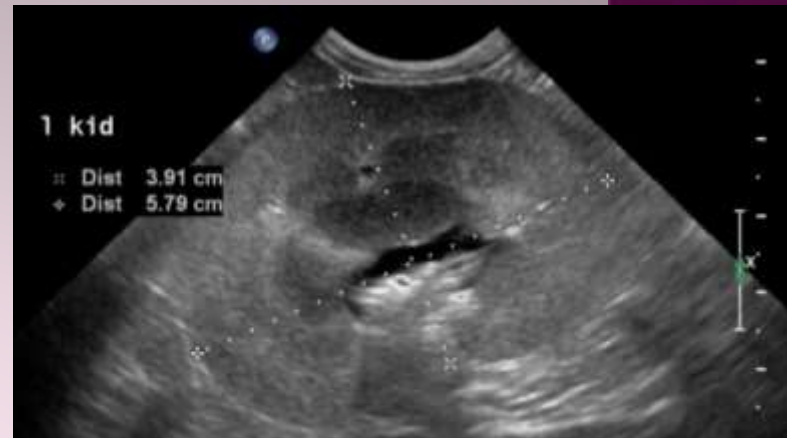
- Hyperechoic striation, triangular wedge or large region
- Often causes atrophy and indentation



ABNORMAL KIDNEYS

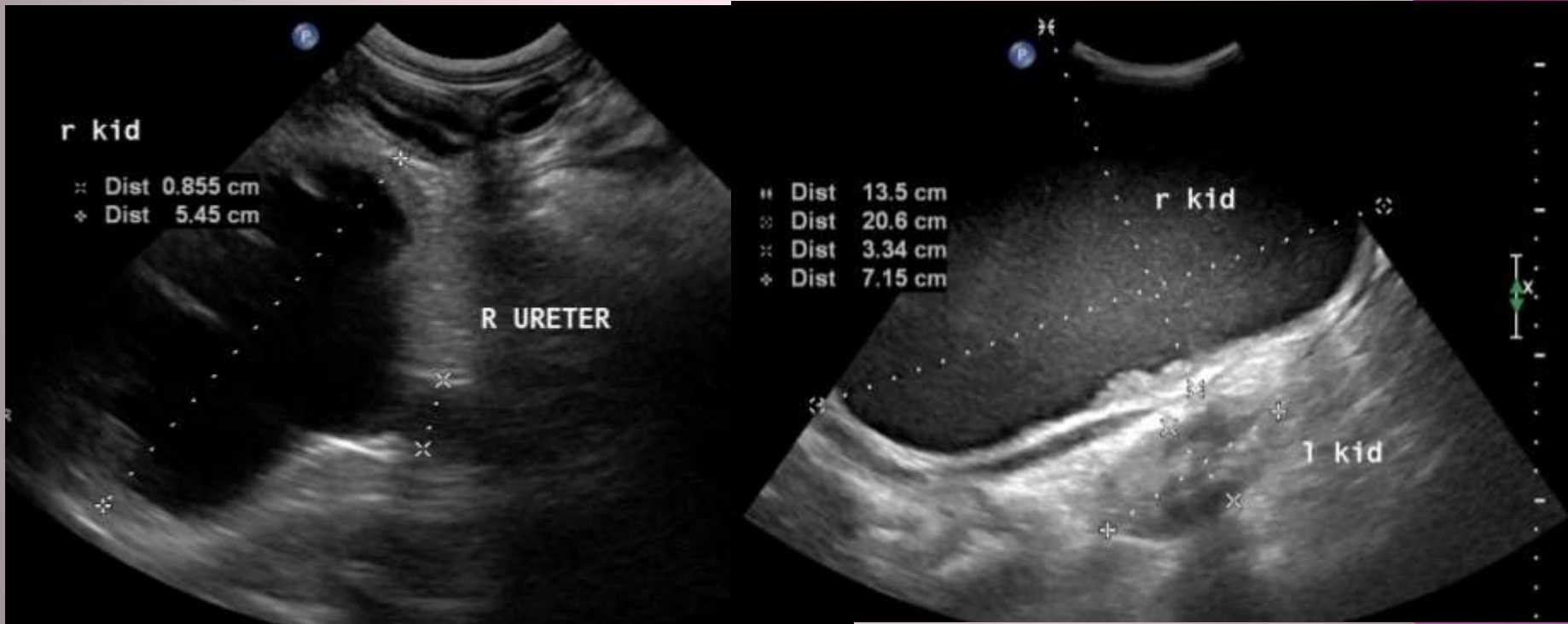
○ Pyelectasia

- Slight/mild
 - polyuria of any cause
