

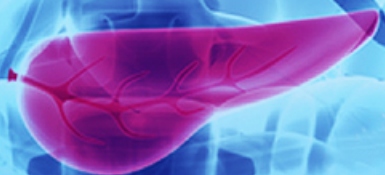
2019 CAPER

Collaborative Alliance for
Pancreatic Education and
Research

PANCREAS ACADEMY

July 24, 2019

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100 Lytton Avenue | Pittsburgh, PA 15213
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IMAGING MODALITIES FOR PANCREATIC DISEASE

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Outline

- Imaging generalities based on disease category
- Modality advantages / disadvantages
- Protocol considerations / Tips
- Overview of findings of pancreatitis
- Future directions

Categories of Disease

Pancreatitis



TA Ultrasound
CT
MRI

Pancreatic Tumors



TA Ultrasound
CT
MRI

Modality	Advantages	Disadvantages
Transabdominal Ultrasound	<ul style="list-style-type: none"> • No radiation* • Availability • Portability • No IV contrast 	<ul style="list-style-type: none"> • Limited by bowel gas / habitus • Limited FOV • Suboptimal vessel assessment • Lower sens / spec
CT	<ul style="list-style-type: none"> • Optimal for Ca⁺⁺ • Wide FOV • Speed 	<ul style="list-style-type: none"> • Radiation* • Suboptimal duct assessment • Iodinated contrast
MRI	<ul style="list-style-type: none"> • No radiation* • Best soft tissue contrast (duct) • Wide FOV • Possible non-contrast exam 	<ul style="list-style-type: none"> • Poor assessment of Ca⁺⁺ • Long exams* • Small space • +/- gadolinium contrast
Endoscopic Ultrasound	<ul style="list-style-type: none"> • Proximity • Potential to biopsy 	<ul style="list-style-type: none"> • Invasive • Limited FOV
ERCP	<ul style="list-style-type: none"> • Potential to intervene 	<ul style="list-style-type: none"> • Invasive

Categories of Disease

- +/- tumor
- Status of vessels
- Invasion of local structures
- +/- metastatic disease

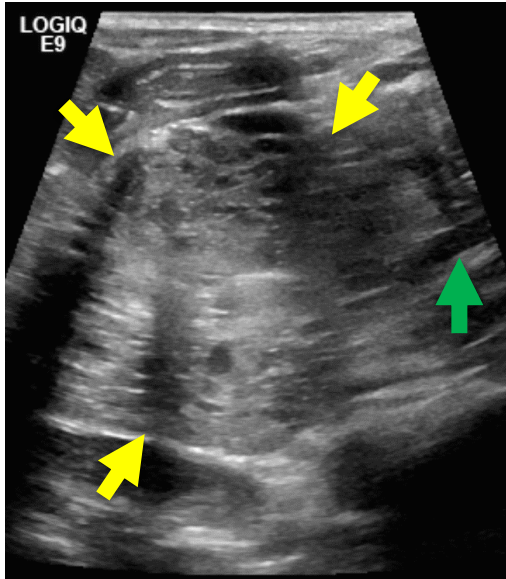
Pancreatic Tumors



~~TA~~ Ultrasound

CT
MRI

Categories of Disease



Pancreatic Tumors



~~TA Ultrasound~~

CT
MRI

Categories of Disease

- +/- tumor
- Status of vessels
- Invasion of local structures
- +/- metastatic disease

IV Contrast

Pancreatic Tumors



Ultrasound

CT
MRI

Protocol Considerations / Tips

Pancreatic Tumors

- IV contrast is a must
 - Multiphase post-contrast imaging can help
- Oral contrast can help
- MRI vs. CT is a preference

Pancreatic Tumors



Categories of Disease

- +/- tumor
- Status of vessels
- Invasion of local structures
- +/- metastatic disease

Pancreatic Tumors



TA Ultrasound

CT

MRI

FDG PET

EUS/ERCP

Protocol Considerations / Tips

Pancreatitis

- IV contrast
 - A must for CT
 - Single phase (portal venous) sufficient*
 - Can help for MRI (autoimmune, necrosis, vessels)
- Oral contrast can help (CT)
- Build redundancy into MRCPs

Protocol Considerations / Tips

Radiology

Reporting Standards for Chronic Pancreatitis by Using CT, MRI, and MR Cholangiopancreatography: The Consortium for the Study of Chronic Pancreatitis, Diabetes, and Pancreatic Cancer

The Consortium for the Study of Chronic Pancreatitis, Diabetes, and Pancreatic Cancer

Timel Tirkes, MD • Zarine K. Shah, MD • Naoki Takahashi, MD • Joseph R. Guja, MD • Stephanie T. Chang, MD • Sudhakar K. Venkatesh, MD • Darwin L. Conwell, MD • Evan L. Fogel, MD • Walter Park, MD • Mark Topazian, MD • Dhruv Yadav, MD, MPH • Anil K. Duggan, MD • For the Consortium for the Study of Chronic Pancreatitis, Diabetes, and Pancreatic Cancer

