



# Imaging Predictors of Poor Prognosis in Pancreatic Adenocarcinoma Beyond Traditional Staging Criteria

Bhavik N. Patel, MD, MBA

*Dept. of Radiology, Duke University Medical Center, Durham, NC*

*No Financial Disclosures*



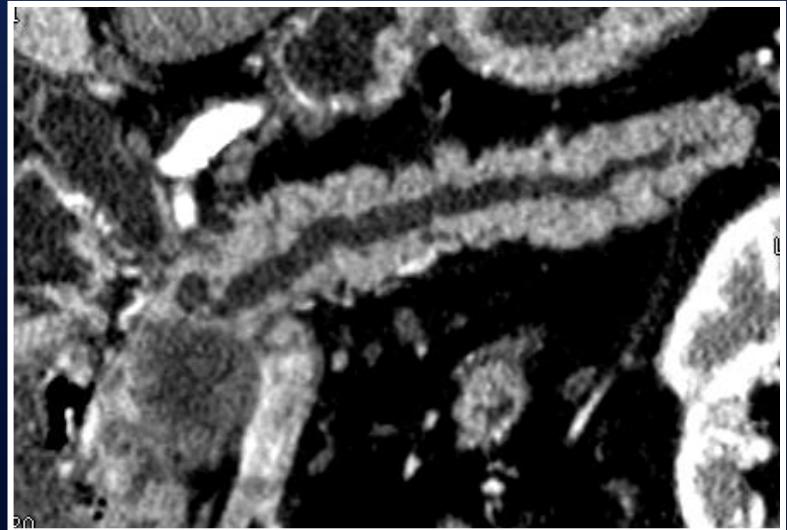
Duke Radiology

 @bpatel\_mba



# Background on Pancreatic Cancer

- Fourth leading cause of cancer related deaths in the U.S.
- Overall 5-year survival rate is < 5%
- Factors contributing to poor survivability:
  - Lack of tumor marker for early detection
  - Systemic therapy not as effective as for other tumors
  - Aggressive biological behavior with early dissemination, even with small tumors (<2 cm)



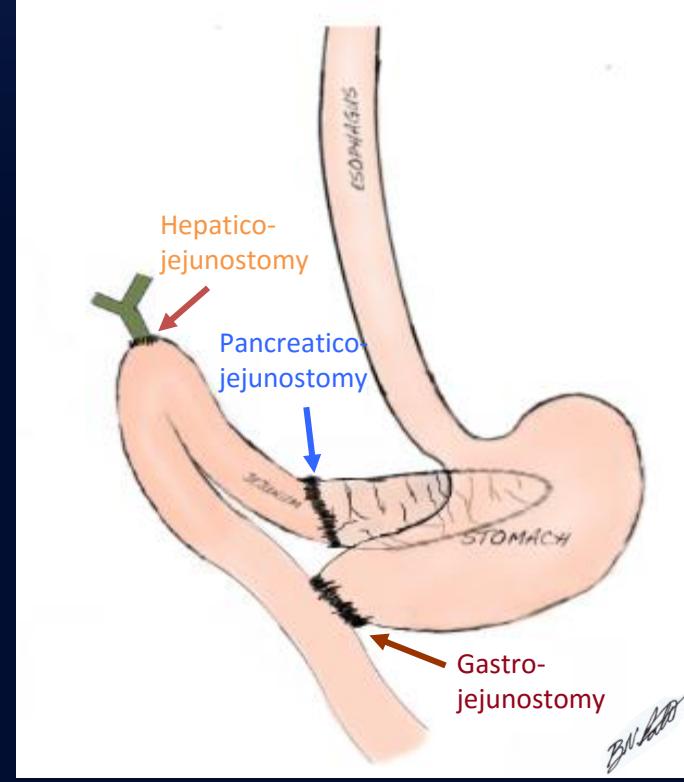
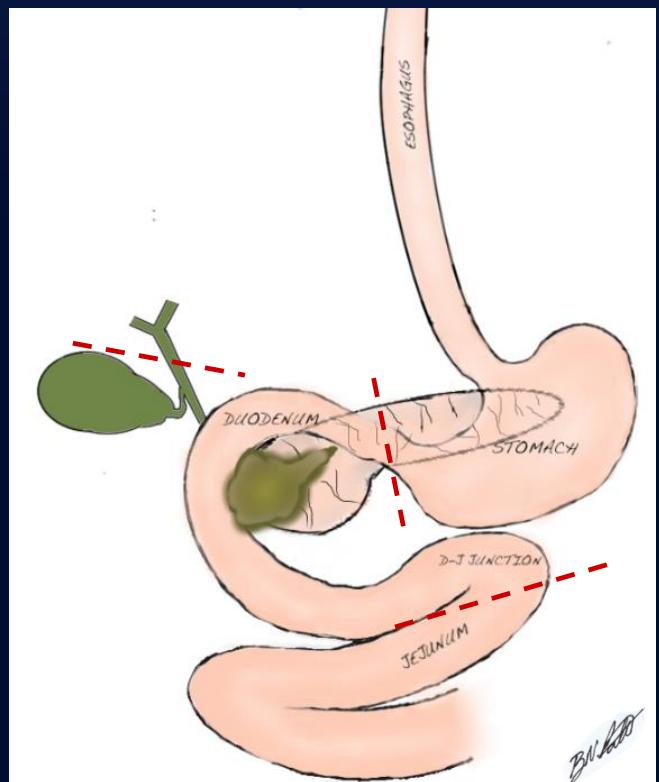
59 year old male with jaundice and resectable pancreatic head mass on CT (red arrow). Patient underwent resection (R0) but expired in 11 months.





# Current Treatment - Whipple

- Only **curative** option is pancreaticoduodenectomy
- Median survival 17 months after surgery
- Perioperative mortality of 5% and morbidity of 20-30%





# Current Treatment - Whipple

*R* staging: Pathologist will confer R stage based on the absence (R0) or presence of microscopic (R1) and/or macroscopic (R2) positive surgical margins.

Survival (yr)	R0 (%)	R1, R2 (%)
1	52	32
2	34	8
3	19	2
4	12	0
5	11	0

Todd KE HA. Prognostic Considerations in Pancreatic Cancer. Canada: American Cancer Society; 2001.