 - Early obstruction- blocked cat
 - Pyelonephritis
- Moderate/ severe
 - Obstruction- ureteral
 - Pyelonephritis



ABNORMAL KIDNEYS

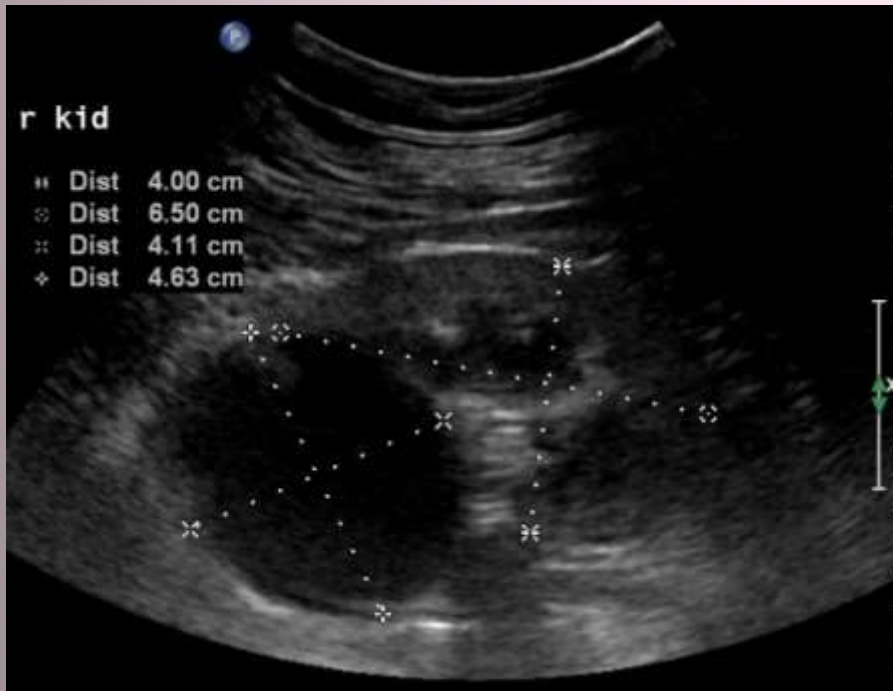
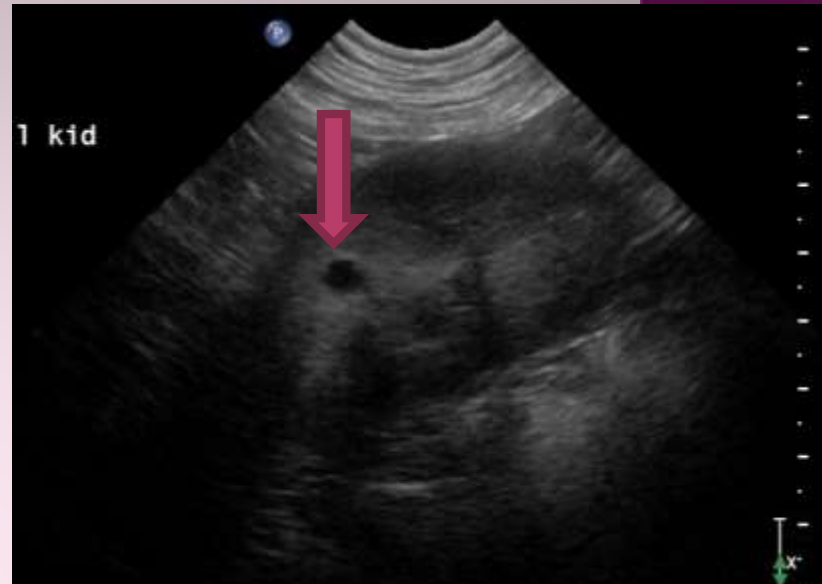
○ Pyelectasia continued



