

Contouring GTV for Hepatic Tumors: An Image Guided Approach

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Hepatic Tumours

- Hepatocellular Cancer
- Cholangiocarcinoma
- Liver Metastasis

Hepatocellular Cancer: SBRT

IMAGING: TRIPHASIC CECT

- Very Specific Imaging Features on Triphasic CECT
- Rapid Wash in and Rapid Wash Out
- Tissue diagnosis not needed in a vast majority of patients.

Breathhold Scans Critical: 4DCT best avoided

Careful attention to respiratory motion

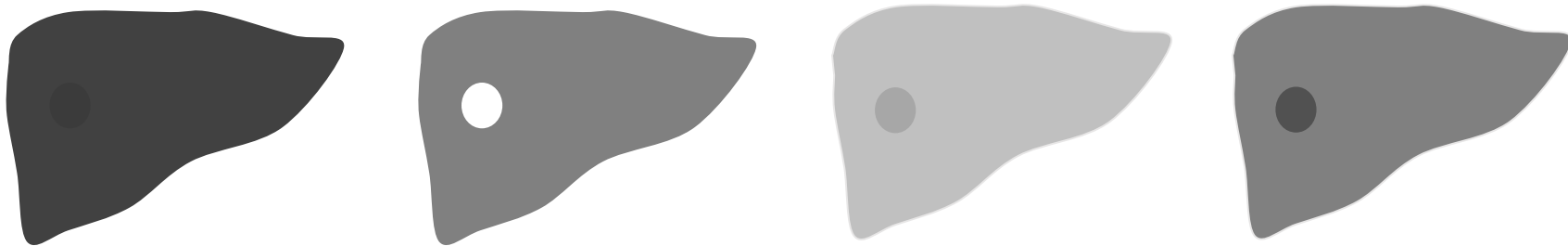
Breath Hold Most Preferable

Free breathing CT scans can only be performed if motion assessment shows (e.g. fluoroscopy) shows < 5 mm displacement with respiration – but best avoided.

Contrast enhanced 4DCT can be very challenging, as the 4D scan takes a longer time

Hepatocellular carcinoma

- Supplied predominantly by the hepatic artery
- Arterial phase hypervascularity
- Portal/delayed venous phase 'washout'

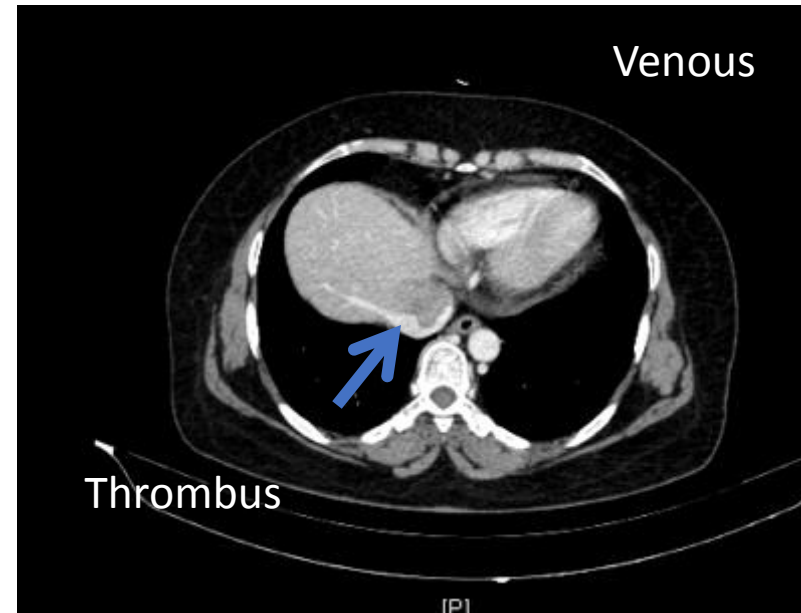
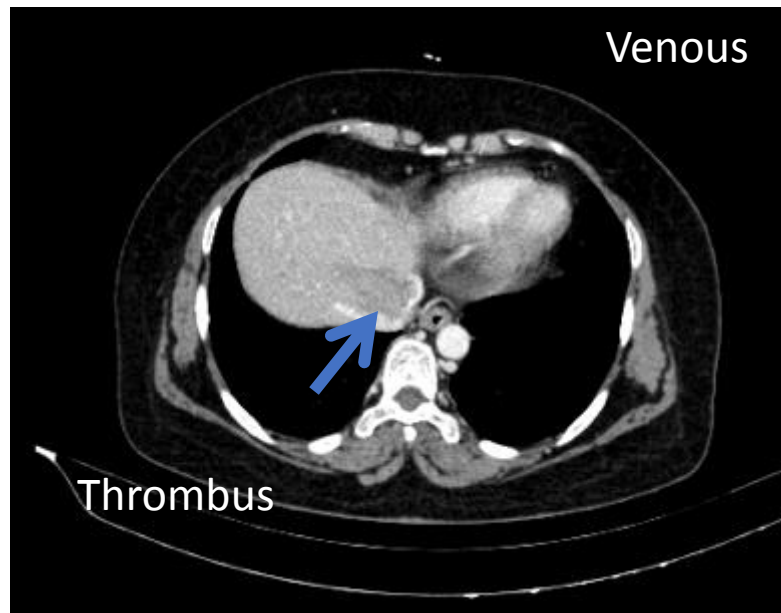
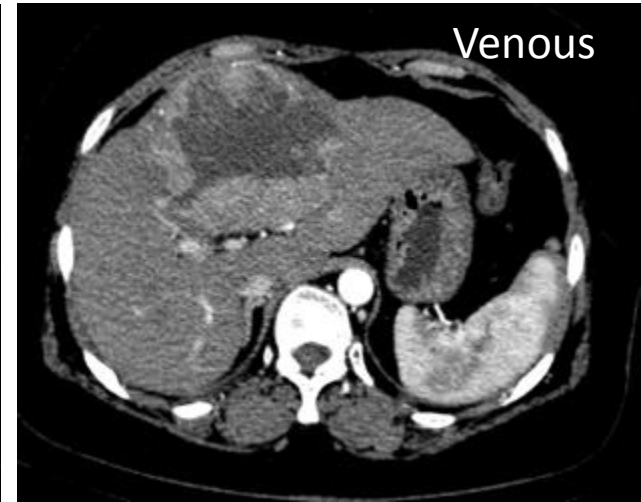
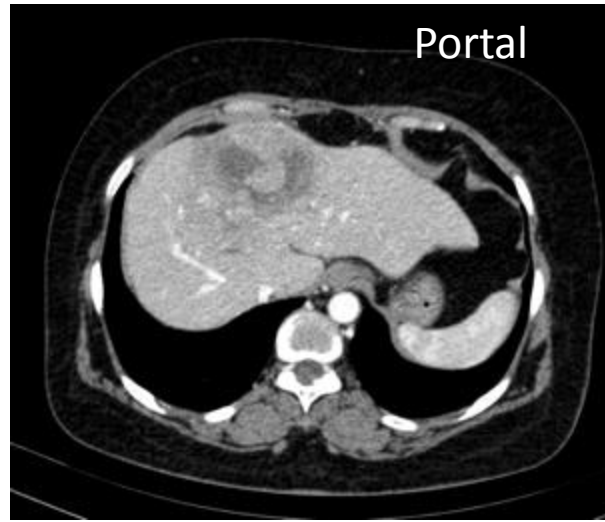
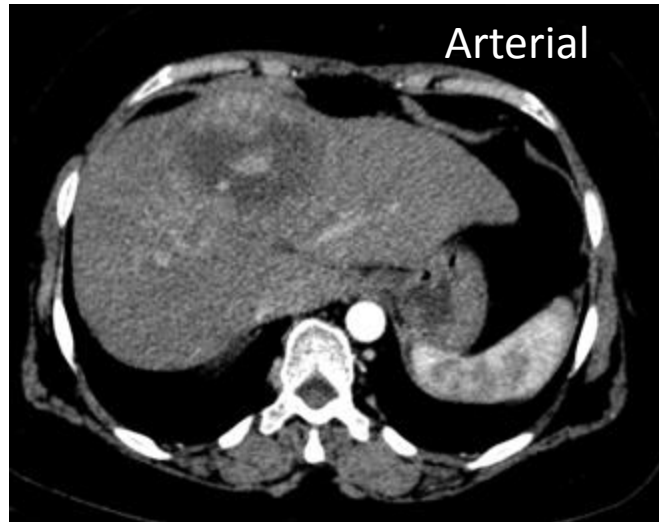


Timing contrast injections

- 2.5 -3 ml/s on a weight based scale

Phase	Timing
Arterial Phase	immediately after aortic peak, or 30 to 35 seconds after contrast infusion
Portal venous phase	45 seconds after peak aortic enhancement as determined by bolus tracking, with images obtained 70 to 75 seconds after contrast infusion.
Delayed venous phase	3 mins after portal venous phase