# Resectability

- Currently, CT plays a role in stratifying patients into resectable, unresectable, or borderline resectable
- Margin status impact survivability

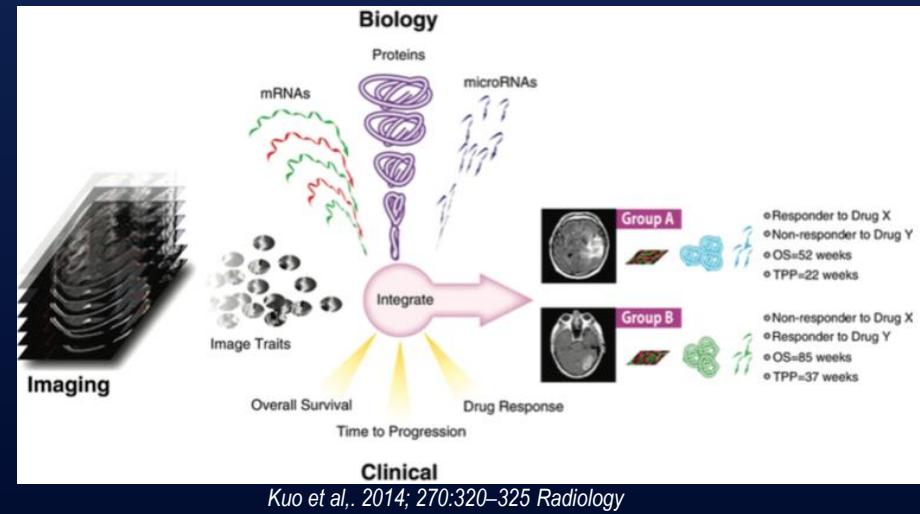
Vessel	AHPBA/SSAT/SSO/NCCN	MDA	Alliance
SMV/PV	Any involvement	Occlusion	Tumor-vessel interface $\geq 180^\circ$ of vessel wall circumference, and/or reconstructable occlusion
SMA	Abutment	Abutment	Tumor-vessel interface $< 180^\circ$ of vessel wall circumference
HA	Abutment or short segment encasement	Abutment or short segment encasement	Reconstructable short segment interface of any degree between tumor and vessel wall
CA	Not involved	Abutment	Tumor-vessel interface $< 180^\circ$ of vessel wall circumference





# Radiogenomics

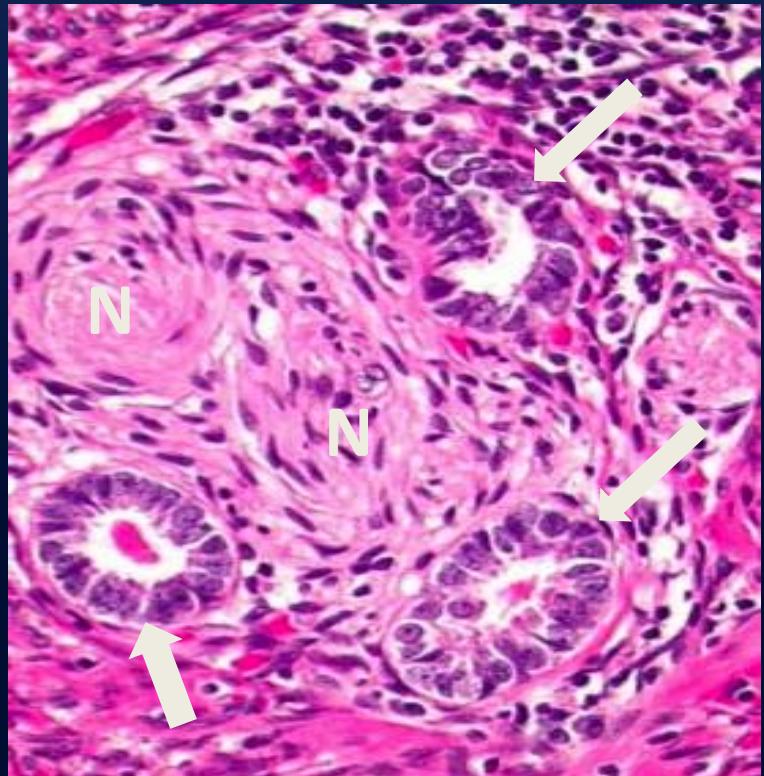
- Can we identify radiologic biomarkers that predict aggressiveness and poor outcomes?
- Are there resectable and borderline resectable tumors that have an aggressive phenotype and should be treated as unresectable?
- Two examples: Perineural invasion (PNI) and duodenal invasion (DI), both shown to reduce PFS and overall survival<sup>1</sup>





# What is PNI?

- Abundance of nerve fibers surrounding the pancreas and complex network with 6 extrapancreatic neural plexuses
- Infiltrative ***neurotropic growth*** along neural fascicles
- Not just ***spread*** along perineurium, but ***invasion*** into all 3 layers (epi-, peri-, and endoneurial spaces)
- Currently not taken into account for determination of resectability as it traditionally a pathologic diagnosis and difficult to detect radiologically.



*Histologic section shows nerve fibers (N) surrounded by adenocarcinoma cells (white arrows)*





