GOALS AND OBJECTIVES

- Review ACR guidelines for appropriate imaging strategies
- Acute Pancreatitis
  - Revised Atlanta Working Group Classification
  - Discuss Imaging Reporting Implications in Management and Outcomes
  - CT Severity Index – Balthazar
- Chronic Pancreatitis
  - Cambridge Classification and Secretin-MRCP
  - Special Cases – Groove and Autoimmune Pancreatitis

Pancreatitis – The Basics

- Etiologies
  - Gallstones (38%)
  - Alcohol abuse (36%)
  - ERCP
  - Trauma
  - IPMN
  - Pancreas Divisum
  - Autoimmune
  - Hypercalcemia
  - Drugs (Tetracycline, Lasix, Estrogens, Diclofenac, SSRI, various Chemotherapy)
  - Infection (Viral: CMV, VZV, EBV, MMR; Bacterial: Mycoplasma, Staphylococcus, Salmonella, Ascariasis)
  - Familial Hypertriglyceridemia
  - Hereditary Pancreatitis (PFIS)
  - Sepsion/Septic admission

Pancreatitis – The Basics

- 210,000 admissions per year in the US for Acute Pancreatitis
- 50,000 additional admissions for Chronic Pancreatitis
- $2.6 Billion/yr from inpatient costs
- Most common Gastrointestinal complaint requiring hospitalization

ACR GUIDELINES

- Provide a framework for advising clinicians about the most appropriate/practical imaging strategy
- Emphasis on clinical status
- Answering specific questions
  - Changes in management (Perc. Drainage, ERCP, Surgery etc.)
  - Outcomes Prediction
- Clinical Decision Support for Imaging
  - Gov’t mandates
  - Guidelines heavily influence
We know it's pancreatitis!
Looking for etiology
Need for ERCP/MRCP?

Necrotizing Pancreatitis?
Other Unexpected Complications?

Prior Imaging
AND
Clinical Determination
Necrotizing Pancreatitis worsening?
New Unexpected Complications?

IMAGING PROTOCOL

- Routine CT Abdomen/Pelvis w/ IV contrast single phase - most cases
- More detailed evaluation, specific clinical questions, equivalent to previous imaging

Dual-phase CECT
- Late Arterial (Pancreatic Phase) (20-30s), (Optimally phase for pancreas and vascular structures)
- Portal Venous Phase (60-70sec)
- IV contrast: 75cc at 3-4cc/sec
- PO contrast: None or water
- Slice Thickness:
  - Late Arterial: 2.5mm for primary interpretation. 0.625-1.25mm reconstructions
  - Portal Venous: 5mm for primary interpretation. 2.5mm reconstructions for problem solving.

Necrotizing Pancreatitis?
Infection?
Vascular Complications?
Other Unexpected Complications?
IMAGING PROTOCOL

- MRI
  - Coronal and Axial T2 SSFSE/HASTE
  - Axial T2 FS FRFSE respiratory triggered
  - Axial T1 SPIR In and Out-of-Phase
  - Axial T1 (LAVA/VIBE) dynamic Pre and Post
    - 3cc/sec [30, 60, 90, 120, 180s]
  - Coronal T1 (LAVA/VIBE) Pre and Post
  - MIP
    - 2D Heavy T2 HASTE/SSFSE THICK, 4mm, Multiple oblique radial images
    - 3D Heavy T2 FS 3mm 3D Coronal (create rotating 3D MIP)
    - Can give Pineapple juice or Blueberry juice 500 cc to null fluid in upper GI tract.