ABNORMAL KIDNEYS

○ Renal cysts

- Acquired vs congenital
- Single vs multiple



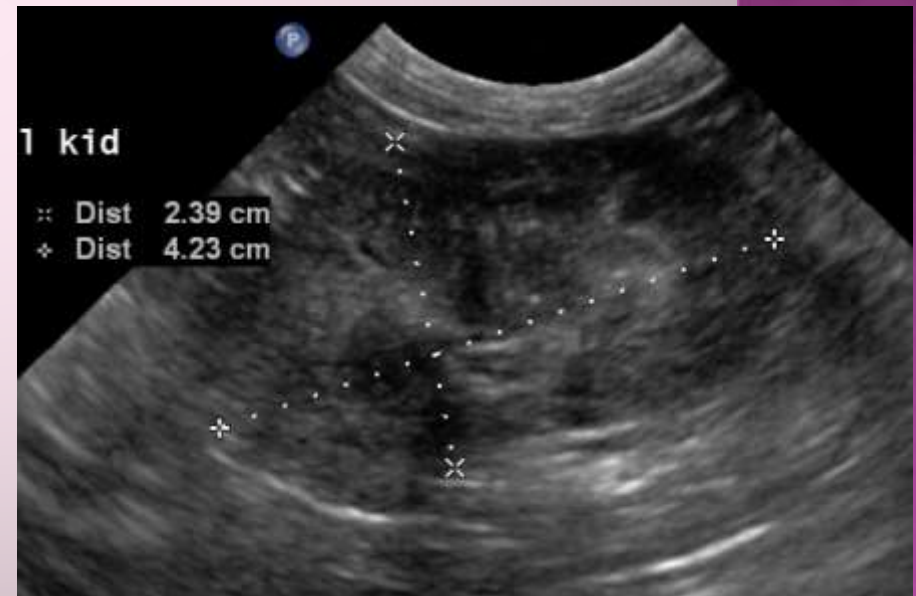
ABNORMAL KIDNEYS

- “Medullary rim”
 - Hyperechoic band at junction of cortex and medulla
 - Non-specific
 - Hypercalcemia- mineral deposits in tubules
 - inflammation- Lyme?



ABNORMAL KIDNEYS

- Reduced CM definition
 - Blurred junction
 - Cortex/ medulla similar echogenicity
 - Non-specific



URINARY BLADDER

○ Anatomy

- Apex- cranioventral
- Neck- tapered sphincter
- Trigone- caudodorsal

○ Wall

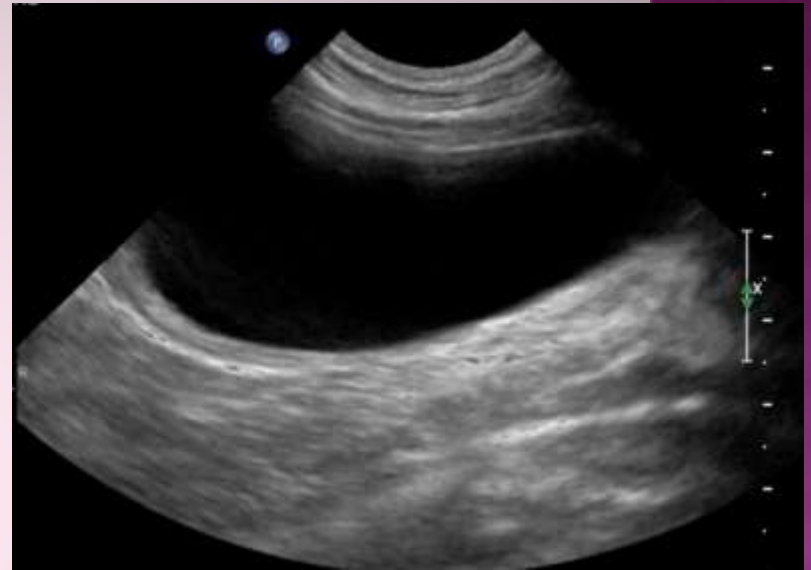
- Thickness depends on fullness
- Most thick at apex
- Mucosa smooth
- Ureteral papillae