# What do we know about PNI?

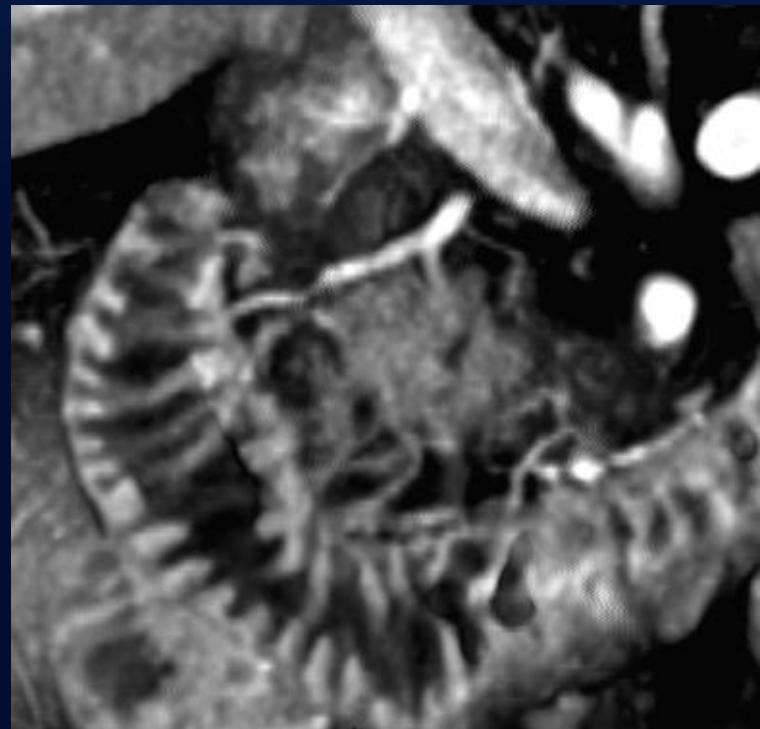
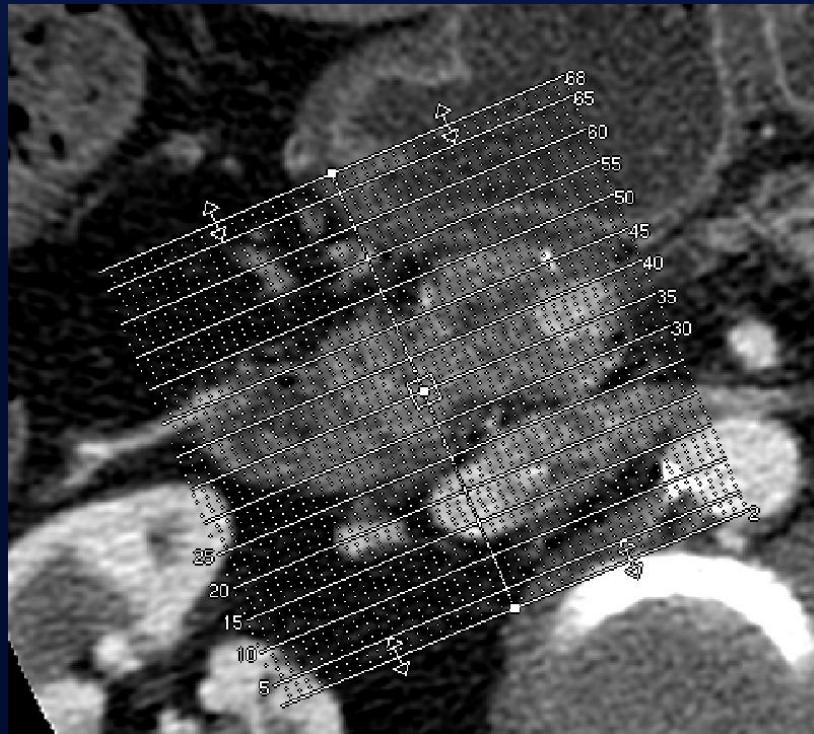
- *PNI portends a poor prognosis & lowers survival*
- Significant cause of positive surgical margins
- Increases likelihood of recurrence
- *PNI shown in early stages as well as small (<2 cm) tumors*
- Even short segment of extrapancreatic PNI (2.5 cm) has been shown to reduce survival compared with intrapancreatic PNI
- Seen in 70-100% of pancreatic adenocarcinomas





# How Can We Detect PNI?

- Small field of view (SFOV) (12cm) 3D VR images are helpful
- Allows visualization of small peripancreatic vessels needed to detect PNI



*Slabs at 20° right coronal oblique plane*

*Coronal SFOV 3D VR*



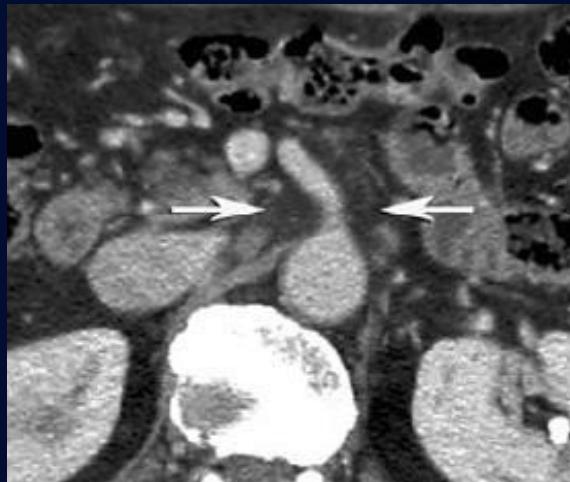
**Duke** Radiology



# MDCT Appearance of PNI

- PNI follows predictable course along neurovascular bundles
- Must have high-res 3D VR images
- Confluent soft tissue attenuation, similar to that of primary tumor, extending along known pathways but different from lymphatic invasion
- Advanced cases may prove difficult to distinguish direct tumor extension, PNI, and lymphatic invasion, latter of which is more lacy/reticular in appearance