ACUTE PANCREATITIS

ATLANTA REVISED CLASSIFICATION

- 1992 Atlanta Classification Working Group for Acute Pancreatitis
- Common nomenclature for GI, Radiology, Surgery, and Pathology
- Clinical severity
- Imaging
- Pathology/Sub
- Surgical findings
- Predicting outcomes and Standardizing management
- 2012 Revision
  - Eliminate/Clarity nomenclature

Acute Pancreatitis

- Definition for Diagnosis
  - At least 2 of the following:
    - Abdominal pain suggestive of pancreatitis (e.g. Acute persistent epigastric pain often radiating to the back)
    - Amylase and/or Lipase ≥ 3 times normal
    - Imaging features consistent with pancreatitis (CT, MR, or US)

Interstitial Edematous Pancreatitis (IEP)

- Pancreatic Enlargement
- Interstitial Edema (Focal or Diffuse)
- Peripancreatic inflammation: Altered contour, fat stranding, fluid in the anterior pararenal space
- 85% of acute pancreatitis
  - Typically normal homogenous parenchymal enhancement on CT and MRI, if edema is severe enhancement may be mildly heterogeneous
  - T2 MRI is more sensitive for parenchymal edema than CECT, DWI can be helpful
Necrotizing Pancreatitis

- Early phase detection of necrosis can be difficult
  - Ischemic pancreas appearance overlaps with severe IEP
  - Overtime nonviable tissue liquefies giving typical appearance
  - May take at least 24-48 hrs. to develop
  - CECT sensitivity <72 hrs is only 60-70% (Tsuji Y, AJR 2014)

CECT assessment of peripancreatic fat for necrosis is challenging and any suspicious areas of heterogeneity should be considered part of the necrosis

MRI necrosis
- T1 hypointense, non-enhancing
- Variable T2 signal dependent on amount of liquefied and non-liquefied parenchyma.
- Pre-contrast T1 hyperintensity indicates hemorrhagic fat necrosis, associated with poor outcomes
Focal Necrosis in the Midbody and Head

Diffuse Necrotizing Pancreatitis

Only small area of normal enhancing pancreas in head

We'll see the f/u of this later

Early Phase Fluid Collections < 4 Weeks

- Acute Peripancreatic Fluid Collection (APFC)
- Acute Necrotic Collection (ANC)
  - Unencapsulated
  - APFC are amylase rich and uniformly low density
  - ANC has mixed liquefied and solid material
    - Heterogeneous fluid on CECT or mixed T2 signal on MRI (more evident >1 week)

Early Phase Fluid Collections < 4 Weeks

- Early in 1st week APFC and ANC may be INDISTINGUISHABLE
- ANC usually intrapancreatic AND peripancreatic
- Intrapancreatic fluid collection < 4 weeks should be considered ANC
Thickened Fascia
Not a capsule
Necrotizing Pancreatitis
w/ ANC
Remember case this we’ll see the followup later...

Late Phase Fluid Collections >4 Weeks

- Pseudocyst
  - 10-20% of all pancreatitis cases
- Walled Off Necrosis (WON)
  - 1-9% of all pancreatitis cases
- Encapsulated
- Pseudocyst uniformly low attenuation, amylase rich
- WON liquefied and non-liquified components

Features favoring WON:
- Internal fat or solid density, large size, extension to paracolic gutters, retrocolic space, irregular borders, multiple septations
- Dilated pancreatic duct more common in Pseudocyst
- Demonstrating persistent ductal communication or disconnected duct is not critical to the diagnosis of the collection but is important in determining management (e.g., prolonged percutaneous drainage, stenting, surgery)
- MRI/MRCP better than CECT.
Follow up of our prior diffuse necrotizing pancreatitis imaged in ER read as IEP. Patient slowly improved over time but remained symptomatic. No imaging follow up in first week. Patient discharged and readmitted few weeks later.

Lesson learned. False sense of security on initial CT. Period of necrosis development at 48-72 hours missed. 2 years later. Only small atrophic parts of pancreas remaining.