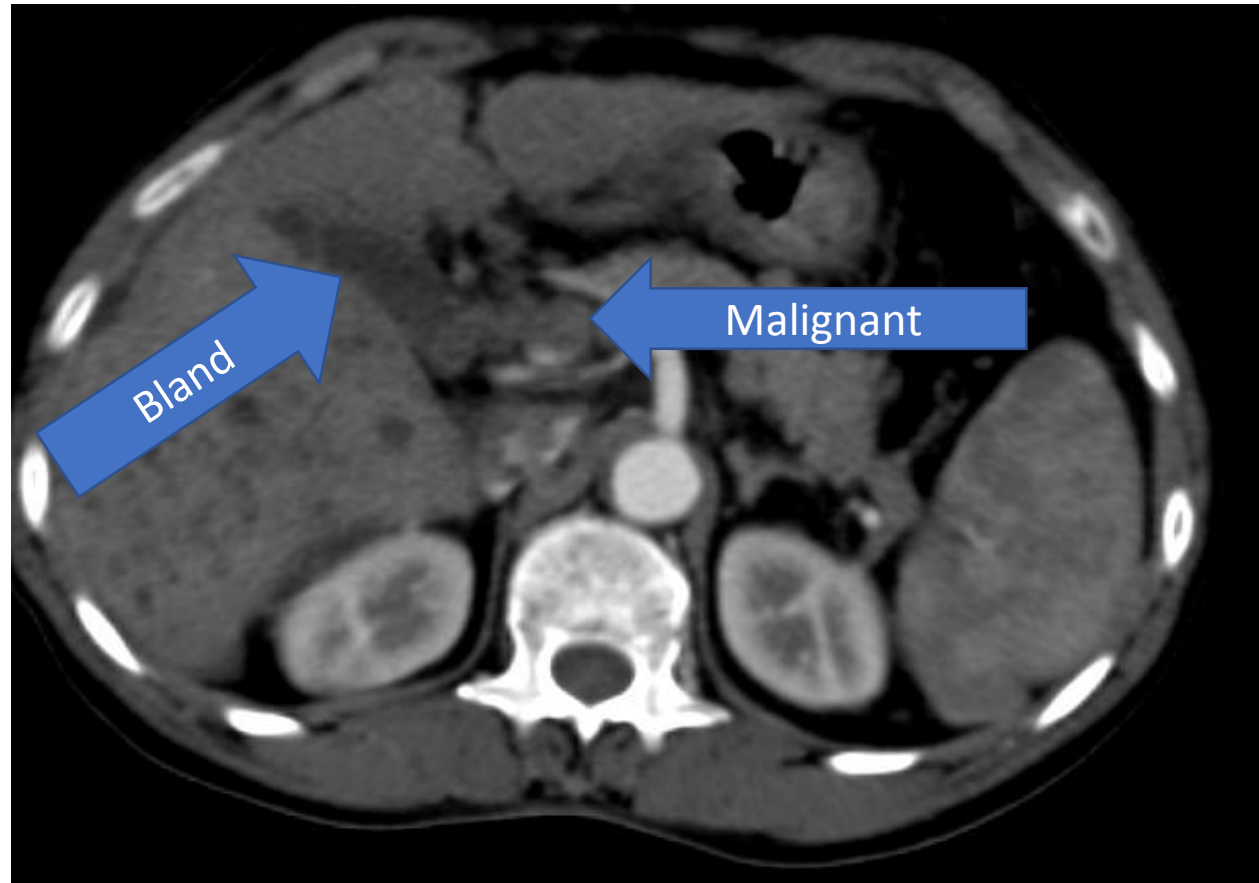
High Quality Triphasic Scan with IV Contrast



Tumour Thrombus

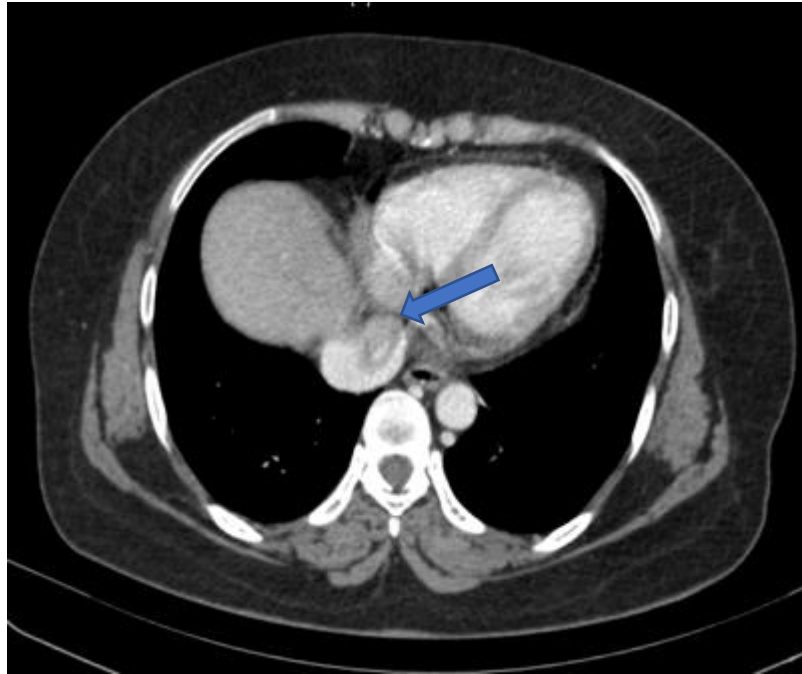
- Tumor thrombus in the portal vein is best identified in the portal venous phase (hypointense against the contrast in the portal vein)
- Non-tumor thrombi – should not be considered as GTV, but may be included in CTV
- Non-tumor extrahepatic vascular thrombus is not included in GTV or CTV