Tirkes T, et al. *Radiology*. 2019 Jan;290(1):207-215

Table 2: Guidelines for Imaging of CP by Using MRI, MR Cholangiopancreatography, and CT

MR Protocol Guidelines	CT Protocol Guidelines
Axial T1-weighted 3D two-point Dixon gradient-echo sequence generating water-only and fat-only images in addition to in-phase and opposed-phase images	All imaging must be performed with a multidetector helical CT scanner.
T2-weighted images (axial with fat suppression)	Scanning settings including kV, mAs, and pitch can be per individual institutional preference.
T2-weighted images: fast spin-echo or a variant of fast spin-echo (axial and coronal without fat suppression)	Imaging should be performed per pancreas protocol, which should include unenhanced and contrast material-enhanced phases (specifically, pancreatic parenchymal and portal venous phases).
MR cholangiopancreatography images	Water should be administered as oral contrast agent.
2D MR cholangiopancreatography: 40-mm thick, eight paracoronar projections to best show the pancreatic duct from different angles	Scanning should be performed from hepatic dome to iliac crest in all phases. Scanning in portal venous phase can extend from hepatic dome to pubic symphysis.
3D MR cholangiopancreatography: 2–3 mm, respiratory synchronized 3D fast spin-echo sequence. Create maximum intensity projection from source images.	Axial images should be reconstructed preferably at thickness of ≤ 2.5 mm.
Secretin-stimulated 2D MR cholangiopancreatography (thick slab): Secretin dose for adults is 16 μ g administered via slow intravenous injection over 1 min and flushed with 20 mL of saline. After infusion, ductal system is imaged with a coronal single-shot fast spin-echo sequence, repeated every 30 sec up to 10 min.	Contrast dose should preferably be 100–150 mL but can be altered at the discretion of the radiologist.
Postcontrast T1 weighted images: 3D gradient-echo with fat suppression (precontrast, arterial, portal venous, 5-min delayed venous phases)	Contrast injection rate should be greater than or equal to 2 mL/sec, preferably 4–5 mL/sec.

Note.—CP = chronic pancreatitis, 3D = three-dimensional, 2D = two-dimensional.

Findings of Pancreatitis

Acute Pancreatitis

- Swelling
- Edema
- Fluid collections
- Necrosis

Chronic Pancreatitis

Parenchyma

- Atrophy
- Loss of T1 signal
- Calcifications*

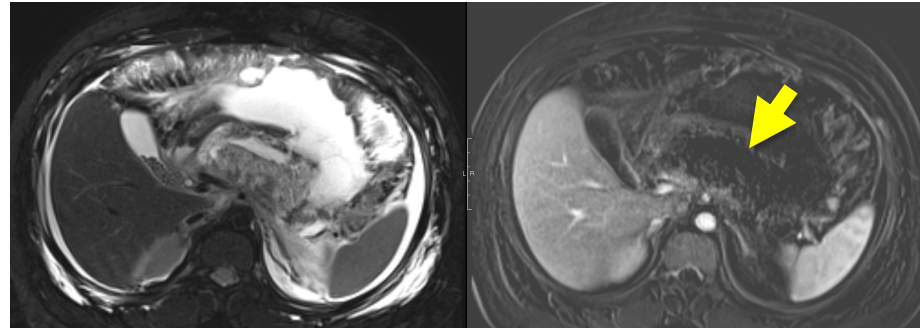
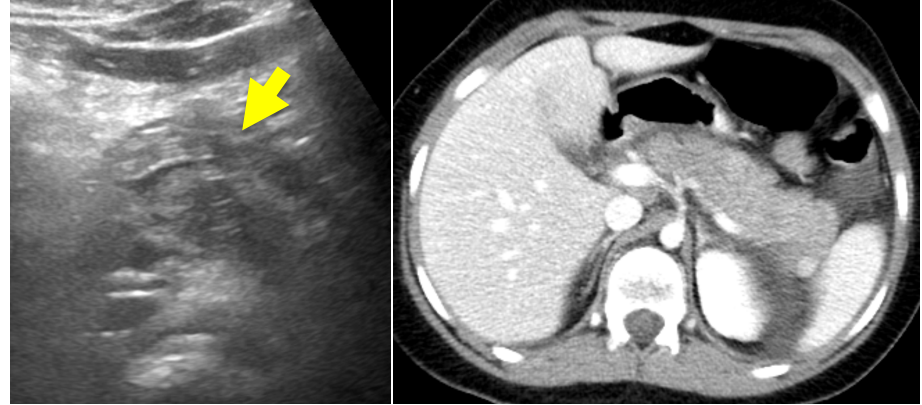
Duct