Lymphatic Invasion



Perineural Invasion



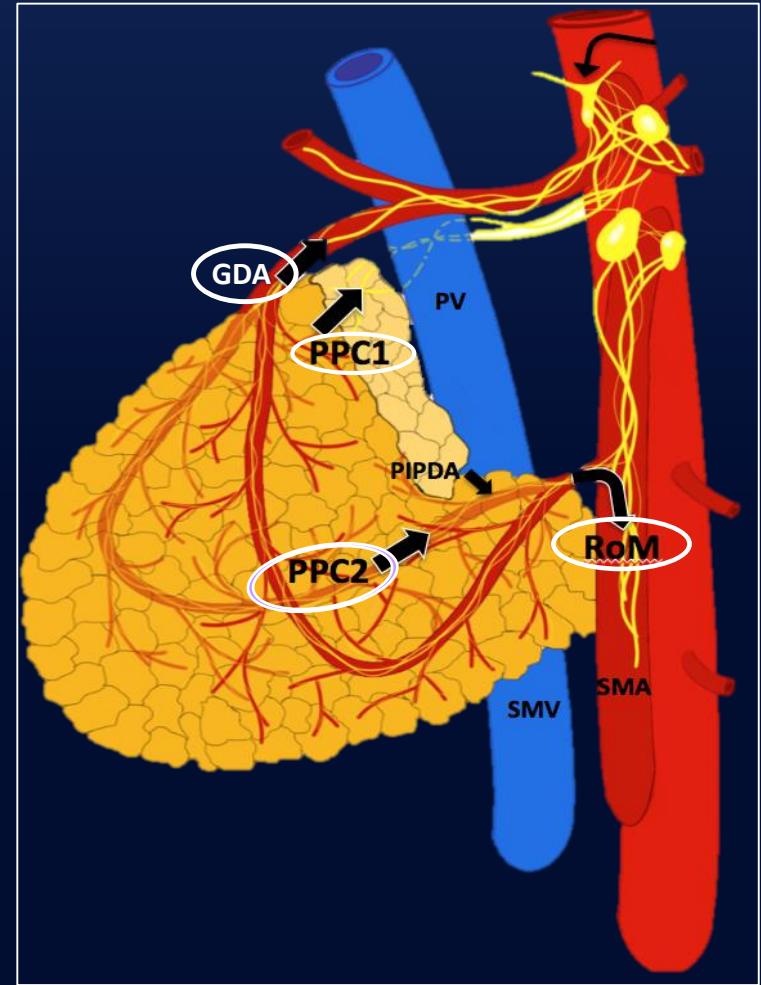
versus

Sai M et al. Abdom Imaging. 2010 Apr;35(2):154-62



# 4 Pathways of Extrapancreatic PNI

- **PPC I**
  - right celiac ganglion → upper medial margin of head/uncinate via posterior to PV
- **PPC II**
  - SMA → uncinate via PIPDA mesenteric ganglion
- **Anterior Pathway**
  - Anteriorly along GDA → CHA plexus
- **Root of Mesentery Invasion (RMI)**
  - SMA → uncinate via PIPDA caudally to infiltrate RoM

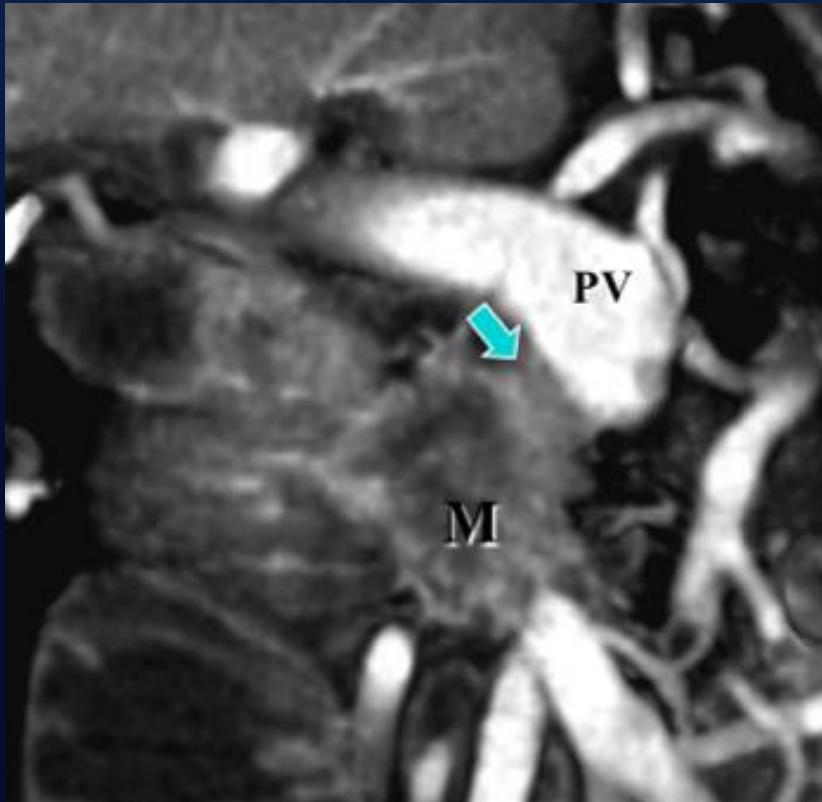


Drawing by B. N. Patel





# PPC I: Case Example



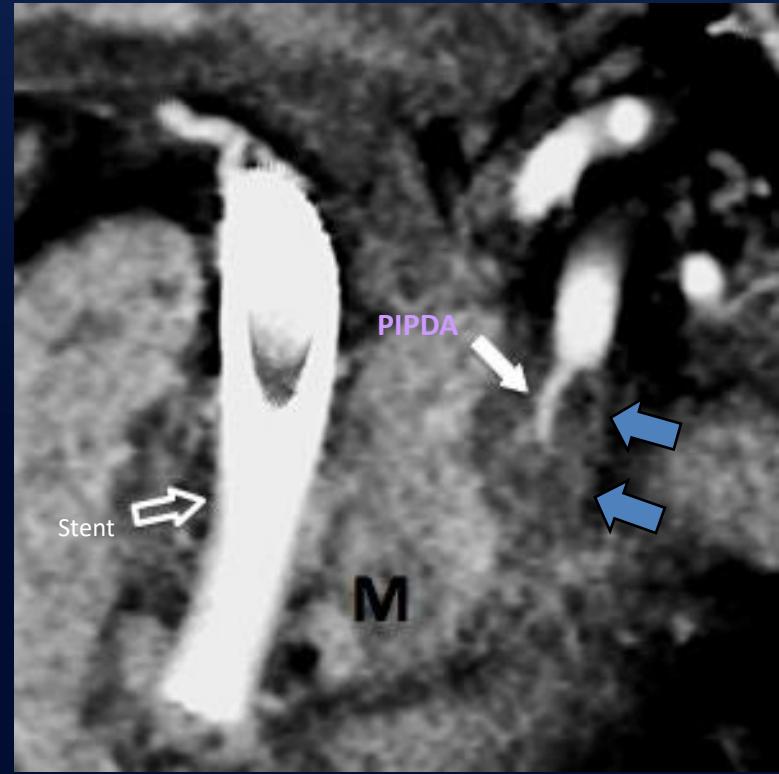
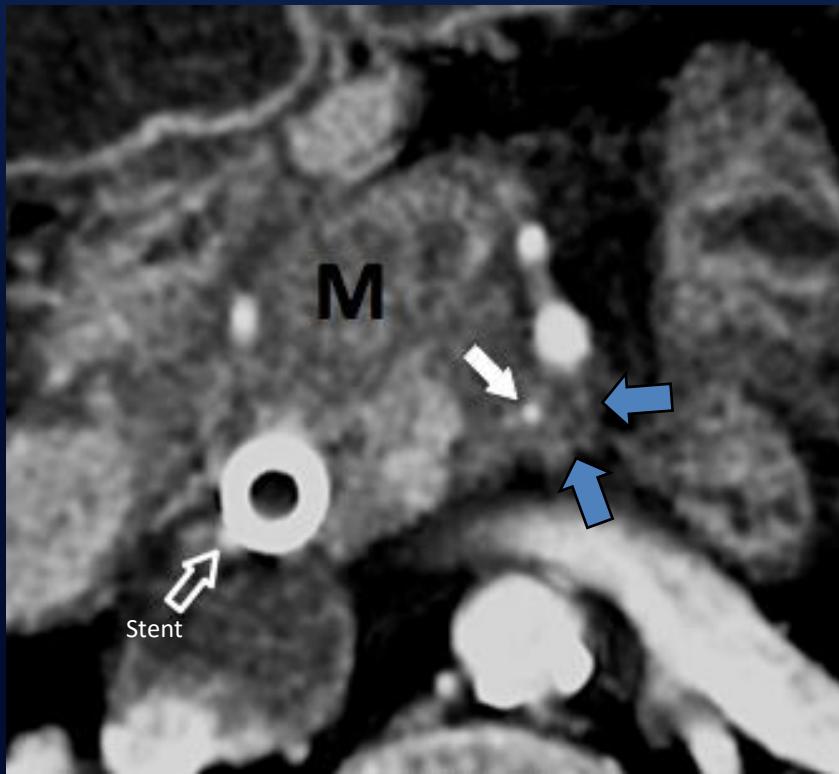
*Coronal 3D VR Image shows a pancreatic mass (M) and PNI (arrows) extending posterior to the portal vein, ultimately towards the celiac ganglia.*