Necrosis can be very difficult to appreciate, even with old comparisons.
Pseudocysts – Patient had history of multiple prior episodes of pancreatitis

Prior history of pancreatitis. Stable finding over many years

Multiple Pseudocysts
Largest was symptomatic due to mass effect

Focal Necrosis in Body and Neck

Multiple Fluid Collections (ANC)
Patient not improving. Paracentesis suggested

Pancreatic Ascites – Disconnected Duct/Gas leak
Infection

- Almost never seen < 1 week from onset of symptoms
- Most commonly 2-3 weeks after disease onset
- ANY pancreatic fluid collection may be either sterile or infected
- ONLY definitive CT sign is GAS in the collection
- BUT... only seen in 12-22%, also rarely seen if fistula present
- Most are diagnosed clinically and confirmed with FNA

Clinical Course and Severity

- **Course and Severity of Disease**
  - **Clinical** - Primary Method of Assessment
    - APACHE II (severe >8)
    - Marshall
    - Ranson Severity Index
  - **Imaging** - CT Severity Index
    - **Phases**
      - Early <1 week
      - Late >1 week
  - **Note:** Amylase and Lipase levels DO NOT correlate w/ likelihood or necrosis, organ failure or mortality

Clinical Outcomes/Imaging Timing

- **Early Phase (1st Week)**
  - **Non-Severe Pancreatitis**
    - Mild (0-15% mortality)
    - No organ failure
    - No local or systemic complications
    - Moderate (~2% mortality)
    - Transient organ failure <48 hrs
    - Local or Systemic complications without persistent organ failure
  - **Severe Pancreatitis** (20-30% mortality)
    - Persistent Organ failure >48 hrs
    - Local or Systemic complications

CT Severity Index

- **Balthazar et al. 1994**
  - 10 Point simple system of imaging findings
  - Currently the best Imaging tool for predicting outcomes
  - Validated in multiple studies across disciplines
  - Bollen T et al. 2011, AJR 175 consecutive cases of acute pancreatitis.
  - CT Severity Index vs APACHE II
    - NO Difference in mortality, ICU stay, organ failure, clinical severity
    - Trended toward better predicting infection
  - CT better predictor for intervention
  - CT better with more recently proposed Modified CTSI by Mortele 2004

CT Severity Index - Balthazar System

<table>
<thead>
<tr>
<th>Condition</th>
<th>Points</th>
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<tbody>
<tr>
<td>Pancreatic Fluid Collection</td>
<td>0</td>
</tr>
<tr>
<td>Enlargement of Pancreas (mm)</td>
<td>1</td>
</tr>
<tr>
<td>Peripancreatic Fluid Collection</td>
<td>2</td>
</tr>
<tr>
<td>Acute Peripancreatic Fluid Collection</td>
<td>3</td>
</tr>
<tr>
<td>&gt;2 Acute peripancreatic Fluid Collections</td>
<td>4</td>
</tr>
<tr>
<td>Pancreatic Necrosis</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>&lt;30%</td>
<td>2</td>
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<td>&gt;50%</td>
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Category:
- Mild 0-3 pts
- Moderate 4-6 pts
- Severe 7-10 pts

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Treatment

- **IEP** - Self Limited Supportive Care
  - APFC only 25% become symptomatic or infected requiring drainage
  - Most Pseudocysts are asymptomatic and resolve spontaneously
  - Symptomatic or infected can be treated with simple percutaneous drainage
  - Endoscopic drainage/cystogastrostomy in cases of sterile pseudocyst not accessible by percutaneous route

Systemic Inflammatory response syndrome (SIRS) two or more criteria:
- Heart rate >90 beats/min
- Core temperature <36°C or >38°C
- White blood count <4000 or >12000/mm³
- Respirations >20/min or PCO₂ >32 mm Hg
Treatment

Necrotizing Pancreatitis

- ANC progression: sterile WON 60%, infected WON 20%, resolve spontaneously 20%
- Infected ANC or WON
  - High mortality ~30%
  - Surgical debridement traditional standard of care
  - BUT: High mortality 34-45% and mortality 11-39% if performed early
  - Percutaneous drainage ALONE often insufficient (non-liquefied material). PCD alone failure is 50%
  - Large bore catheters 12F-30F and multiple
  - Step up approach; early PCD then endoscopic or delayed surgical necrosectomy

Sterile Necrosis

- Asymptomatic or Clinically stable and improving cases DO NOT necessarily require drainage
- Short term follow up CTs 7-10 days to exclude developing infection and demonstrate no progression of necrosis
- Prolonged critical illness with imaging that is ambiguous should have FNA to prove sterility
- Sterile collections in critically ill patients that do not improve may benefit from percutaneous drainage. Controversial. Risk of secondary infection.