Malignant vs. Bland Thrombus

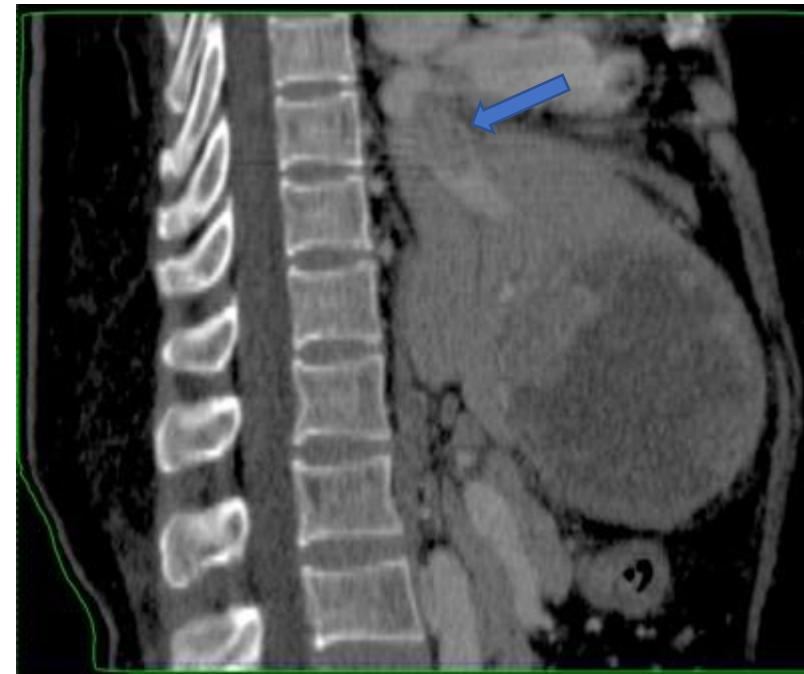


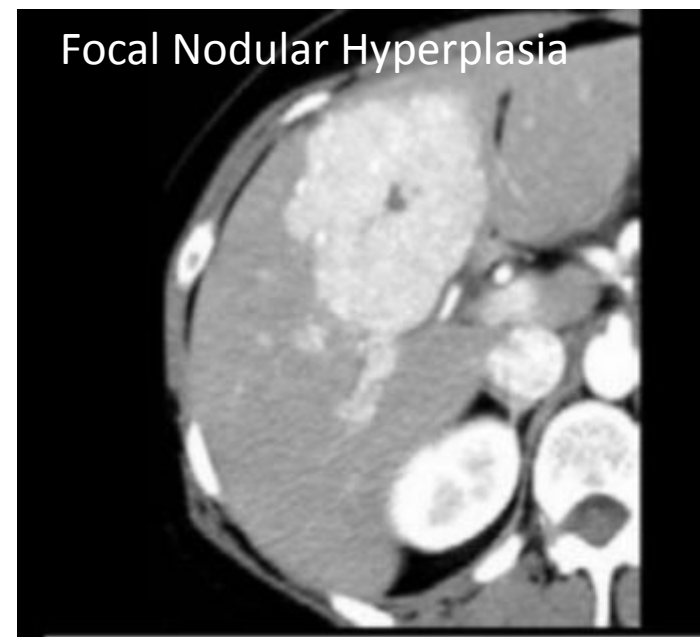
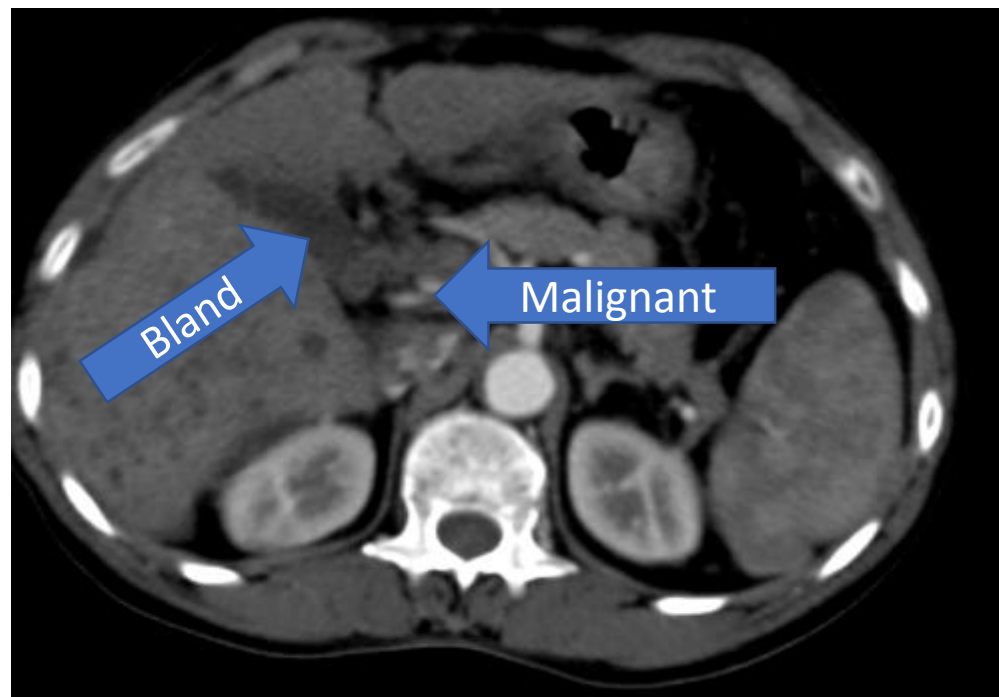
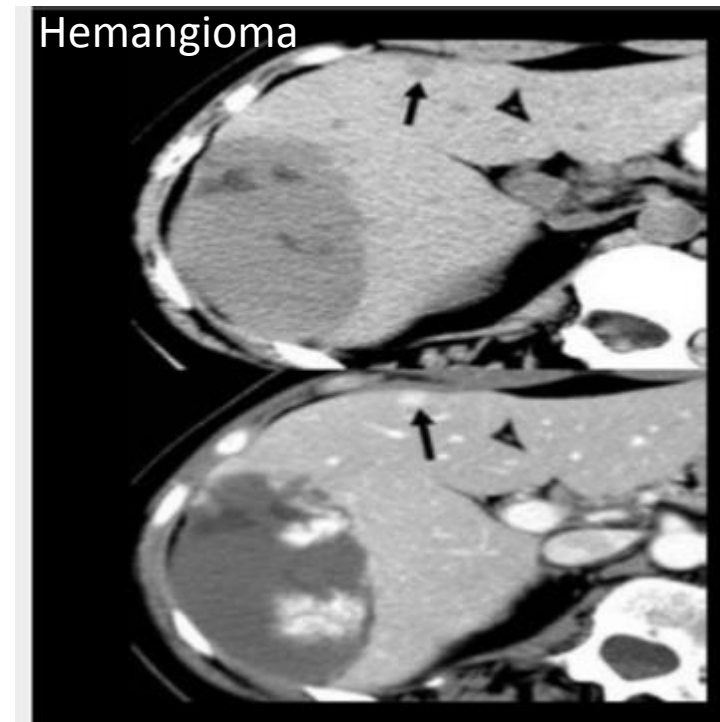
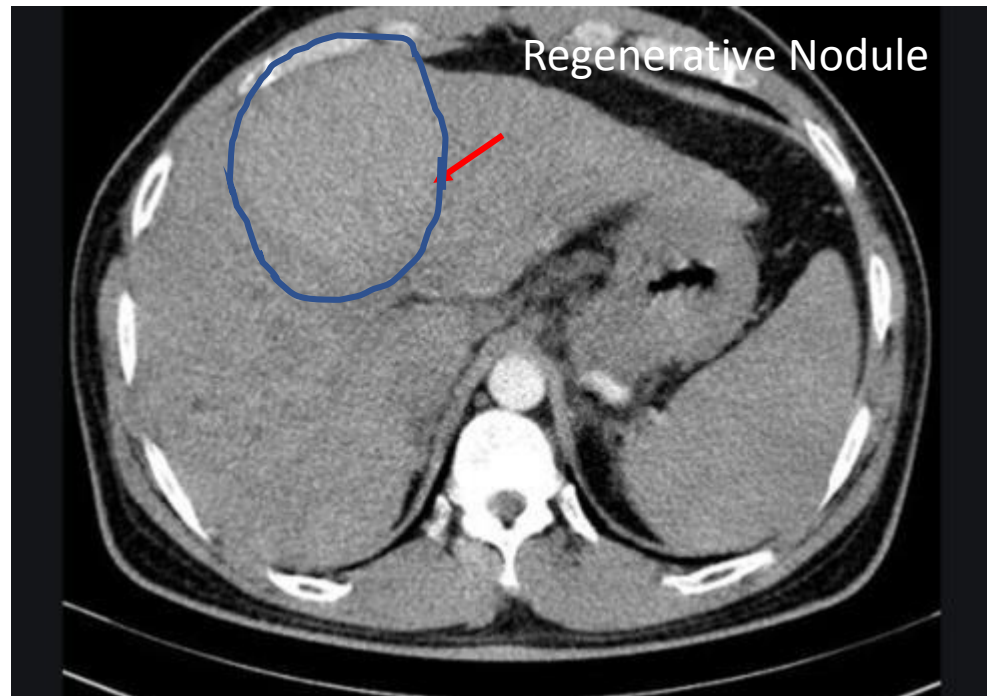
Extend Imaging to Thorax and Lower Abdomen

Coronal



Sagittal



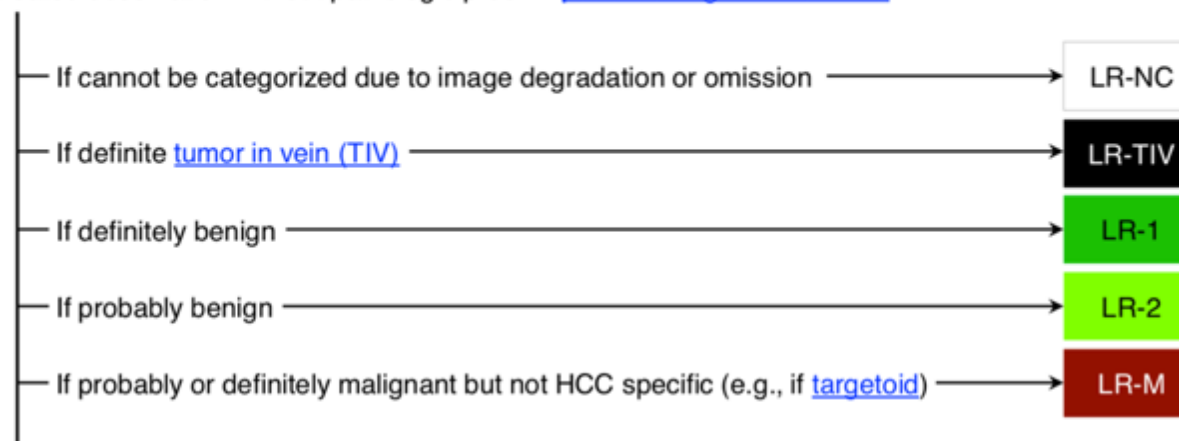


Lesion	T1 W image	T2 W image	Contrast enhancement pattern
Regenerative nodule	Variable	Hypointense	Enhances during portal venous phase
Dysplastic nodule	Hyperintense	Hypointense	Enhances during portal venous phase
HCC (small)	Hypointense	Hyperintense	Enhances during arterial phase
HCC (large)	Heterogeneous	Hyperintense	Enhances during arterial phase

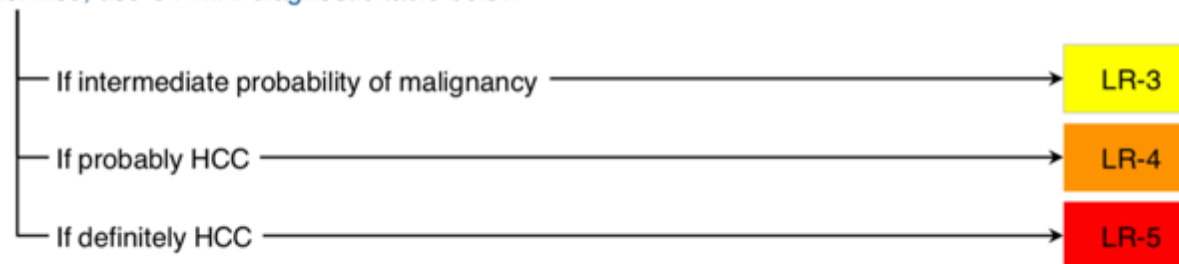


CT/MRI LI-RADS® v2018 CORE

Untreated observation without pathologic proof in [patient at high risk for HCC](#)



Otherwise, use CT/MRI diagnostic table below



CT/MRI Diagnostic Table

Arterial phase hyperenhancement (APHE)		No APHE		Nonrim APHE		
Observation size (mm)		< 20	≥ 20	< 10	10-19	≥ 20
Count additional major features: • Enhancing "capsule" • Nonperipheral "washout" • Threshold growth	None	LR-3	LR-3	LR-3	LR-3	LR-4
	One	LR-3	LR-4	LR-4	LR-4 LR-5	LR-5
	≥ Two	LR-4	LR-4	LR-4	LR-5	LR-5

