



OPTIMAL ORDERING OF CROSS SECTIONAL IMAGING EXAMINATIONS

MRI, CT, AND ULTRASOUND

- Which study should I order?
 - Often not a wrong answer, just a best answer
- Look at completely different properties of tissue
 - That's why one might be best
 - That's why the reason for exam may change "best"
- How do I order it?
 - When do I order contrast?
 - How do I specify the location of the examination?

MR, CT AND ULTRASOUND

- Ultrasound has its own special properties and specific uses
- Most of the time we are choosing between CT and MR
- Patient factors – habitus (too much and too little), respiratory and other motion, cooperation

ORDERING MRI AND CT EXAMINATIONS

- Look at completely different properties of tissue
- Which study should I order?
- How do I order it?
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MR vs. CT

- CT is less likely to cause claustrophobia than MR
- CT has fewer contraindications than MR
- CT is approximately $\frac{1}{2}$ the price of MR
- CT has better resolution so better for really small structures and fine detail than MR

MR vs. CT

- MR has better tissue differentiation (“contrast”) than CT
 - Between normal tissues
 - Between normal and abnormal tissue
- MR has no radiation and no known risk
 - CT is a type of x-ray, so radiation exposure to patient
 - Important in pregnancy and patients who need repeat exams
- MR contrast causes fewer reactions than CT contrast
- MR easier to get images in optimal plane(s) than CT

When is MR the Modality of Choice?

- Neuro (Brain, pituitary, IAC, spinal cord, and peripheral nerves) – Most work ups
- Spine (discs and nerves) – Most work ups
- Joints/Extremities – Most work ups
 - Includes musculoskeletal pelvis

When is CT the Modality of Choice?

- Head – Trauma
- Body = Chest, Abdomen and/or Pelvis (organs)
 - Most work ups
- Sinuses – Most work ups
- Complex fractures – When xray isn't enough
- Temporal bones – structures of the inner ear

When can either be best?

- Orbits – depends on what you are looking for
- Soft Tissue Neck – Each has strengths
- Bone – Finding lesions. Both will miss some. Both will find some that other misses.
“Complementary”
 - Same is true for Nuc. Med. Bone Scan

When can either be best – Vascular?

- MR does not need contrast, CT does
- CT has better resolution, so sees smaller abnormalities
- MR sees flowing blood so it is seeing the lumen, but not the wall of vessel
- CT can see plaque and calcification, MR can't
 - That's why heart scans (screening) are done with CT

When can either be best – Vascular?

- Brain – usually MR because looking for narrowing, occlusion or aneurysm
 - Not degree of stenosis
- Neck (Carotids) – usually MR but CT not uncommon
- Chest (Aorta) – usually CT. Always CT for r/o PE
- Abd/Pel (Aorta and Renal A's) – usually CT
 - Contrast allergy or renal failure – MR
- Run-off (Bifurcation through Ankles) – usually MR

When else do we use MR?

- Abdomen and Pelvis – problem solving
- Brachial plexus
- Breast
- Cardiac

When else do we use CT?

- Spine and Bones/Joints – For evaluation of small or complex fracture or to evaluate if fusion/healing is solid
- Neuro – Problem solving

CONTRAST

- Helps to visualize and/or characterize pathology in certain situations
- Has some toxicity so has risk
 - Morbidity and mortality
- It is the radiologist's legal responsibility to determine the need, so it's really our call
- Better for you that way
- Expensive
- No problem previously doesn't ensure next time

CONTRAST – CT

- Iodine based
- Allergic reaction can cause hives, shortness of breath, anaphylaxis, and death
 - Death risk has decreased over the years and is now minimal (<1/100,000 administrations)
- Some renal toxicity in patients with compromised renal function
- No relation to seafood allergy
- Pretty safe

CONTRAST – MR

- Gadolinium based so allergy to one doesn't have any real significance for allergy to the other
- Allergic reaction can cause hives, shortness of breath, anaphylaxis, and death
 - Death risk is almost 0
- Morbidity extremely unlikely, but can occur
- Very safe

What body part do you order?

- Matters because it affects how the examination is performed – “protocol”
- Head vs Face vs Facial Bones vs Salivary Glands
- Head vs Orbits vs Pituitary vs IAC
- Neck vs Cervical
- Shoulder vs Scapula
- Shoulder vs Arm vs Biceps vs Elbow
- Wrist vs Hand
- Hand vs Finger/Thumb

What body part do you order?