- Dilation
- Irregularity / Strictures
- Side branch dilation
- Filling defects

Findings of Pancreatitis

Acute Pancreatitis

- Swelling
- Edema
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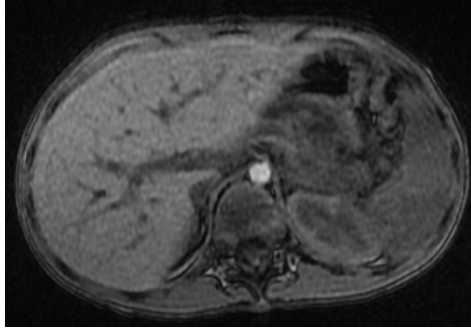
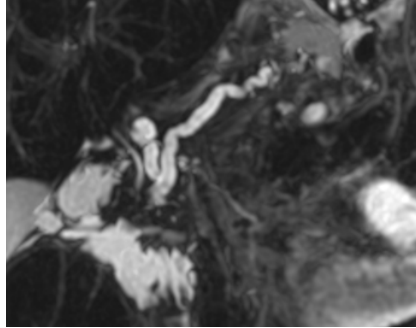


Findings of Pancreatitis – Fluid Collections

Fluid Collection	Description
Acute Peripancreatic Fluid Collection (APFC)	<ul style="list-style-type: none">- Assoc. w/ interstitial edematous pancreatitis- No necrosis- No intrapancreatic extension- Simple fluid
Acute Necrotic Collection (ANC)	<ul style="list-style-type: none">- Assoc. w/ necrotizing pancreatitis- Fluid + necrotic debris- Intra and/or extrapancreatic
Pseudocyst	<ul style="list-style-type: none">- Develops from APFC- Encapsulated- Simple fluid
Walled off Necrosis (WON)	<ul style="list-style-type: none">- Develops from ANC- Encapsulated- Complex



Findings of Pancreatitis



Chronic Pancreatitis

Parenchyma

- Atrophy
- Loss of T1 signal
- Calcifications*

Duct

- Dilation
- Irregularity / Strictures
- Side branch dilation
- Filling defects

Future Directions

- Faster MRI protocols
- Quantitative Imaging



Faster MRI Protocols

MR Protocol Guidelines

Axial T1-weighted 3D two-point Dixon gradient-echo sequence generating water-only and fat-only images in addition to in-phase and opposed-phase images
T2-weighted images (axial with fat suppression)

T2-weighted images: fast spin-echo or a variant of fast spin-echo (axial and coronal without fat suppression)

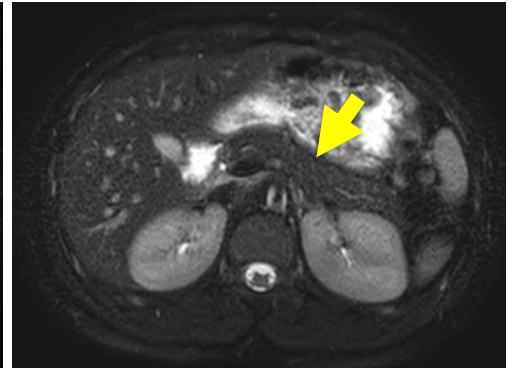
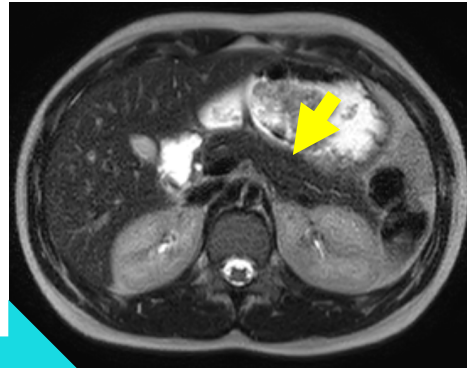
MR cholangiopancreatography images

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Postcontrast T1 weighted images: 3D gradient-echo with fat suppression (precontrast, arterial, portal venous, 5-min delayed venous phases)