○ Location

- Neck cranial to pubis
- Intrapelvic bladder

○ Anechoic urine

- Suspended “specks”- fat droplets, concentrated urine in cats



URINARY BLADDER

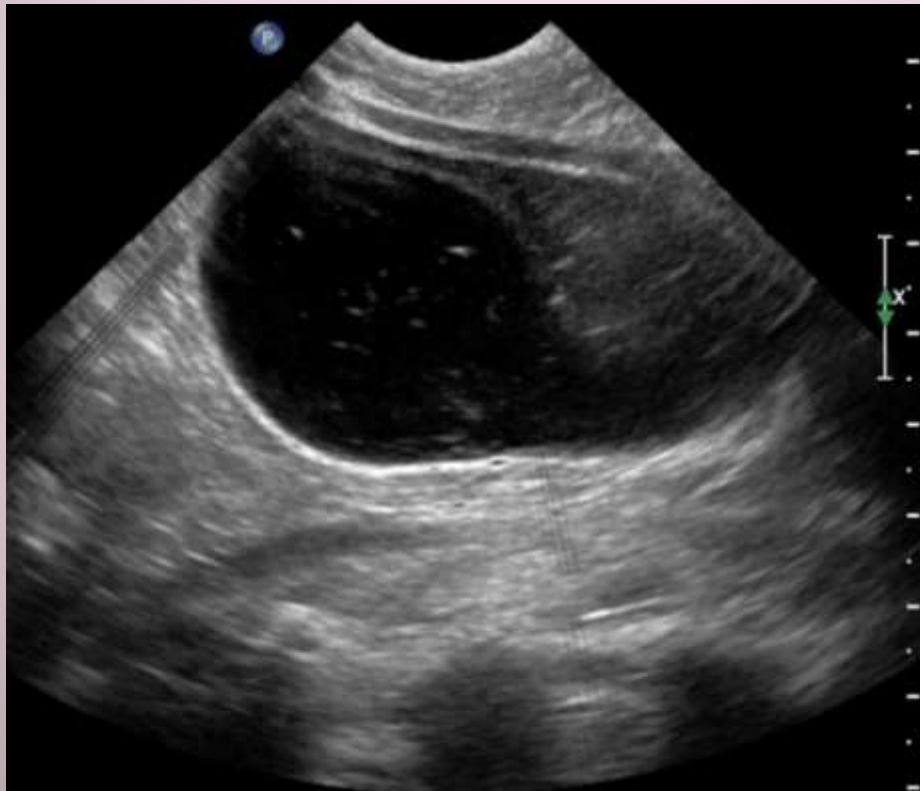
○ Ureteral papillae

- Cranial border of trigone
- Urine “jets”
- Common location for stone obstruction



URINARY BLADDER: CATS

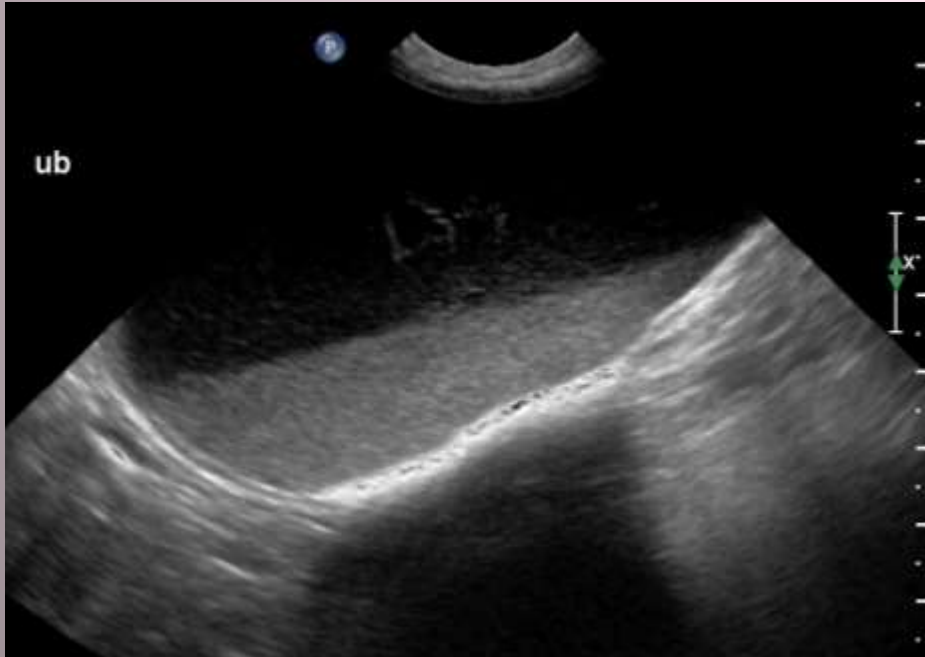
- Fat droplets
 - Stay suspended/ don't settle out