MRI FOR TARGET DELINEATION

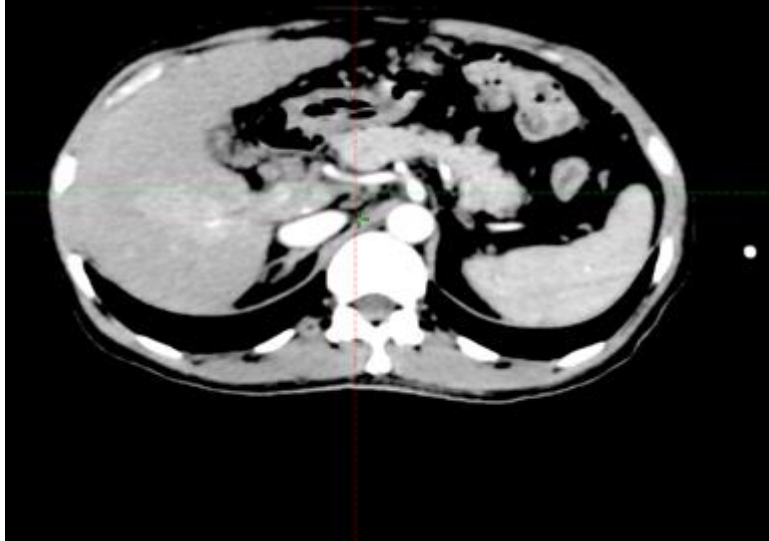
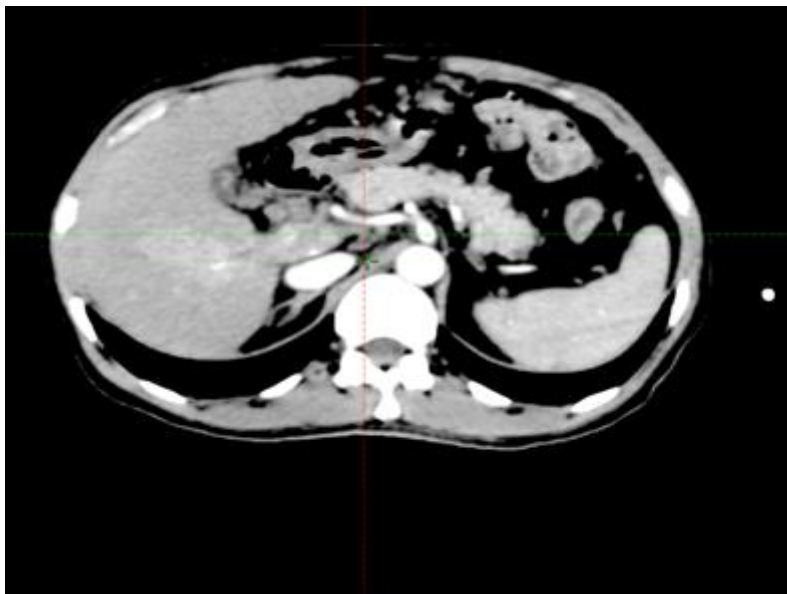
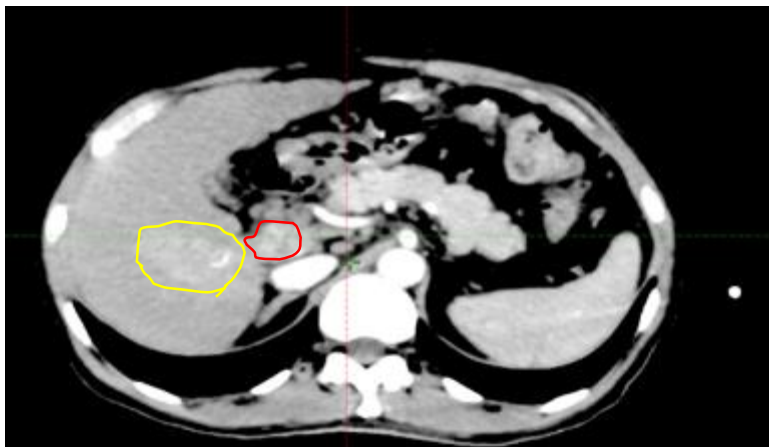
- MR provides additional information to CT based planning.
- MR Simulation for HCC: Patient is scanned in the treatment position with the corresponding motion-limiting device.
 - Axial slices
 - T2 FSE
 - T1 Vibe – non contrast, multiphase arterial, venous and 3min delay
- Breathhold Acquisition preferred
- Liver to liver fusion, guided by external liver surface and/or implanted fiducials.

FDG-PET has no role in delineation of HCC

Checklist before Contouring

- ✓ Review Imaging with Diagnostic Radiologist
- ✓ Triphasic CECT Ideal/ MRI Complimentary
- ✓ No Need for PET for HCC (Background Uptake interferes with interpretation)
- ✓ Background of Cirrhosis Tumour vs Regenerative Nodules
- ✓ Areas of previous Treatment (RFA/Lipidiol/ Surgical Clips)
- ✓ Vascular Thrombosis

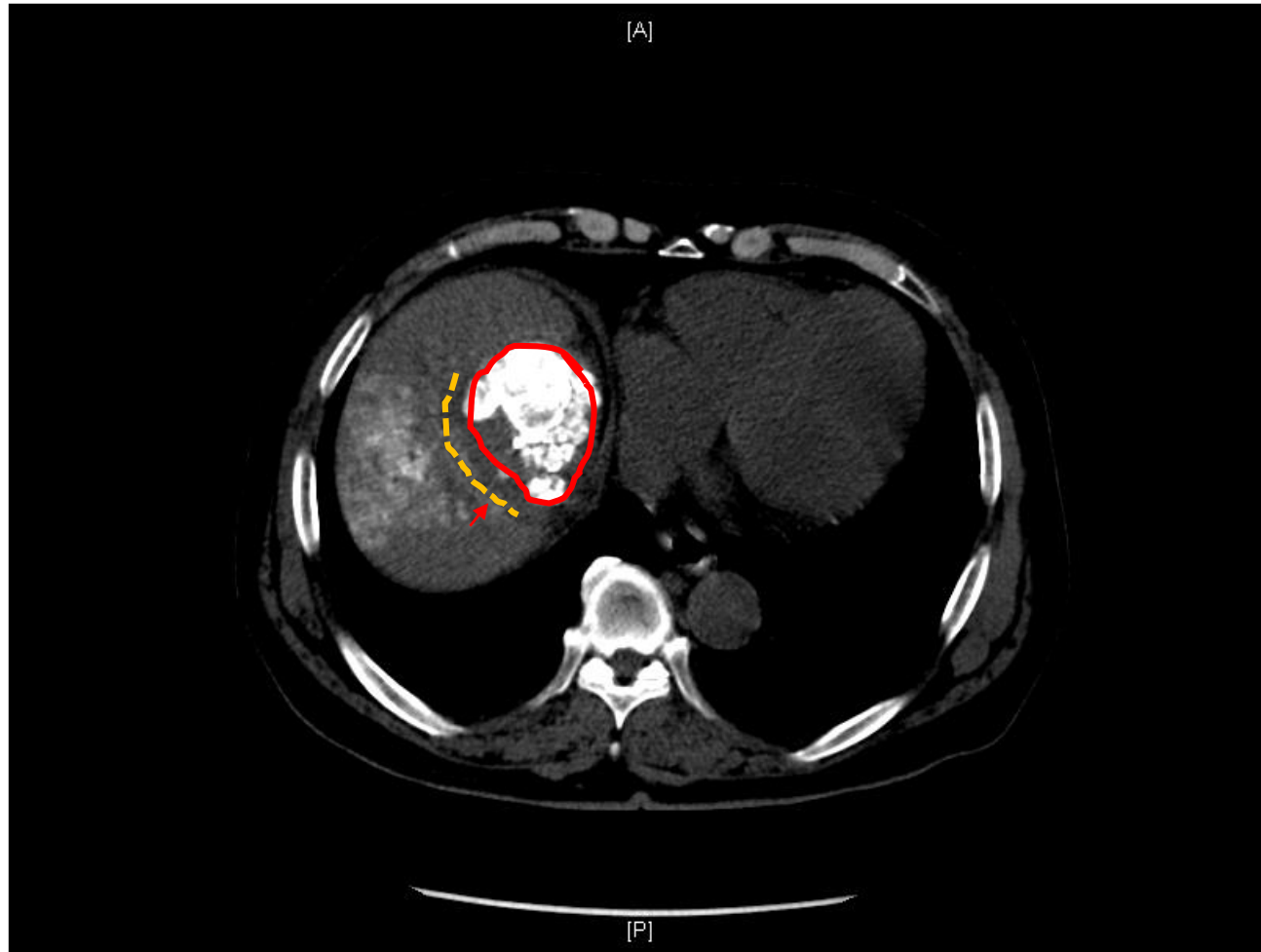
Target Delineation



Arterial Enhancing Component

(GTV p)