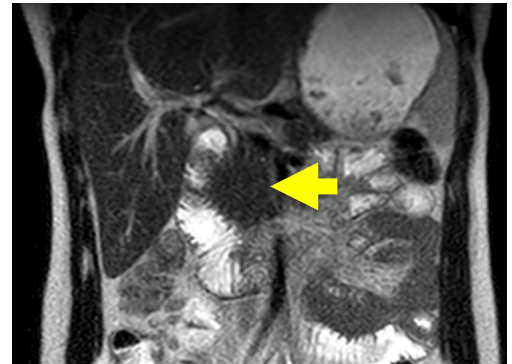
AP protocol

3-4 sequences

<15 minutes

Free breathing

No contrast

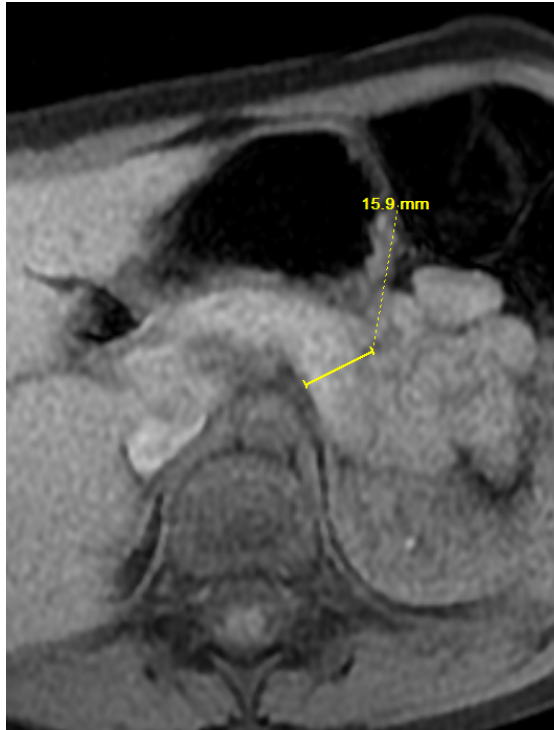


Quantitative Imaging

- Pancreatic measurements
- Elastography
- MR signal mapping
- Secretin for exocrine function



Quantitative Imaging – Panc. measurements



Norms exist

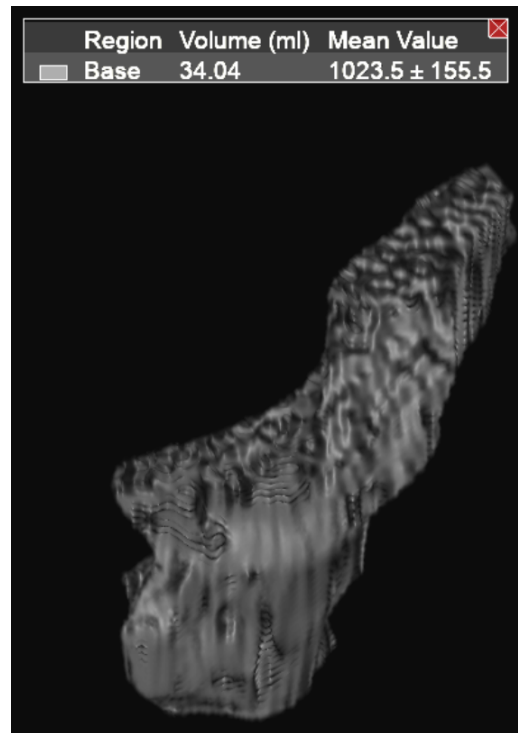
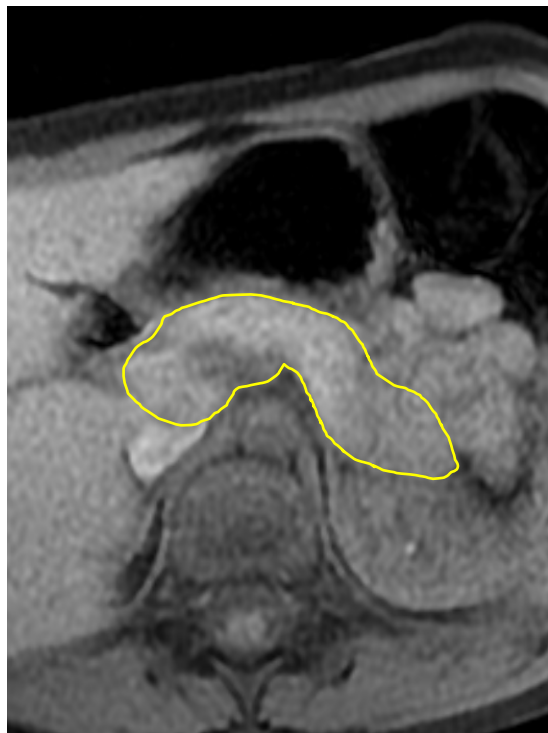
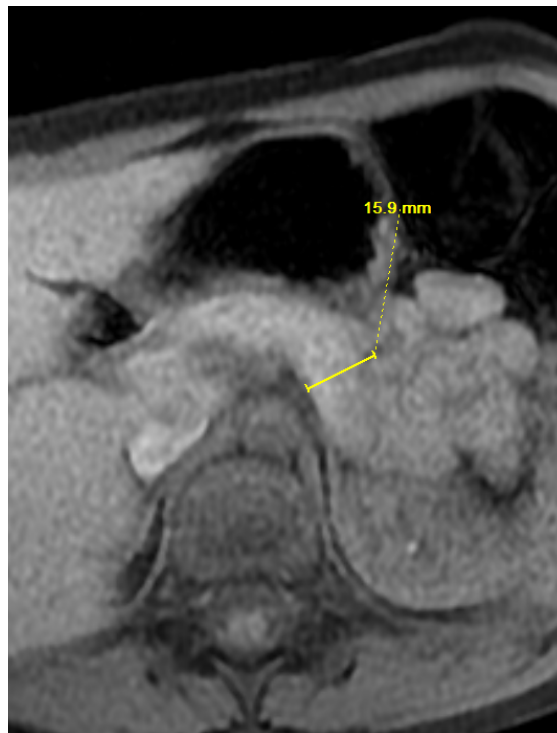
— Adult