URINARY BLADDER: ABNORMAL

○ Calculi

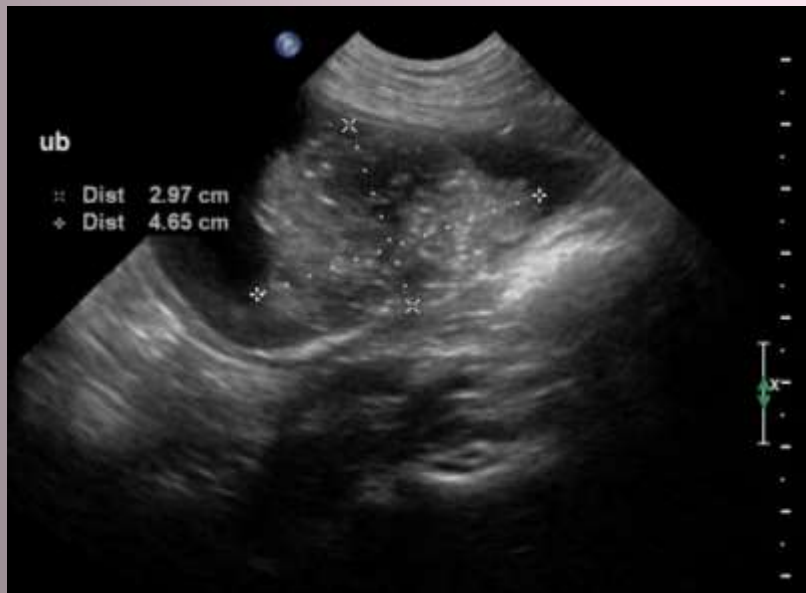
- Non-radiopaque stones
- “Sand”



URINARY BLADDER: ABNORMAL

○ Masses

- Mucosal vs. mural
- Location- trigone vs. apex
- Patterns of abnormalities
 - Trigonal, mineralized, vascular, mucosal mass in dog = transitional cell carcinoma
 - Apical, “finger-like” or stalk, avascular mucosal mass in dog = inflammatory polyp