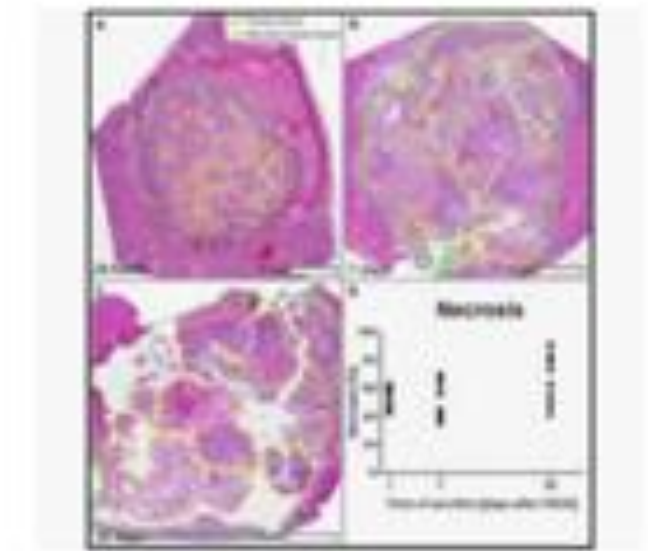
Vascular Thrombosis (GTV pv)



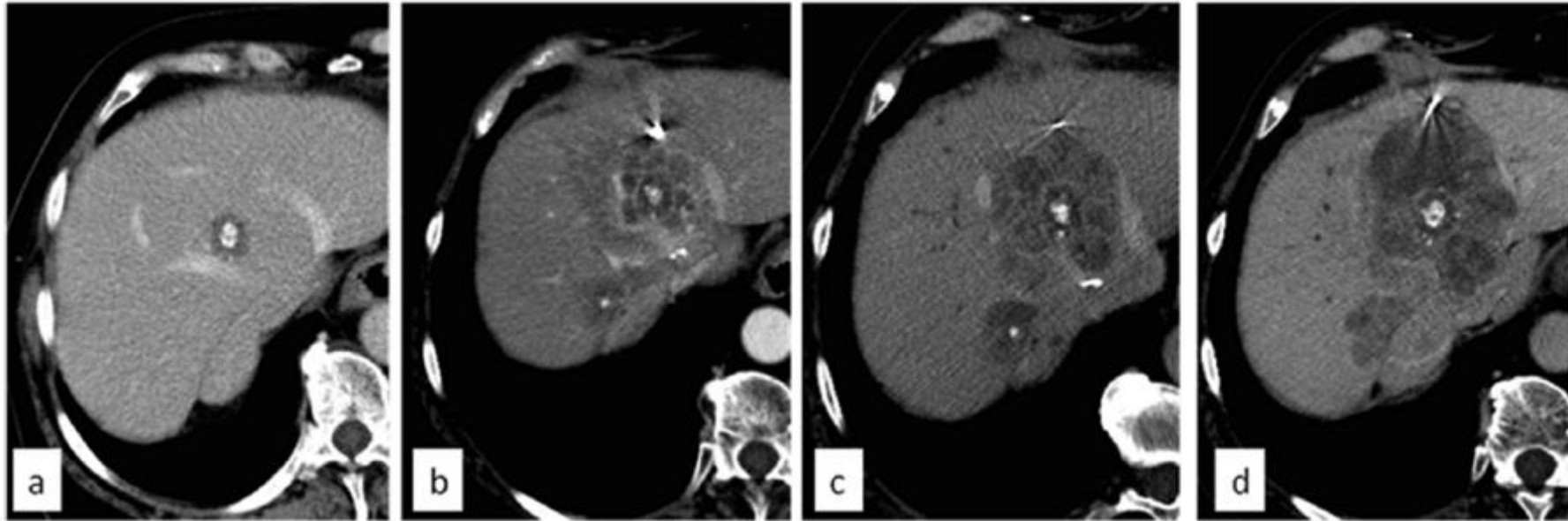
Previous TACE Cavity

Patchy Regions within Lipiodol deposition

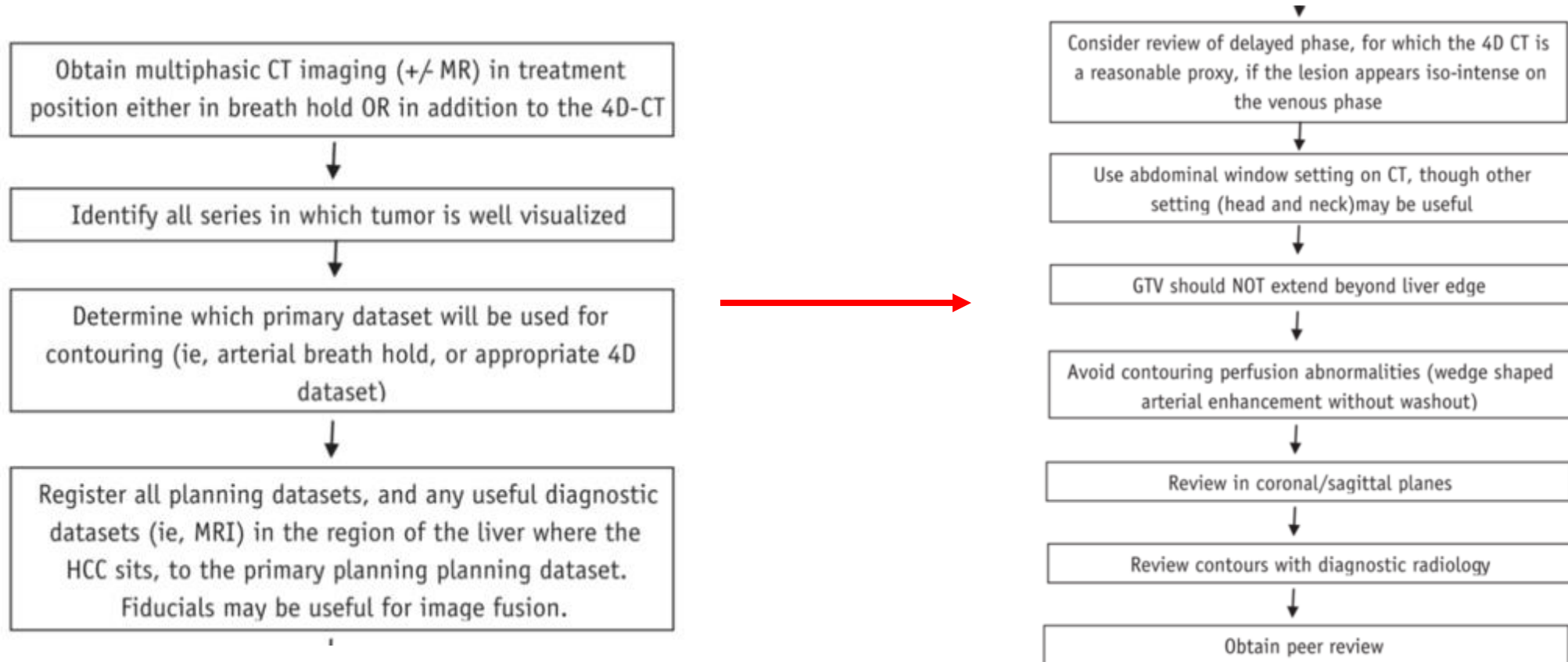
Exclude contrast wash in wash out regions