- Heuck A, et al. *Gastrointest Radiol.* 1987;12(1):18-22

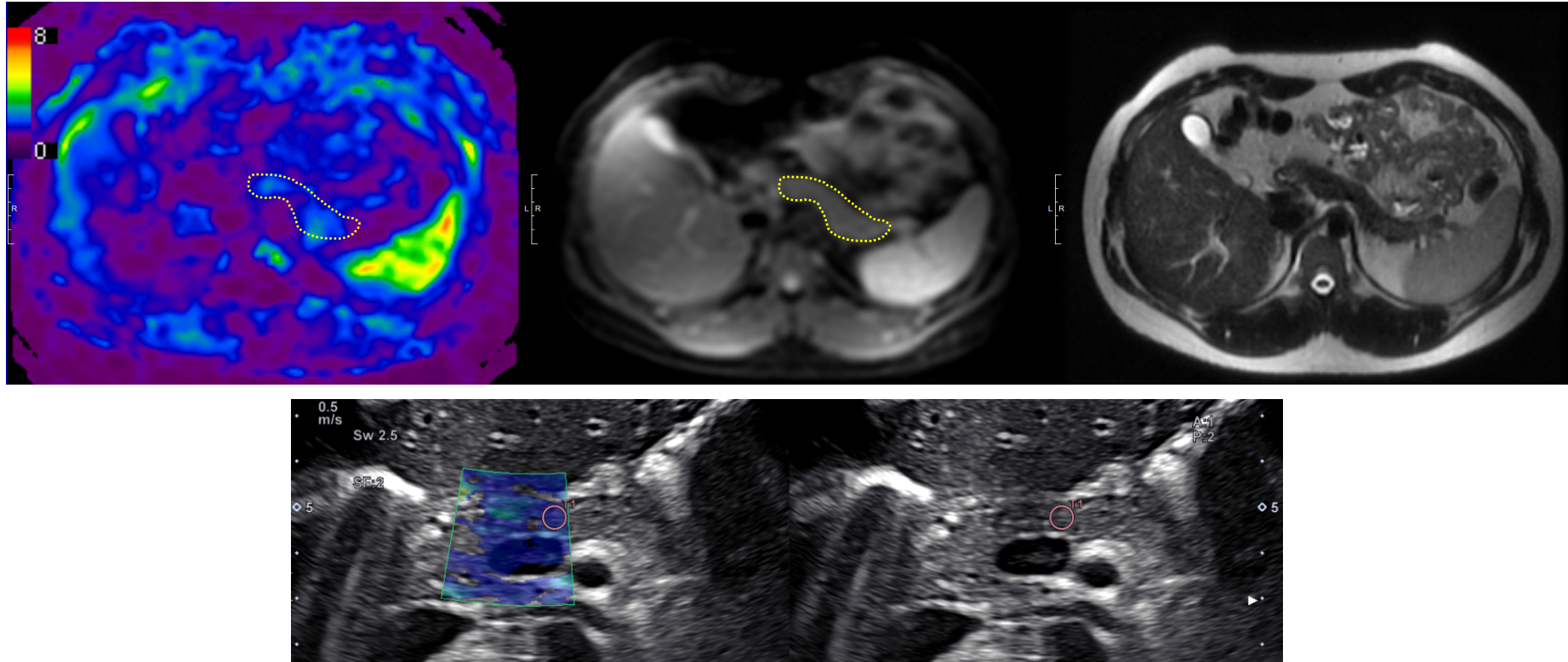
— Pediatric

- CT: Trout AT, et al. *Pediatr Radiol.* 2018 Oct;48(11):1600-1605
- Ultrasound: Siegel MJ, et al. *Radiology.* 1987 Oct;165(1):15-8

Quantitative Imaging – Panc. measurements



Quantitative Imaging - Elastography



Quantitative Imaging - Elastography

- MR elastography
 - Adult — \uparrow stiffness in tumors and CP
 - Pediatric — \downarrow stiffness in CP/ARP
- Ultrasound elastography
 - Adult — \uparrow stiffness in tumors and CP
 - Pediatric — stiffness similar to healthy liver