- Chest vs Breast vs Chest Wall vs Brachial Plexus
- Pelvis Organs vs. Pelvis MSK
- Pelvis MSK vs Hip(s) vs SI joints vs Sacrum/Coccyx
- Thigh vs Femur
- Calf = Tib/Fib
- Ankle vs Foot (vs Midfoot)
- Arm, Forearm, Thigh, Calf will not get you a joint

Who can't get an MRI

- **EXTREMELY** powerful magnet



Who can't get an MRI

- EXTREMELY powerful magnet
- 30,000 times Earth's magnetic field
- If you drive a forklift into the room, the magnet will pick it up and pull it in

Who can't get an MRI = CONTRAINDICATIONS

- Absolute vs. relative. Dynamic.
- METAL IN THE BODY IS NOT A CONTRAINDICATION because:
 - Often not magnetic and/or
 - Body puts more stress on it than magnet and/or
 - Tightly held in place and/or
 - Not near anything important
- Possible metal in eye – xray. Absolute if behind globe
- Metal in spinal canal - absolute

Who can't get an MRI

- Aneurysm clip – Almost absolute
- Pacemaker – Absolute
- Cochlear implant – Absolute
- Stapes implant – Almost absolute
- Bone or nerve stimulator – Absolute
- Pumps – Turn off and reset
- Ankle bracelet – Take off
- Claustrophobia – Can usually get study done

Who can't get an MRI

- Pregnancy – First trimester – Relative
- Uncooperative patient
- Metal in area being scanned can ruin images
 - Cannot predict – don't assume

Who can't get a CT

- Almost no one
- Claustrophobia very very very rarely
- Metal can ruin scan
- Pregnancy
- Cooperation
- Contrast allergy or renal function can preclude administration
 - Do without or switch to MR (or use MR contrast)

Ordering in General

- Give us as much accurate information as possible
 - At my site the order is reviewed at least twice to try to optimize study. Unfortunately, not true most places
 - Be precise with language e.g. “flank”
- Specify structure or region of interest
- Contrast
 - Only refers to Intravenous
 - Really radiologist’s call legally

MR Neuro

- Screening usually is without contrast
- Be specific about symptoms and body part
 - If only hearing loss, then IAC only
 - Orbits vs. Brain and Orbits
 - Pituitary vs. Brain and Pituitary
- If specific cranial nerve symptoms, tell us
 - Trigeminal neuralgia, Bell's palsy, Vision
 - Sensorineural hearing loss

MR Neuro - Contrast

- Contrast used when there is indication for tumor
 - Metastases, Acoustic neuroma, Pituitary
 - Not bone metastases
 - Not just that a tumor could cause the symptoms (headache)
- Studies are always Without OR Without & With
 - Not like CT
 - Only do With by itself when following a surprise on a Without

MR Spine

- Cervical and/or Thoracic and/or Lumbar
- Cervical usually gets down to at least T2-3
- Lumbar usually gets at least T11-12 and down to S2
 - Does not include sacrum and coccyx
- Can extend or shift 1 or 2 levels if there is a reason
- Can't do whole spine with 2 studies

MR Spine - Contrast

- “Never” for screening in unoperated back
- Lumbar if surgery in last two years
 - Once in a while will have to bring a patient with surgery more than 2 years ago back for with
- Don’t need for post-op in Thoracic or Cervical
- If a surprise finding on a without, will either add (if the patient, schedule, and insurance allow) or bring patient back
- Contrast does not help look for bone metastases

MR Joint or Extremity

- Specify joint or segment of extremity
- Can't get segment with one or both adjacent joints as one study
- Usually without
 - Consider contrast if looking at a mass (not lipoma) or evaluating for abscess and/or osteomyelitis

MR Other

- Neck – Usually without and with
- Chest – Usually vascular evaluation, so without
- Abdomen – Usually problem solving (mass characterization, so without and with
- Pelvis (organs including prostate) – Usually problem solving (mass characterization), so without and with

MR Other

- Brachial plexus – without
- Vascular – Usually without
- MR Biliary system and Pancreatic Duct
 - MRCP – without
- Breast – Without and with
 - Follow up of mammogram finding
 - Follow up of malignancy

CT Neuro including contrast

- Cheaper screen e.g. headaches, but only if do w/o
- Trauma
 - Without for less than 8 days
 - Without and With for 8-21 days
 - With for > 21 days

A 2 year old boy presents immediately after a fall from bed onto a wood floor. No LOC or vomiting. Left forehead lump. Best option?