Duke Radiology



# PPC II: Case Example



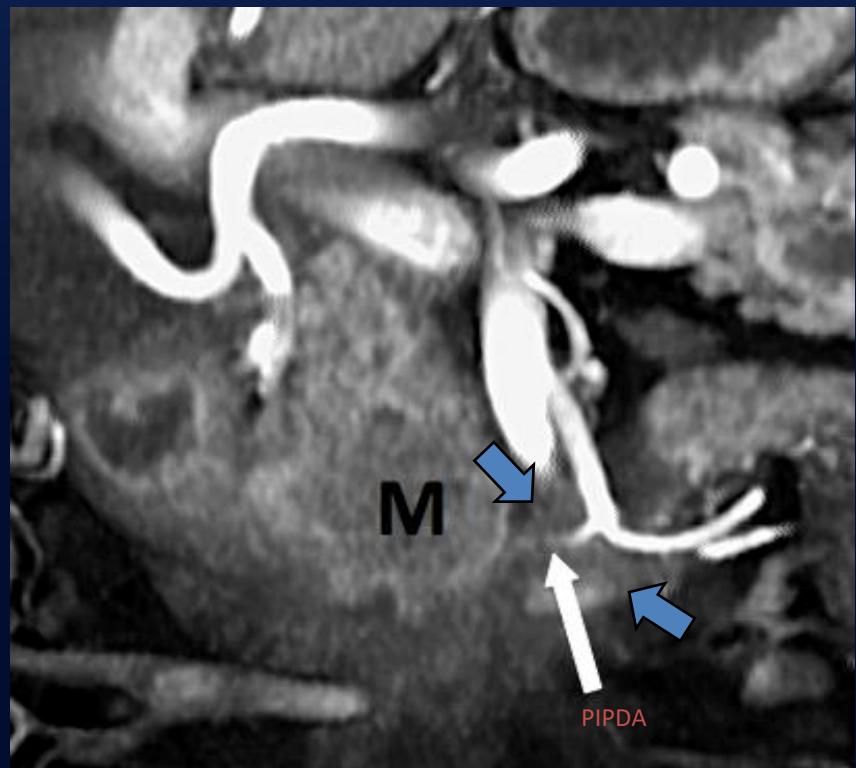
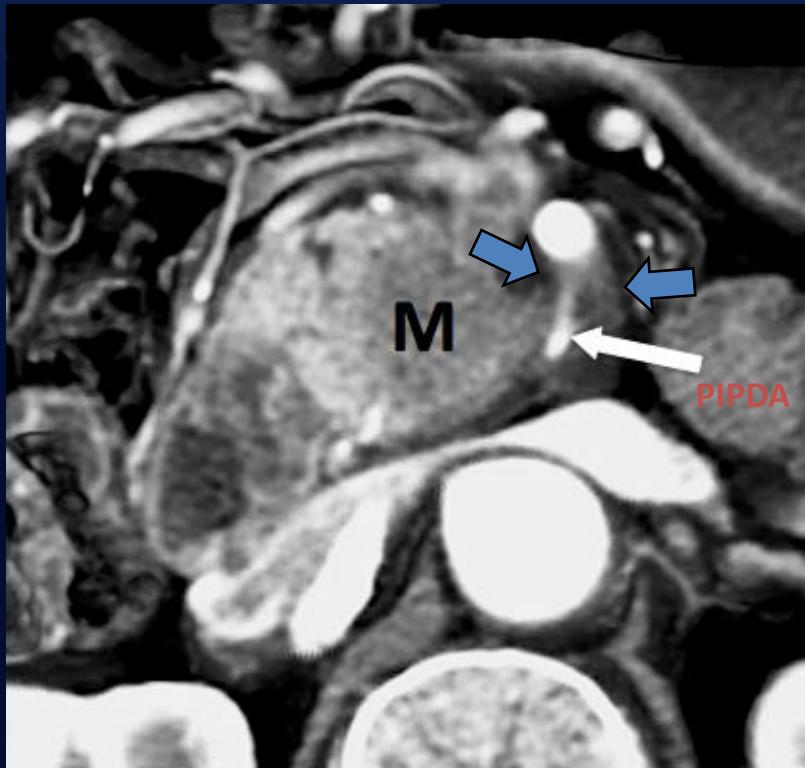
Axial 3D VR (left) and coronal 3D VR (right) show a pancreatic uncinate mass (M) with PNI (blue arrows) along the PIPDA (white arrow).