ACG Concensus Guidelines: ABX

1. Antimicrobials SHOULD BE GIVEN for an extrapancreatic infection
   - Eg: cholangitis, catheter-acquired bactemia, bacteremia, intercurrent infection. (strong recommendation, moderate quality of evidence).

2. Routine prophylactic antibiotics with severe AP is NOT RECOMMENDED (strong recommendation, moderate quality of evidence).

3. Antibiotics in sterile necrosis to prevent infected necrosis is NOT RECOMMENDED (strong recommendation, moderate quality of evidence).

4. Infected necrosis SHOULD BE CONSIDERED in patients with pancreatic or extra-pancreatic necrosis who deteriorate or fail to improve after 7-10 days of hospitalization. (strong recommendation, moderate quality of evidence).

5. FNA to guide therapy: Gram stain and culture. (strong recommendation, moderate quality of evidence).

6. Routine administration of antifungal agents along with prophylactic or therapeutic antibiotics is NOT RECOMMENDED (conditional recommendation, low quality of evidence).

ACG Concensus Guidelines: Surgery

1. Patients with mild AP, with gallstones, cholecystectomy +/- ERCP or intraop cholangiography should be performed before discharge to prevent a recurrence of AP. (moderate recommendation, moderate quality of evidence).

2. Patients with necrotizing biliary AP, in order to prevent sepsis, cholecystectomy is to be deferred until stable inflammation and fluid collections resolve or stabilize (strong recommendation, moderate quality of evidence).

3. Asymptomatic pseudocysts and pancreatic and/or extrapancreatic necrosis DO NOT warrant intervention regardless of size, location or extension (moderate recommendation, high quality of evidence).

4. Stable patients with infected necrosis surgical, radiologic or endoscopic drainage should be delayed preferably for more than 4 weeks to allow liquefaction of contents and the development of a fibrous wall around the necrosis. (walled-off necrosis) (strong recommendation, low quality of evidence).

5. In symptomatic patients with infected necrosis, minimally invasive methods of necrosectomy are preferred to open necrosectomy. (strong recommendation, low quality of evidence).

Other Complications

- Gastric outlet obstruction
- Pseudoaneurysm (Mortality 12.5% treated, 90% untreated)
- Venous thrombosis
- Pancreatic fistulas
- Pleural effusions
Chronic Pancreatitis

- Relapsing inflammation leading to permanent exocrine and endocrine pancreas damage
- Progressing degrees of fibrosis from patchy (early) to diffuse (late)
- Advanced disease results in atrophy but overlaps with age-related atrophy and not usually a useful imaging criteria
- Similar complications to acute pancreatitis
- Imaging primarily use to establish presence of chronic pancreatitis and determine early vs late disease status

Chronic Pancreatitis

- Late disease is obvious
  - Calcifications
  - Atrophy
  - Irregular pancreatic morphology
  - Diffuse ductal abnormalities: Areas of dilatation and strictures of main duct and side branch diffuse ectasia

Chronic Pancreatitis

- Early disease is challenging
  - CT, conventional MRI and US relatively insensitive
  - Absent parenchymal changes
  - Main duct often normal and side branch dilatation not appreciable, insufficient resolution
  - ERCP, traditional method of diagnosis, contrast distension of ducts improves resolution or side branch abnormalities, reveals subtle strictures
  - Invasive, requires anesthesia, iatrogenic pancreatitis
  - Cambridge Classification (MRCP)
Cambridge Classification - MRCP

- **Cambridge 1** Not identifiable MRCP abnormalities
- **Cambridge 2 (Mild)** Two or more of the following abnormalities:
  - Pancreatic duct 2 to 4 mm in the body of the pancreas
  - Mild pancreatic enlargement
  - Heterogeneous parenchymal structure
  - Small cysts (< 10 mm)
  - Duct irregularities
  - More than 3 abnormal side branches