- A. CT head without contrast.
- B. CT head with contrast.
- C. Skull X-ray.
- D. Close follow-up for 24 hours.

CT Chest - Contrast

- Almost never without and with
- Nodule – without
- Hilar or mediastinal mass – with
- Trauma – without unless
- Vascular – with
- Hi resolution chest – without
- Screening in patients with risk factors - without
- Pulmonary Embolus – very specific protocol
 - With

CT Abdomen/Pelvis

- Have to ask for one or both specifically
- HISTORY IS CRUCIAL to optimize protocol
- Give us symptoms and location if relevant
- Any history of systemic disease including CA
- Any history of significant trauma
- Tell us about any relevant prior studies
- Done differently if only looking for fracture

CT Abdomen/Pelvis Contrast

- Refers only to IV – radiologist decides about oral
 - Need good info for best decision
- Without and with expensive and usually unnecessary
- Pain – screening so usually without
 - If thinking kidney stone – definitely without
- Possible mass – with
- Evaluating known mass – without and with
- Trauma - with

CT Abdomen/Pelvis Contrast

- Modality of choice for appendicitis and kidney stone

CTA (Angiography)

- With
- In chest is different from PE protocol
- Abdomen will include thru bifurcation
 - Let us know if really for renal arteries
- “Runoff” includes from bifurcation thru ankles
- Head – use MR
- Neck

Parents provide history of a 2 y.o. falling from high-chair striking head. No LOC, vomiting or seizure activity, but refusing feedings. Physical exam including neuro unremarkable. Which is most appropriate next step?

- A. Contact Dept. of Child and Family Services
- B. Skull X-rays
- C. CT Brain
- D. MRI Brain
- E. Discharge home

ULTRASOUND = ECHO

- High frequency sound waves pass through or bounce back from different types of tissue in different ways
- Evaluates a completely different property of tissue from MR or CT

ULTRASOUND STRENGTHS

- No radiation
- Fair to good sensitivity - Can see some structures/abnormalities that other modalities can't
- Fair to good specificity
- Fair to good resolution

ULTRASOUND STRENGTHS

- Can visualize the presence and direction of flow
- Sensitive to calcification
- Good at distinguishing solid lesions from cystic lesions
- Relatively inexpensive
- Widely available and can be portable

ULTRASOUND WEAKNESSES

- Limited penetration
 - None through bone or gas
 - Less thru fat
- VERY user dependent
- VERY interpreter dependent
- VERY patient dependent (fat and bowel)
- Fair to good sensitivity, specificity, and resolution

ULTRASOUND SUMMARY

- Very good at a few things
- Pretty good at a few more things
- Not very good at a lot of things

ULTRASOUND VERY GOOD

- Gall bladder
- Thyroid
- Obstetrical
- Gynecology and scrotal
- Newborn brain
- Finding fluid in A/P

ULTRASOUND VERY GOOD

- Solid vs cystic in any organ
 - Thyroid, breast, liver, kidneys, ovaries, etc.
- Solid vs cystic in any extremity
- Vascular – Good for size, presence of flow, speed of flow, direction of flow, obstruction
 - Carotids in neck, aorta in abdomen, veins in legs, etc.

ULTRASOUND PRETTY GOOD

- Prostate
- Liver/spleen (not pancreas)
- Kidney
- Appendix in pediatrics
- OK for some joint abnormalities, but extremely dependent on experience of technologist and radiologist

Which of the following is true about the diagnosis of acute appendicitis?

- A. CT scanning may be less sensitive in thin patients and children.
- B. CT scanning in patients with early symptoms is less sensitive.
- C. Negative US should be followed with CT or observation.
- D. All of the above.

ULTRASOUND OTHER USES

- Breast – problem solving after mammography
- Heart = Echocardiography

IMAGING OPTIMIZATION RESOURCES

- American College of Radiology Appropriateness Criteria
 - “evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical condition”
 - Rates utility of each possible modality on 1-10 scale
 - <https://www.acr.org/Clinical-Resources/ACR-Appropriateness-Criteria>
- Government mediated push for these to be built into the ordering mechanism for imaging studies
 - Because of cost and waste

IMAGING OPTIMIZATION RESOURCES

- Crucial to have relationship with at least one radiologist whom you are comfortable calling with questions