Duke Radiology



# PPC II: Case Example 2



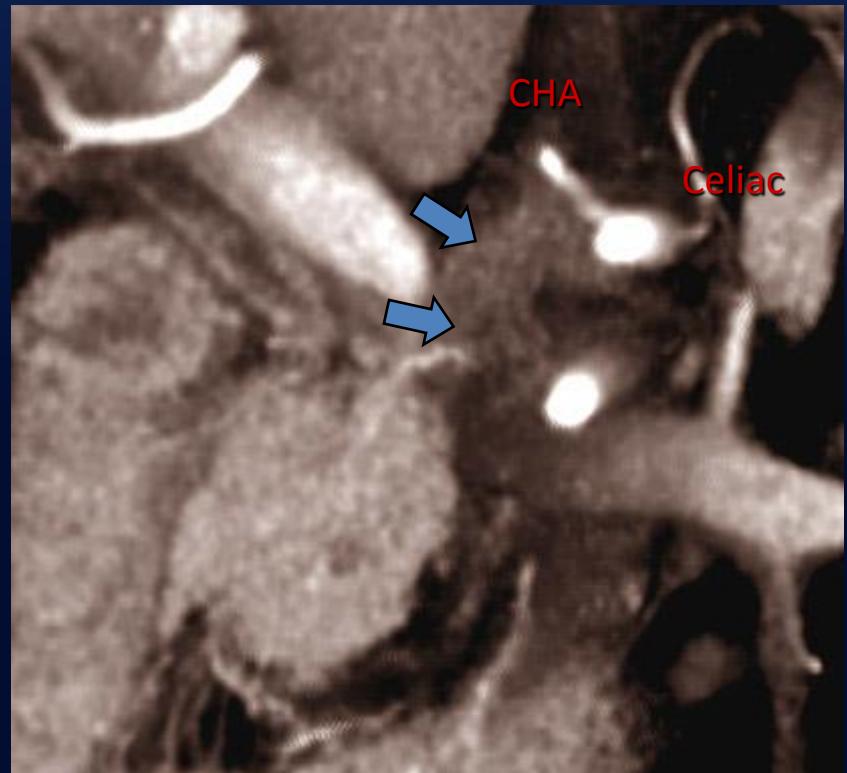
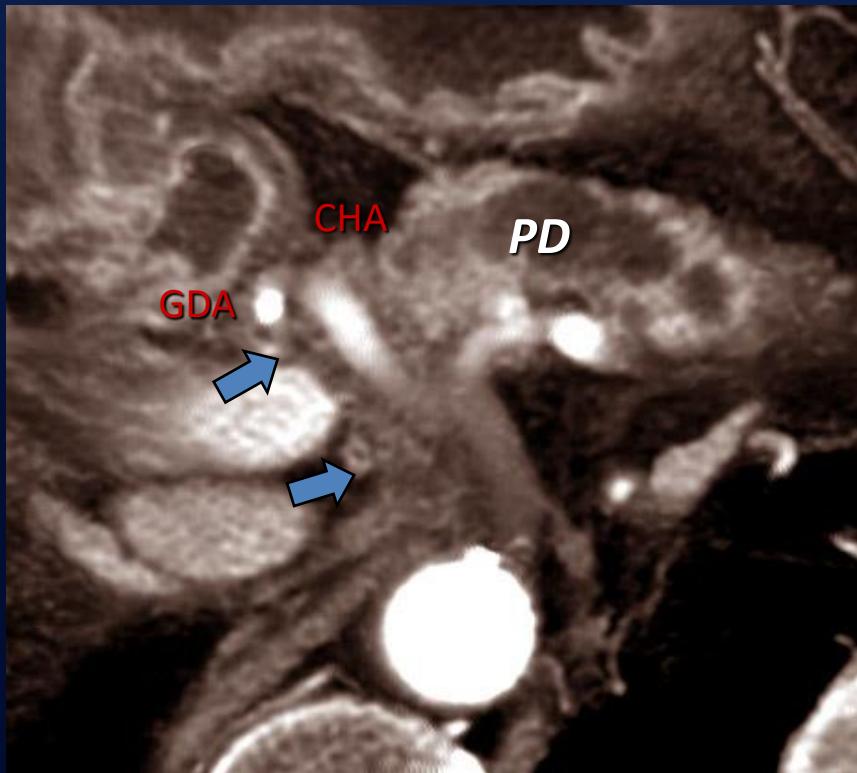
Axial 3D VR (left) and coronal 3D VR (right) show a pancreatic uncinate mass (M) with PNI (blue arrows) along the PIPDA (white arrow) heading towards the SMA.