URINARY BLADDER ABNORMAL

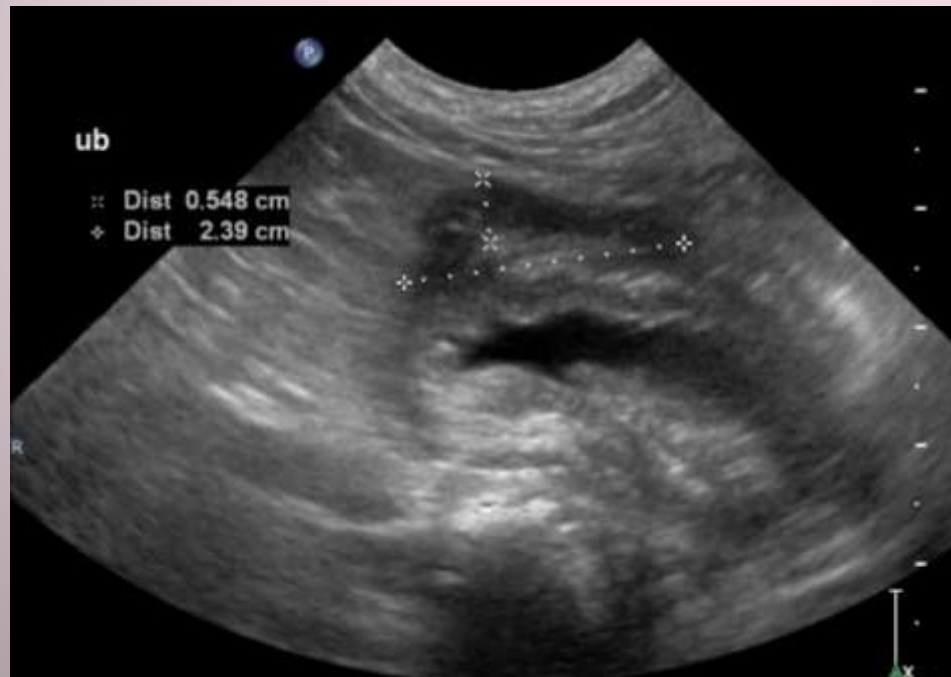
- Mucosal masses continued



URINARY BLADDER: ABNORMAL

○ Masses continued:

- Mural
 - Hematoma
 - Soft tissue sarcoma (leiomyoma/ leiomyosarcoma)



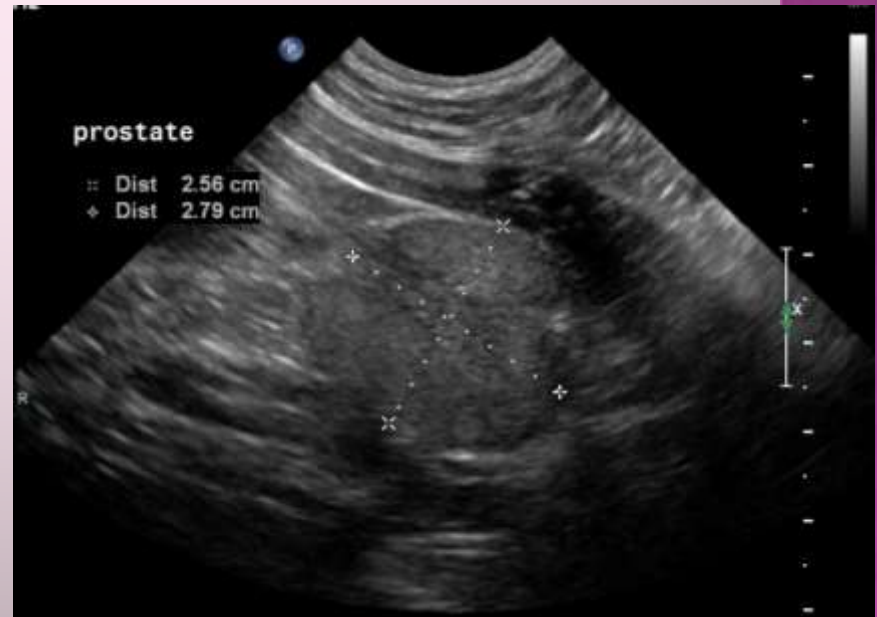
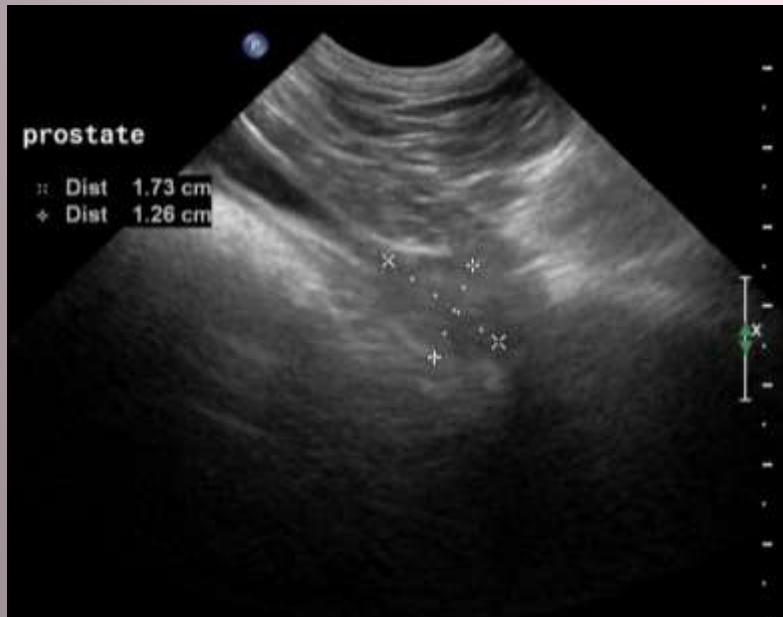
PROSTATE GLAND: DOG