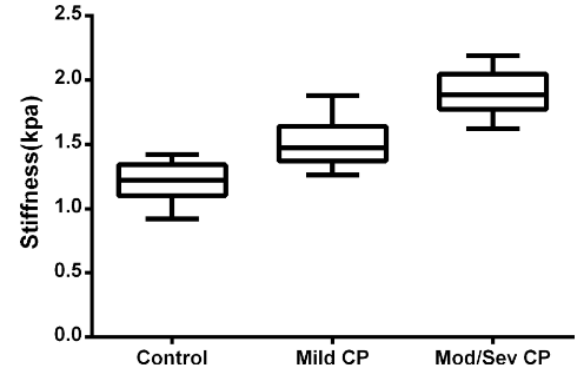
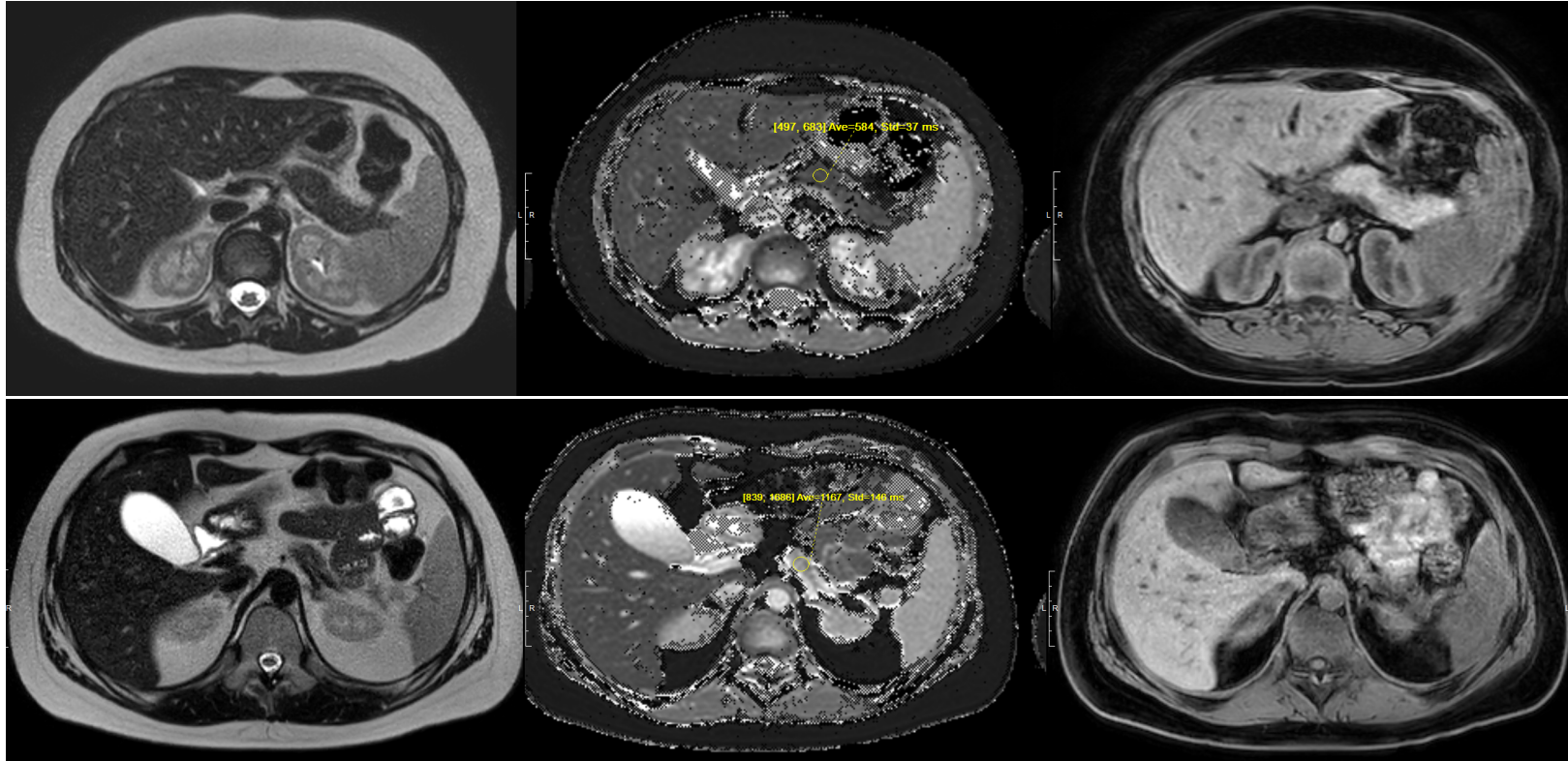