Duke Radiology



# Anterior Pathway: Case Example



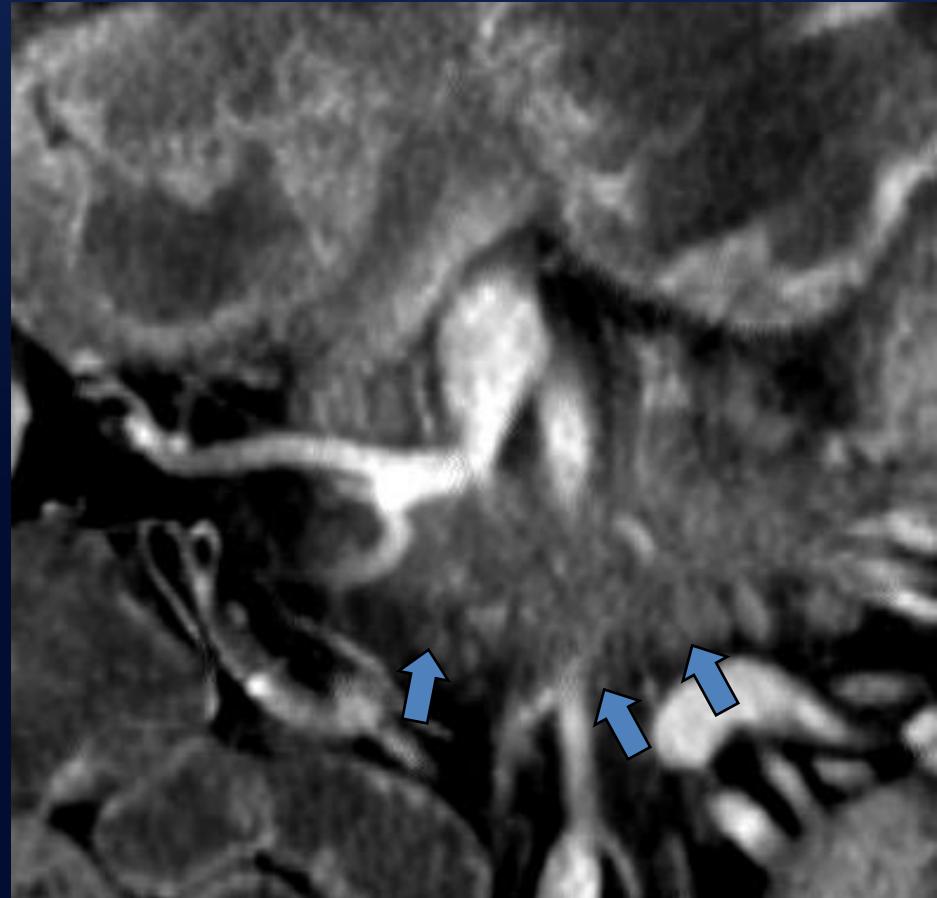
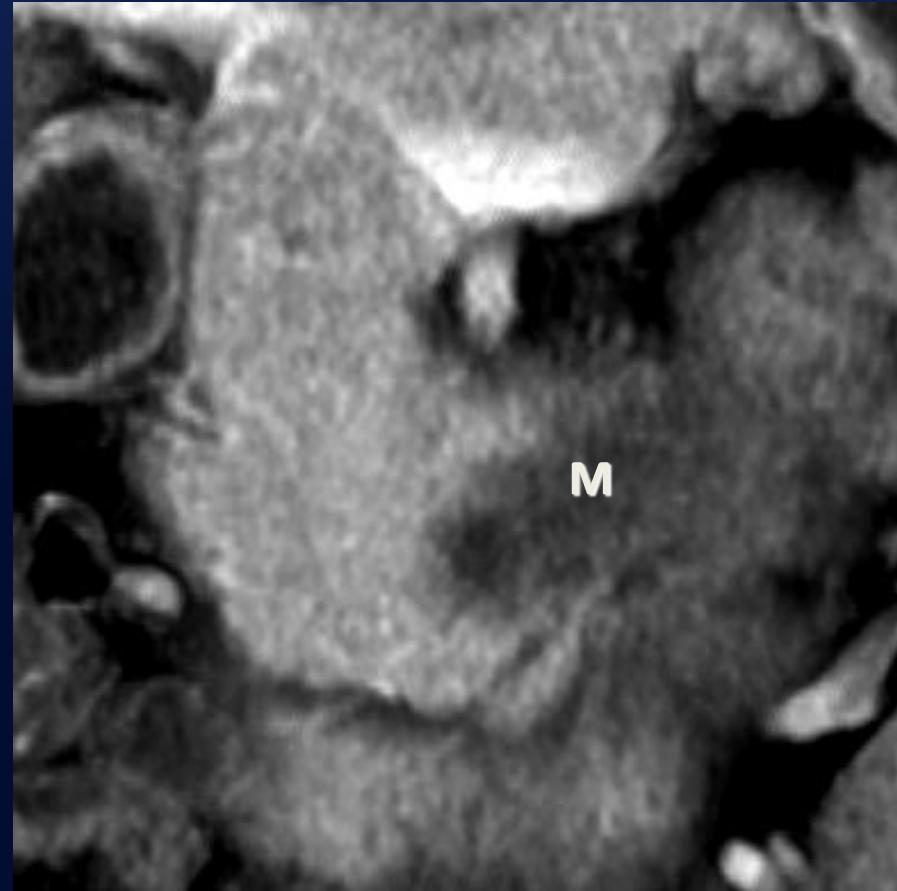
Axial 3D VR (left) and coronal 3D VR (right) show pancreatic ductal dilation (PD) and soft tissue attenuation (blue arrows) around the GDA and CHA, heading towards the right celiac ganglion.



Duke Radiology



# RMI: Case Example



Coronal 3D VR images show a pancreatic mass (M) with PNI (blue arrows) along the mesenteric root.