○ Neutered

- Small, less than 2 cm width
- Hypoechoic, smooth

○ Intact

- Variable size
- Bilobed shape transverse
- Smooth contour
- Hyperechoic, uniform



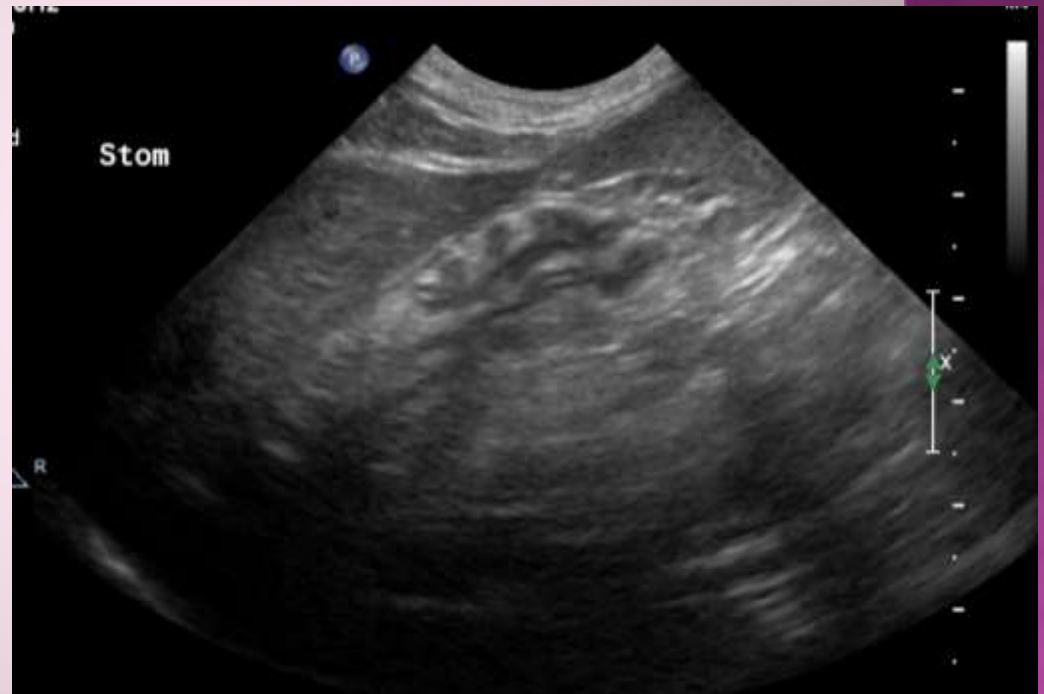
GASTROINTESTINAL TRACT: STOMACH

○ Anatomy

- Best viewed empty
- Cardia, fundus, body and pyloric antrum
- Pyloric sphincter

○ Wall

- Layered like intestine
- Varies 2-5 mm thick
- Rugal folds thicker
- Contracts 3-5/ min