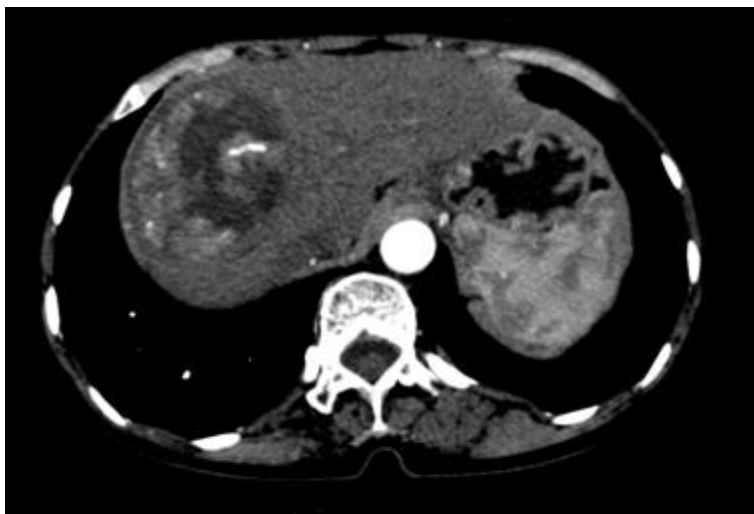


Fiducials and artifacts



Consensus Workflow for GTV Identification





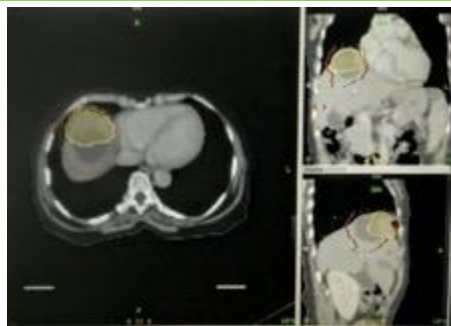
June, 2015

3 TACE

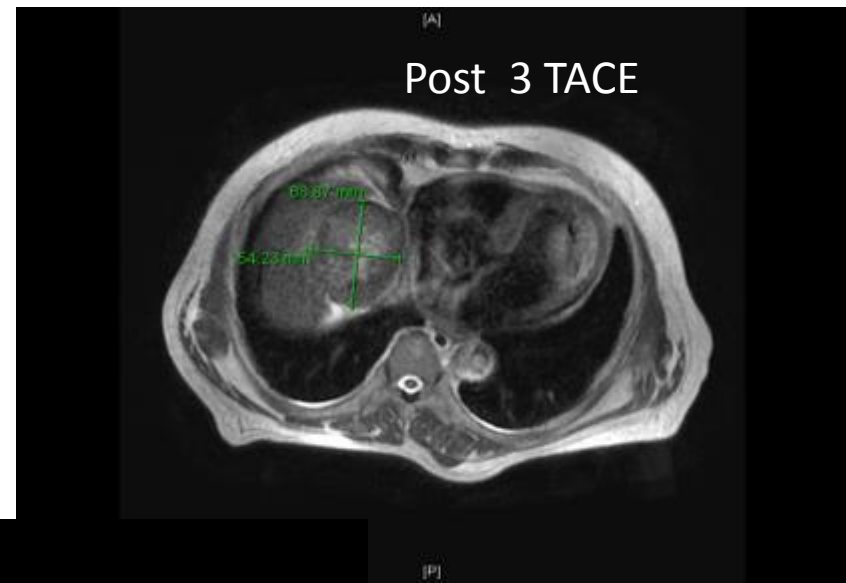
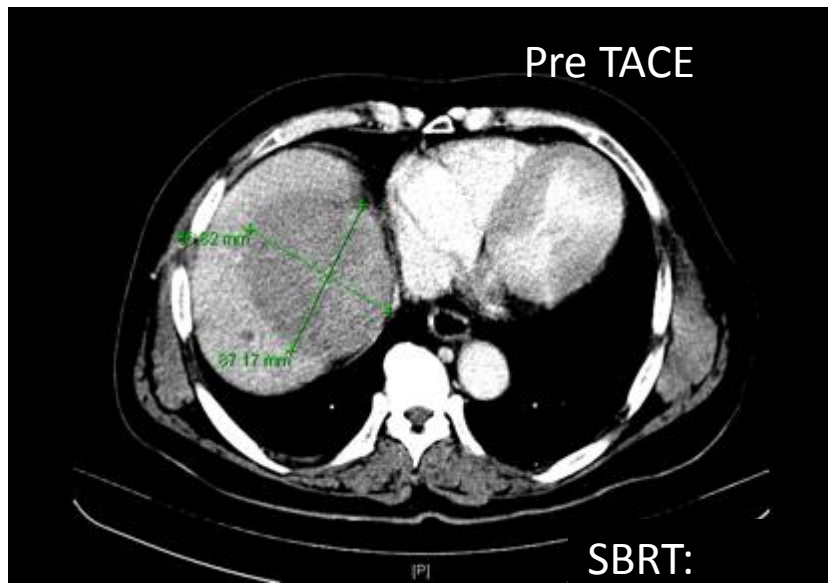


October, 2015

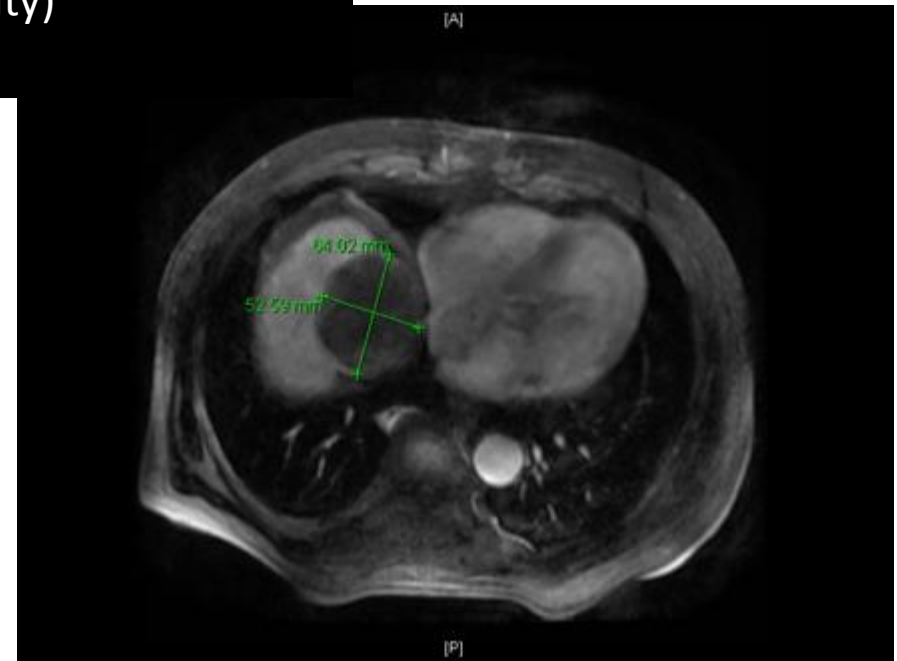
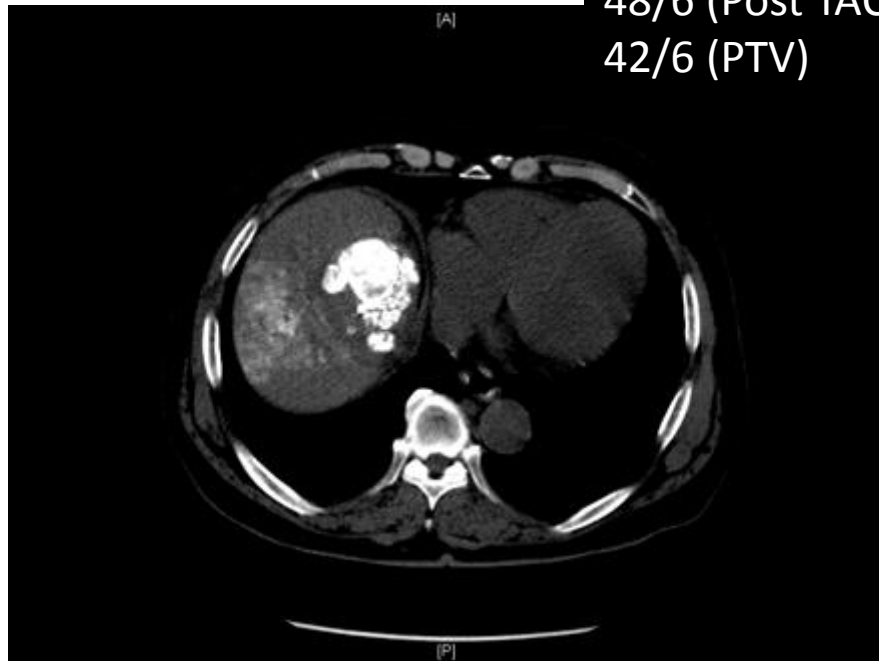
SBRT: 54/6 (GTV)
48/6 (Cavity)
42/6 (PTV)



January 2017



SBRT:
54/6 (Lipidiol Enhancement)
48/6 (Post TACE Cavity)
42/6 (PTV)