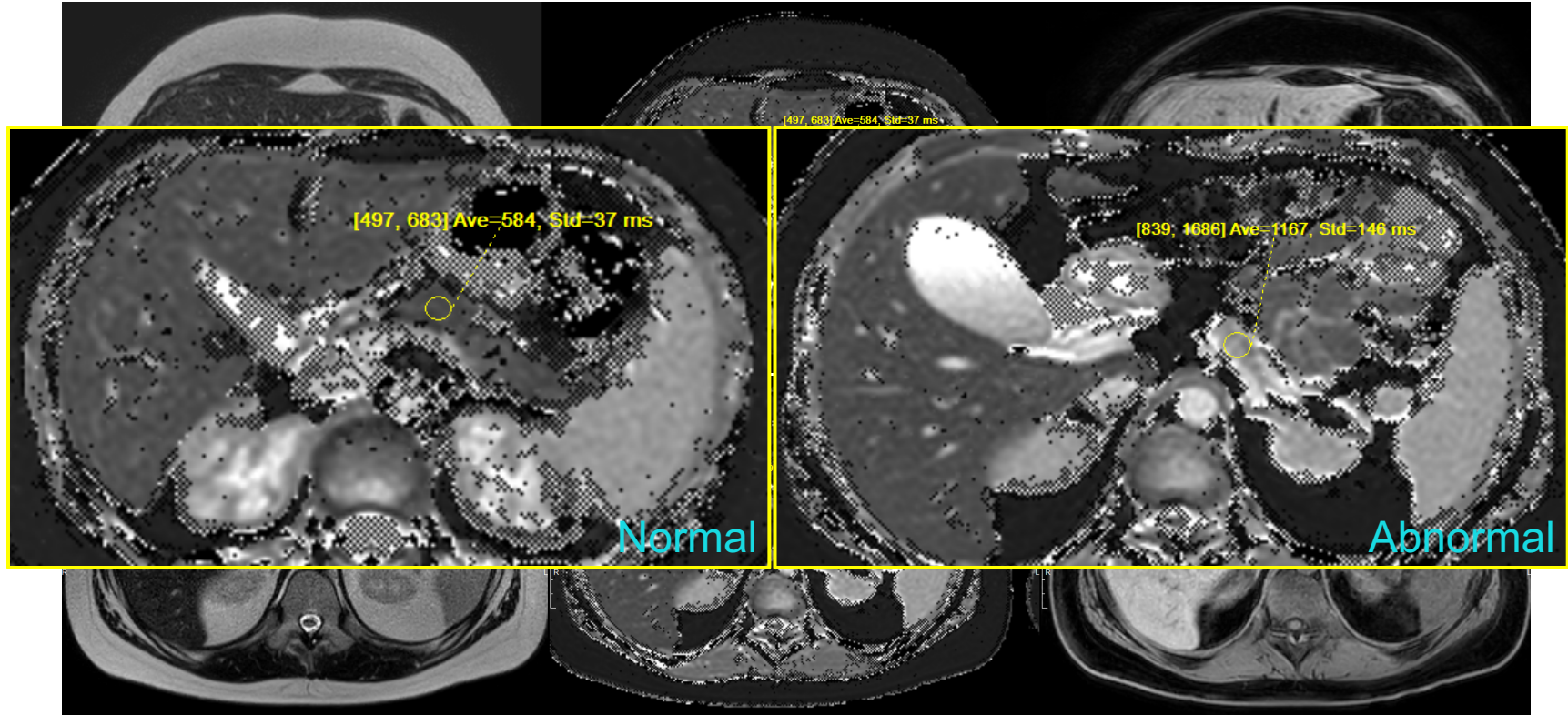
FIGURE 5: Boxplot of pancreatic stiffness in the control (mean = 1.21 kPa, 95% CI: 1.17–1.26), mild CP group (mean = 1.50 kPa, 95% CI: 1.44–1.56), and mod/sev CP (mean = 1.90 kPa, 95% CI: 1.81–1.98). The stiffness of the pancreas in the mod/sev CP and mild CP group were significantly greater than the normal group (both $P < 0.001$).

Wang M, et al. *J Magn Reson Imaging*.
[Epub ahead of print] PubMed PMID:
29537715