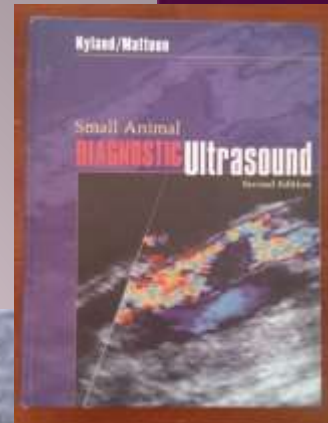
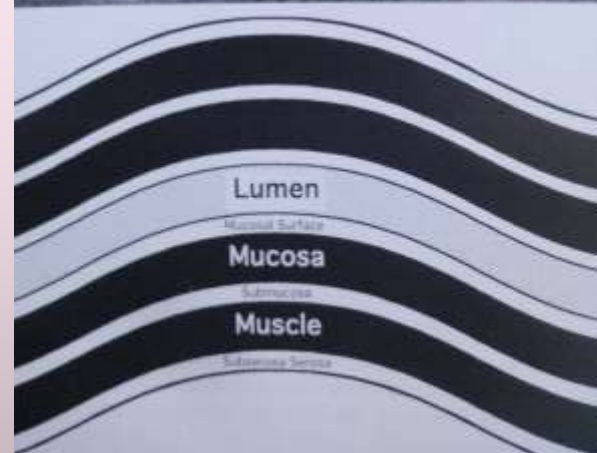
GASTROINTESTINAL TRACT: SMALL INTESTINE (JEJUNUM)

○ Jejunum wall

- Cats up to 3.0 mm
- Dogs up to 3.5 mm
- Five distinct layers-
mucosa thickest

○ Lumen

- peristalsis
- Gas/ small amt fluid only
- Solid material abnormal
- diameter >1.5 cm
abnormal in cats



GASTROINTESTINAL TRACT: SMALL INTESTINE

○ Duodenum

- Thickest segment-
5-6 mm wall
- Duodenal papilla



○ Ileum

- Hyperechoic, thick
submucosal layer
- Prominent muscular
layer in old cats



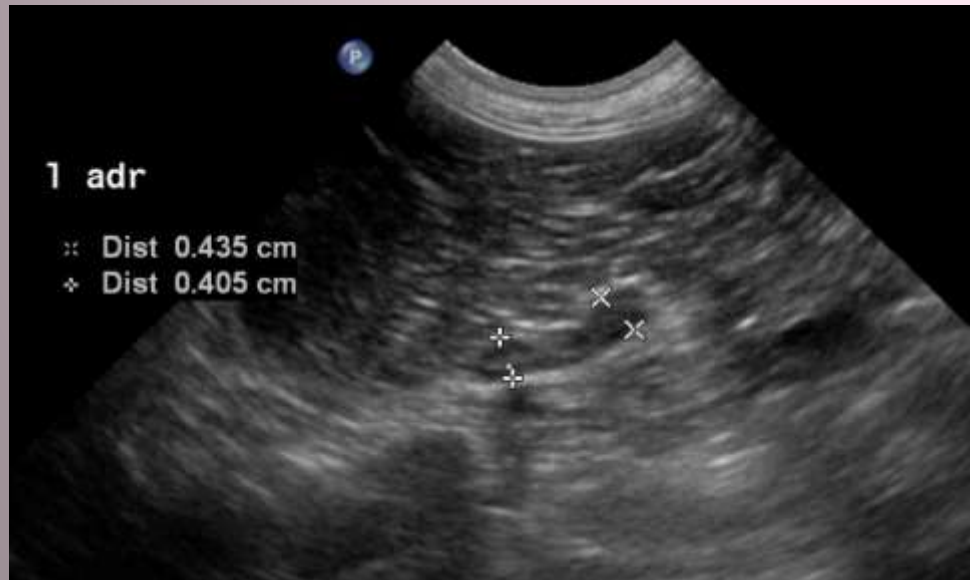
ADRENAL GLANDS

○ Dogs:

- Peanut, bilobed shape
- Cortex and medulla
- Size varies 4-7 mm diameter

○ Cats

- More round shape
- Hypoechoic
- Size <5 mm diameter



PANCREAS

○ Dogs

- Right limb easier
- <1.5 cm height
- Uniformly hypoechoic (iso to liver)



○ Cats

- Left limb easier to see
- 5-7 mm diameter limbs
- Old cats- panc duct visible



LYMPH NODES

○ Mesenteric (jejunal)

- Paired along mesenteric vessels
- Dogs <6 mm, Cats < 4 mm
- Hyperechoic

○ Medial iliac

- Right/left lateral views
- Dogs <7 mm
- Hard to see in cats
- Hyperechoic





THE END

Questions???