Multi Phase Evaluation: Critical

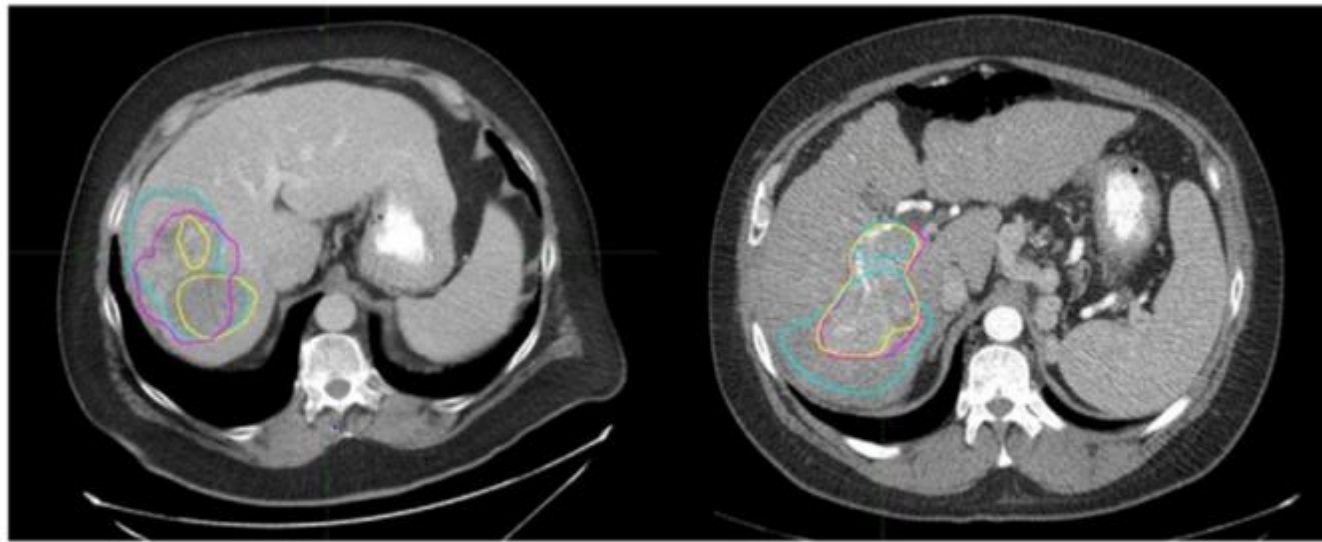
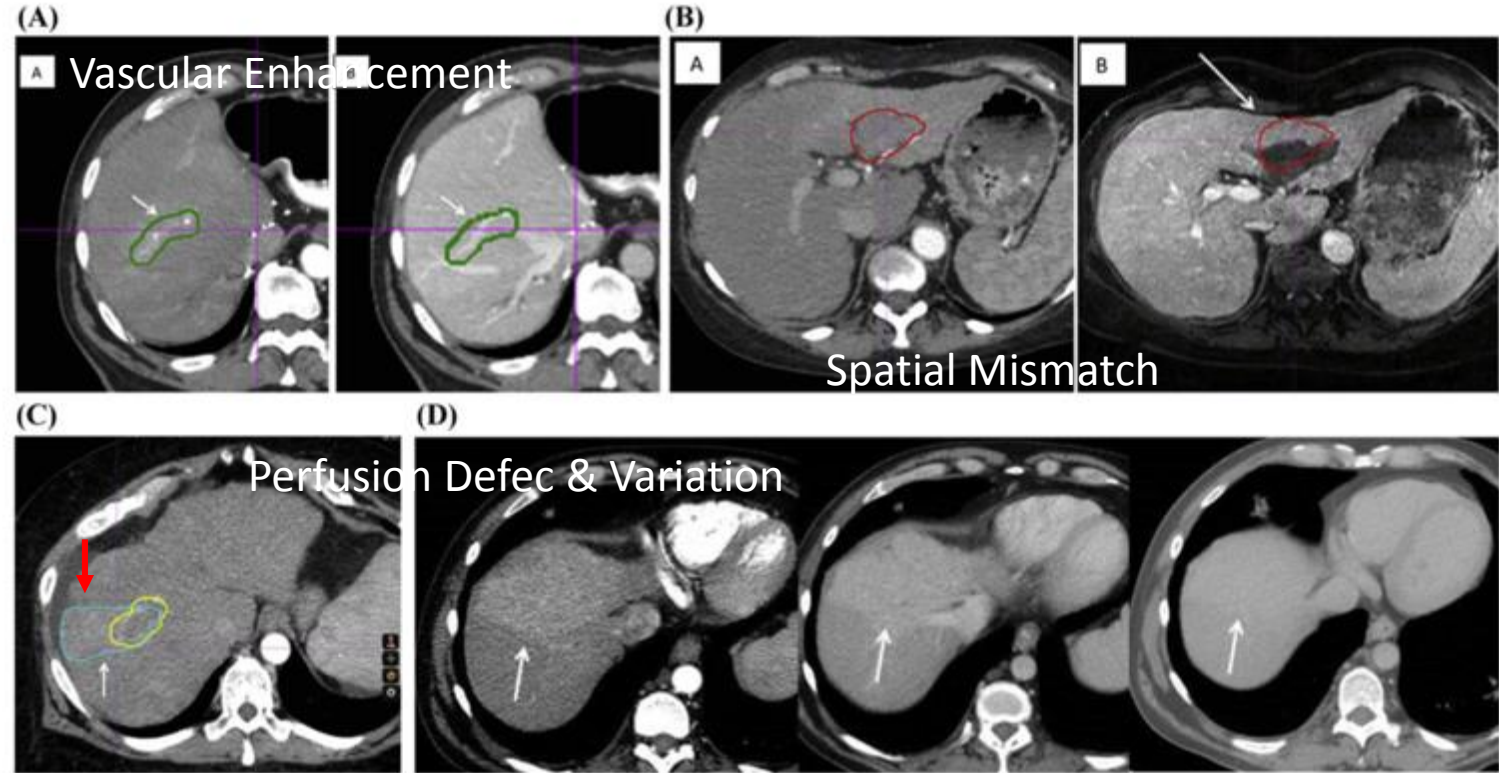
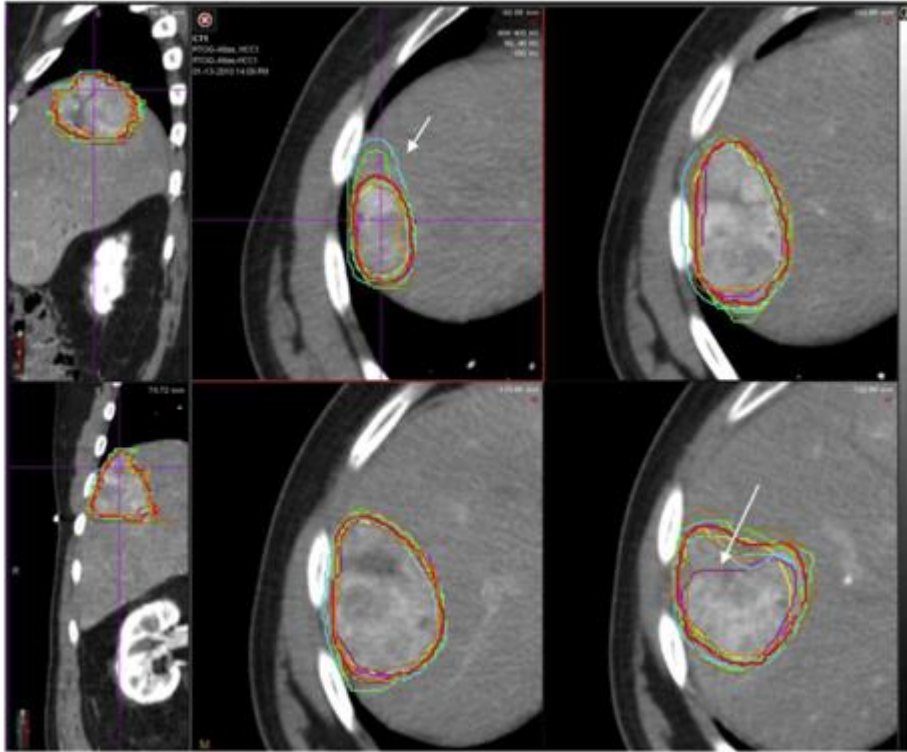


Figure 2 (A) Lack of overlap between contoured gross tumor volumes (GTVs) on arterial (pink), portal venous (blue), and delayed (yellow) phases in hepatocellular cancer (HCC). Contours are displayed on the portal venous phase. (B) Lack of overlap between contoured GTVs on arterial (pink), portal venous (yellow), and delayed (blue) phases in HCC. Contours are displayed on the arterial phase.

Common Errors in Target Volume Delineation



Expert Agreement

Agreement in contours for the total GTV of each case*

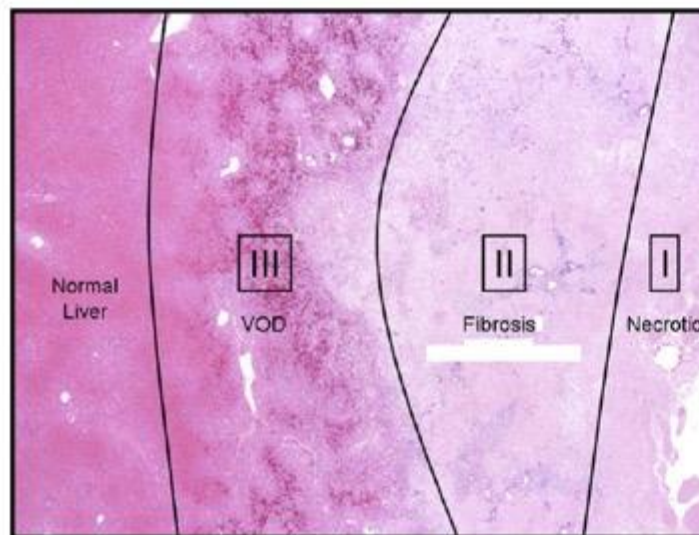
Parameter	HCC1 GTV	HCC2 GTV	HCC3 GTV
No. of experts	11	10	11
Volume maximum (cm ³)	83.71	116.38	211.63
Volume minimum (cm ³)	54.55	87.94	88.78
Volume average (cm ³)	66.47	101.61	157.86
Volume SD (cm ³)	±9.93	±9.79	±43.12
Volume intersection	45.21	52.74	51.22
Volume union	100.34	164.70	311.03
STAPLE volume	66.27	121.23	210.01
Kappa agreement	0.826 Near perfect	0.804 Substantial	0.711 Substantial

NO PROVEN ROLE OF THROMBUS
IRRADIATION TO FACILITATE TACE

Recurring Tumours/ Regenerating Nodules in HCC Post SBRT Changes

Time	Pathology	CT /MR Features
Acute Phase (1-3 mths)	Sinusoidal Congestion	Hypo-enhancement in PV Phase
Subacute (3-6mths)	Decreased inflow of contrast and decreased efflux from sinusoids	Hypo-enhancement in PV and Hyper-enhancement in delayed
Chronic (>6mths)	Hepatocyte function loss Accumulation of Kupffer Cells/Hemosiderin	Hypo-enhancement in hepatobiliary phase