Duke Radiology



# Duodenal Invasion

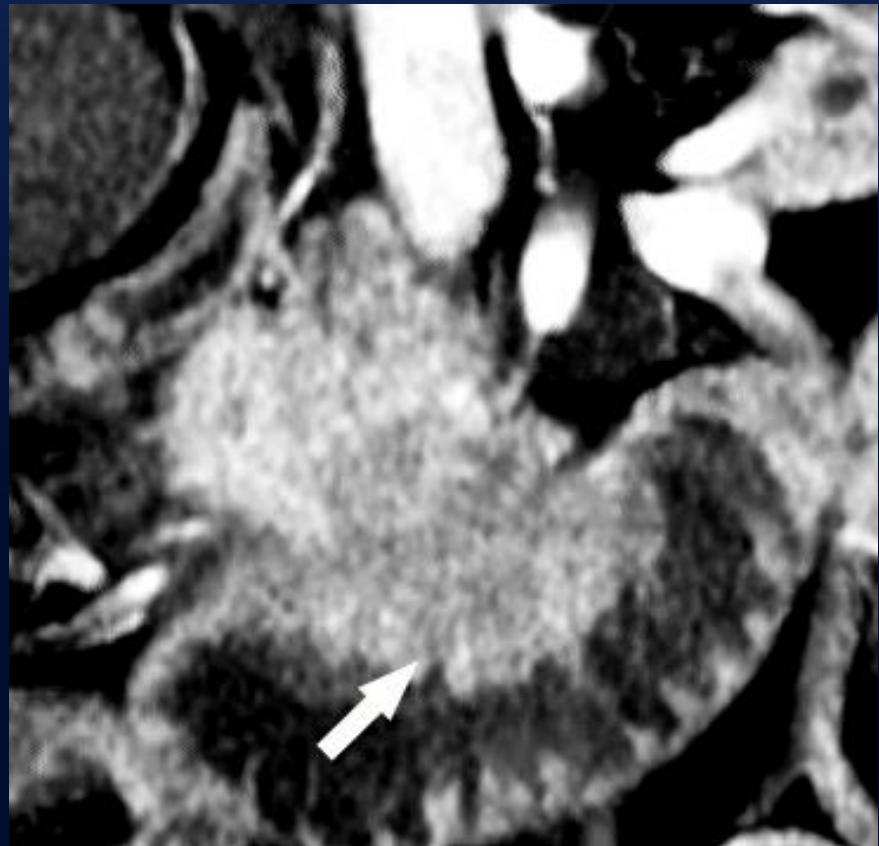
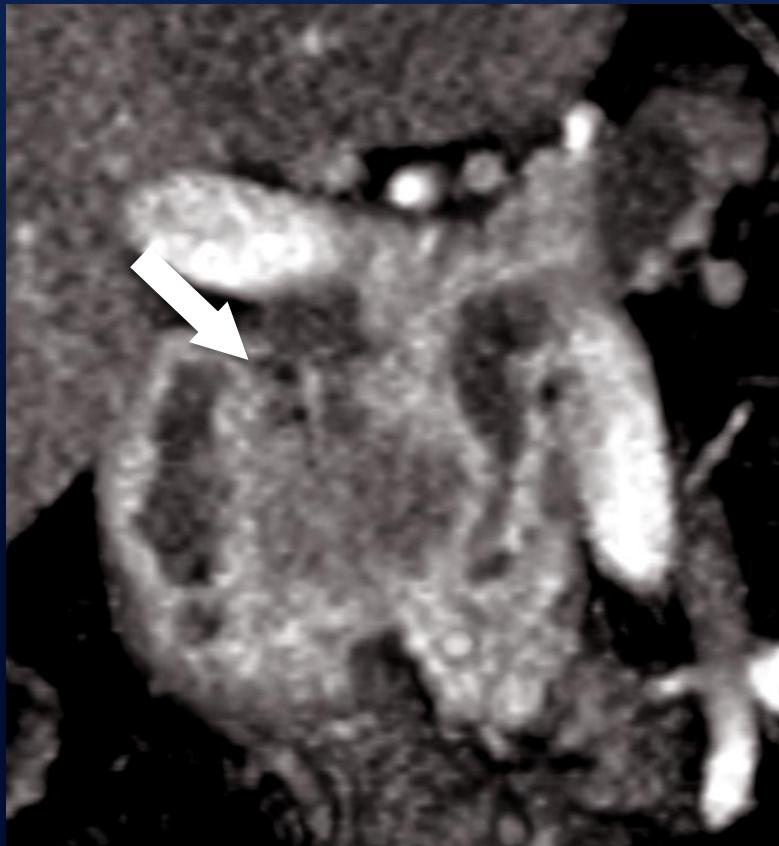
---

- Traditionally, not taken into account or commented on surgical staging CTs as it is part of the surgical specimen
- Can impact choice of neoadjuvant radiotherapy
- Can be difficult to detect, especially without adequate D2 distension with a neutral oral contrast agent (e.g. water or VoLumen)
- Direct tumor extension and interruption of enhancing duodenal wall are key imaging features
- 3DVR and DECT (iodine only) may be useful in helping identify DI





# Duodenal Invasion: Case Examples



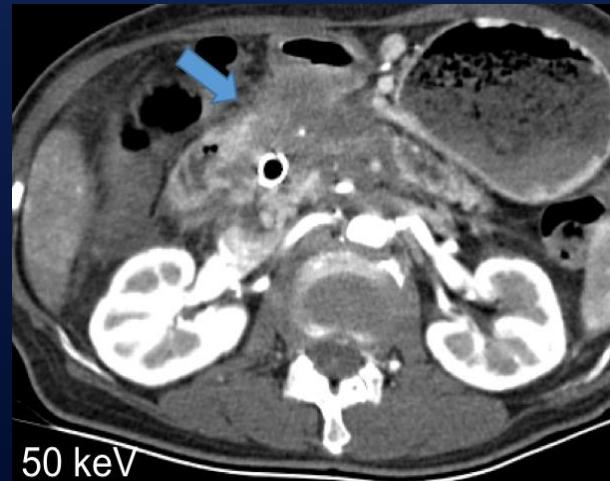
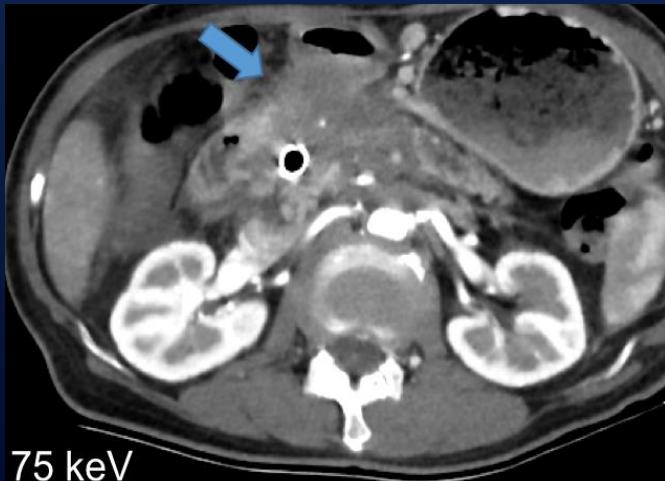
*Coronal 3D VR images of two different patients show direct tumor invasion into the duodenal wall.*



**Duke** Radiology



# Duodenal Invasion: Case Example



*rsDECT images through the pancreas shows direct tumor invasion of the duodenal wall (arrow)*

Iodine



**Duke** Radiology



# Conclusion

---

- Pancreatic cancer continues to be a deadly systemic disease despite advances in imaging and oncology
- PNI and DI have been shown to reduce PFS and survivability
- Conventional staging does not take into account these features
- Future CT staging should incorporate imaging biomarkers as part of assessment





# Thank You!

Bhavik N. Patel, MD, MBA  
[Bhavik.Patel@duke.edu](mailto:Bhavik.Patel@duke.edu)

 *Follow me on Twitter*  
[@bpatel\\_mba](https://twitter.com/bpatel_mba)

Acknowledgement: Dr. R. B. Jeffrey