Quantitative Imaging – Signal Mapping



Quantitative Imaging – Signal Mapping



Quantitative Imaging – Signal Mapping

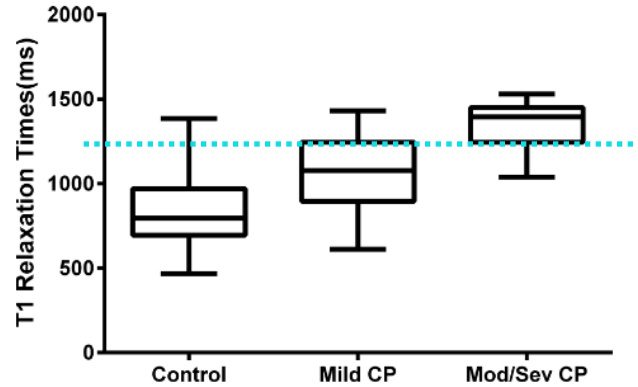
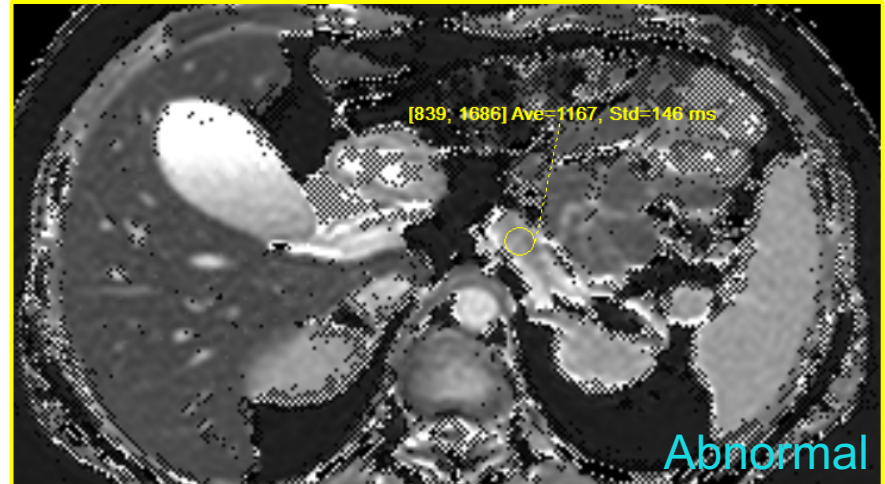


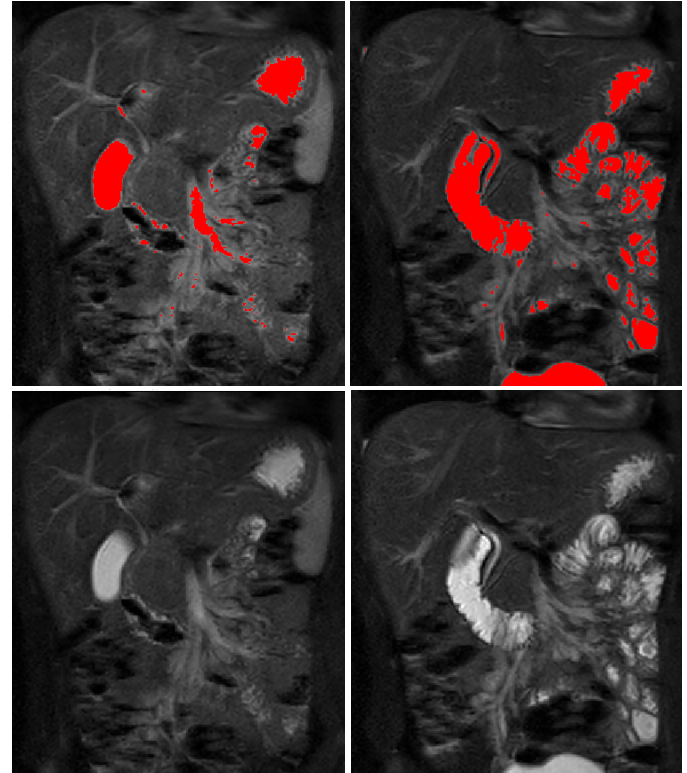
FIGURE 6: Boxplot of pancreatic T₁ relaxation times in the control (mean = 865 msec, 95% CI: 789–940) and mild CP group (mean = 1075 msec, 95% CI: 993–1158) and mod/sev CP (mean = 1350 msec, 95% CI: 1276–1423). The mean T₁ relaxation time of the pancreas in the mild CP and mod/sev CP group were significantly greater than the normal group ($P=0.001$ and <0.001 , respectively).



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29537715

Quantitative Imaging – Exocrine fxn.

- Volumetric quantification of secreted fluid volume
- Norms exist
 - Adult: Mensel B, et al. *AJR Am J Roentgenol.* 2014 Jan;202(1):102-8
 - Peds: Trout AT, et al. *Am J Gastroenterol.* 2018 Sep;113(9):1385



Modality	Advantages	Disadvantages
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MRI	<ul style="list-style-type: none"> • No radiation* • Best soft tissue contrast (duct) • Wide FOV • Possible non-contrast exam 	<ul style="list-style-type: none"> • Poor assessment of Ca⁺⁺ • Long exams* • Small space • +/- gadolinium contrast
Endoscopic Ultrasound	<ul style="list-style-type: none"> • Proximity • Potential to biopsy 	<ul style="list-style-type: none"> • Invasive • Limited FOV
ERCP	<ul style="list-style-type: none"> • Potential to intervene 	<ul style="list-style-type: none"> • Invasive



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