- **Cambridge 3 (Moderate)** All the abnormalities listed in 2, above, along with abnormal main duct (> 4 mm)
- **Cambridge 4 (Severe)** One of the abnormalities listed in 2 or 3, above, and one or more of the following:
  - Cystic structures > 10 mm
  - Parenchymal calcifications
  - Intraductal filling defects (calcium stones)
  - Duct obstruction (stricture)
  - Major irregularity of duct

Secretin MRCP

- No radiation and Noninvasive
- Physiologic imaging
  - Increase pancreatic juice secretion
  - Sphincter of Oddi increased tone during 1st 5 min
- Expensive and Limited availability
- Limited utility in late disease – best use is early chronic pancreatitis
  - Decrease exocrine function and secretin response
  - MRCP5 vs ERCP gold standard, sensitivity and specificity for the diagnosis of mild chronic pancreatitis [Cambridge classification] was 56%–63% and 92%–72%, respectively.
- Initial 2D HASTE Thick Heavy T2 Oblique that best depicts entire ductal system. Inject secretin either weight based or 100 U fixed dose. Repeat sequence every 30 seconds for 10 min.
  - Normal MD: Incr 1-2 mm, peaks at 3-5 min, returns to baseline at 10 min

Pancreas Divisum

- Normal Variants (~7% population based on autopsy series)
  - Dorsal and Ventral ducts remain separate. Main duct drains via the minor papilla.
  - Pancreatitis caused by inadequate duct drainage and increased intraductal pressure from stenosis at minor papilla or congenital small size of the distal duct at the papilla (Controversial)
  - Duct-cross over sign

Duct Cross Over Sign

Duct Cross Over Sign

Patient also currently has BP
Groove Pancreatitis

- Rare variant of chronic pancreatitis
- Pathogenesis controversial
  - Partial obstruction of accessory pancreatic duct of indeterminate etiology
  - Similar demographics to typical chronic pancreatitis (most commonly middle age men w/ alcohol abuse)
- Lipase usually normal
- Pure (groove only) vs Segmental (groove + pancreatic head)

Groove Pancreatitis

- CECT and MRI features
  - Cystic changes near/at accessory pancreatic duct
  - Ill defined fat stranding along pancreaticoduodenal groove
  - Delayed enhancement from fibrosis
  - Sheet-like mass/thickening in groove

- Groove Pancreatitis vs Adenocarcinoma
  - Using above imaging features accuracy is 87% excluding cancer with NPV of 92.9%

Autoimmune Pancreatitis

- Associated with other autoimmune disorders, IBD, Sjogrens, Retroperitoneal fibrosis, PBC, PSC, SLE
- Pancreatic manifestation of IgG4 Sclerosing Disease
- 2-11% of Chronic pancreatitis, M:F 15:2
- Lymphoplasmacytic infiltrates, elevated IgG4 levels
- Focal, Multifocal, Diffuse patterns
- Diffuse is most common: swollen “Sausage-like pancreas”
- Absence of atrophy, peripancreatic fluid, nor any duct dilatation
- Well demarcated boundary or rim
- Focal – T2 hyperintense “mass” with T2 hypointense rim and delayed enhancement, mimic carcinoma, no duct cutoff sign, usually areas of ductal dilatation are appreciated
Summary

- Discuss Imaging strategies for Acute Pancreatitis
- Use Atlanta Revised Classification for Acute Pancreatitis
- Predict outcomes and participate in treatment planning based on imaging findings
- Use CT severity index elements in reporting
- Recognize and better diagnose early chronic pancreatitis
- Use MRCP-S and Cambridge Classification elements in reporting
- Better recognize Groove Pancreatitis and Autoimmune Pancreatitis

Thank you

References

- Thoeni Ruedi. The Revised Atlanta Classification of Acute Pancreatitis—3012: revision of the Atlanta classification and definitions by international consensus. Out 2013;62(1) 103-11

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- Kumar SP, Jotana SH. Groove Pancreatitis: Spectrum of Imaging Findings and Endoscopic Pathology Correlation. AJR 2013; 200:969-976.