Pathological Changes after Liver SBRT



Zones of reaction after SBRT

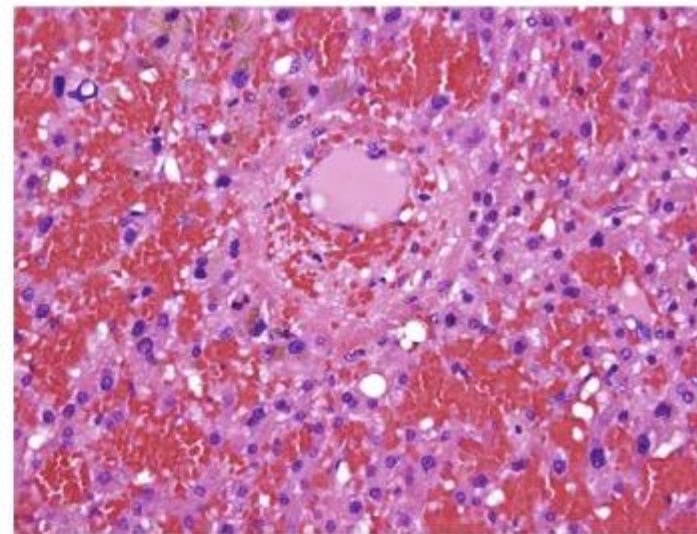
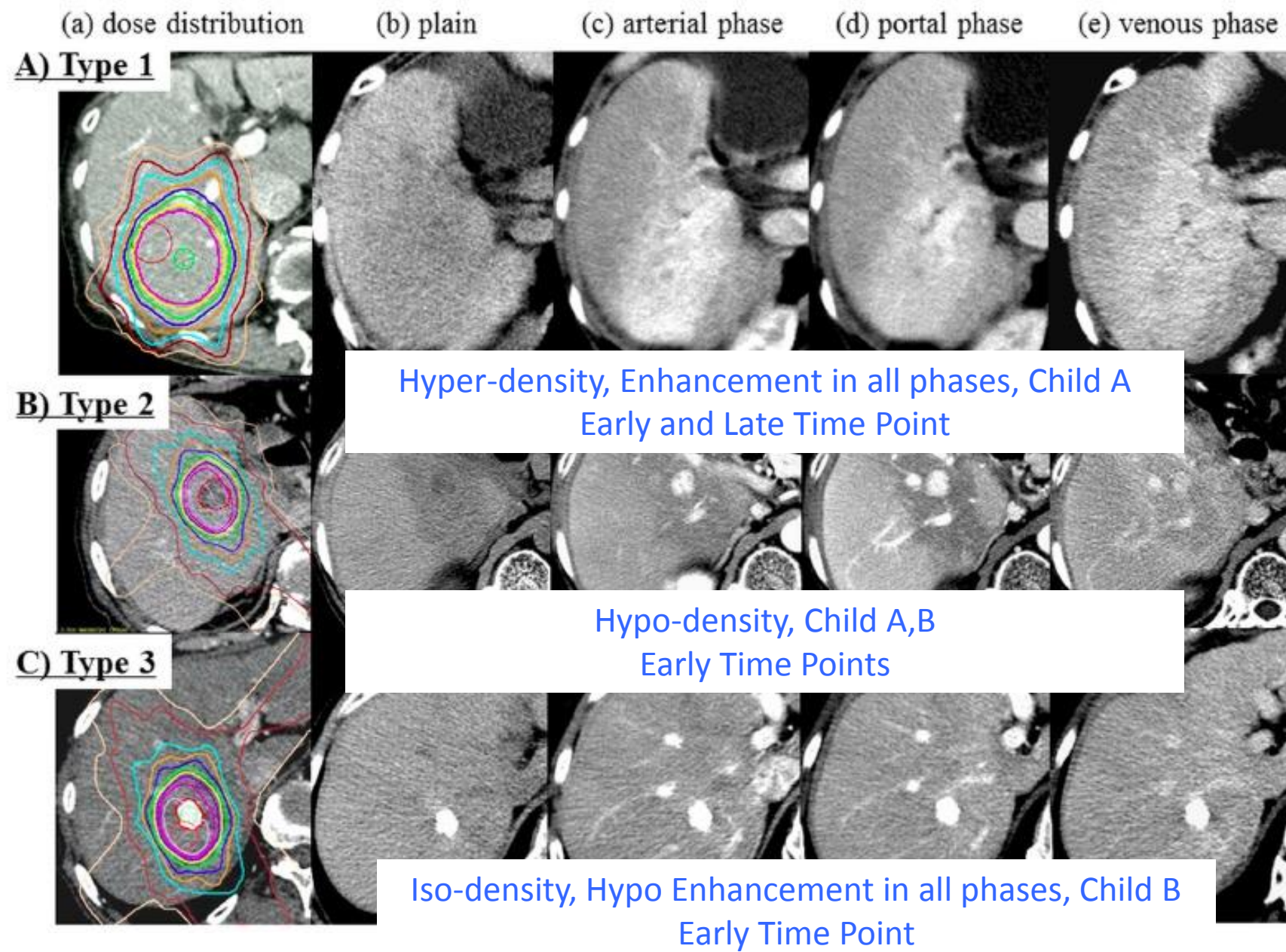
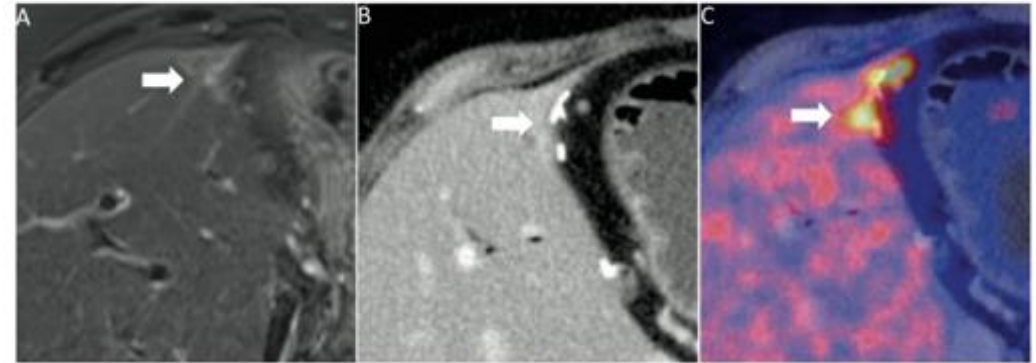
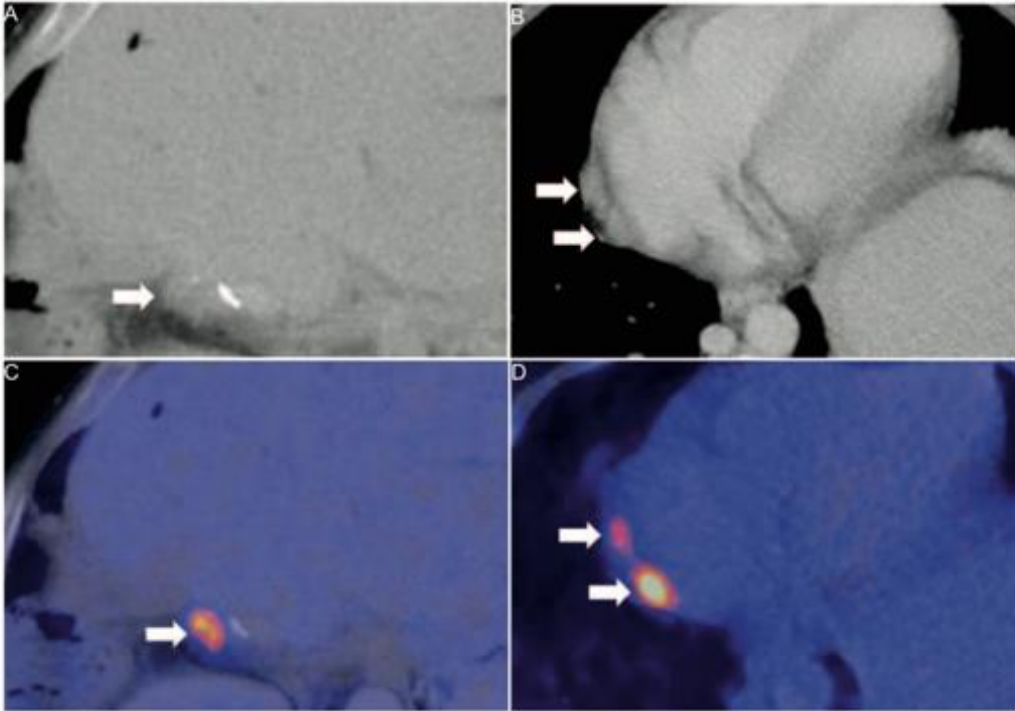


Fig. 8. Histopathologic zone III. See text for details.

Zone	Pathological Change	Increases Enhancement
I	Necrosis	Increases Enhancement
II	Repopulation/Fibrosis	
III	Venoocclusion/ Vascular Leakage	
Normal Liver		



Post Hepatic Resection Recurrences



Summary: HCC Target Delineation

- Triphasic CECT: Gold Standard
- Integration with Diagnostic and Intervention radiology critical.
- Familiarity with Chronic Liver disease related changes.
- Imaging Sequelae of previous treatment. (TACE/RFA/Surgery)

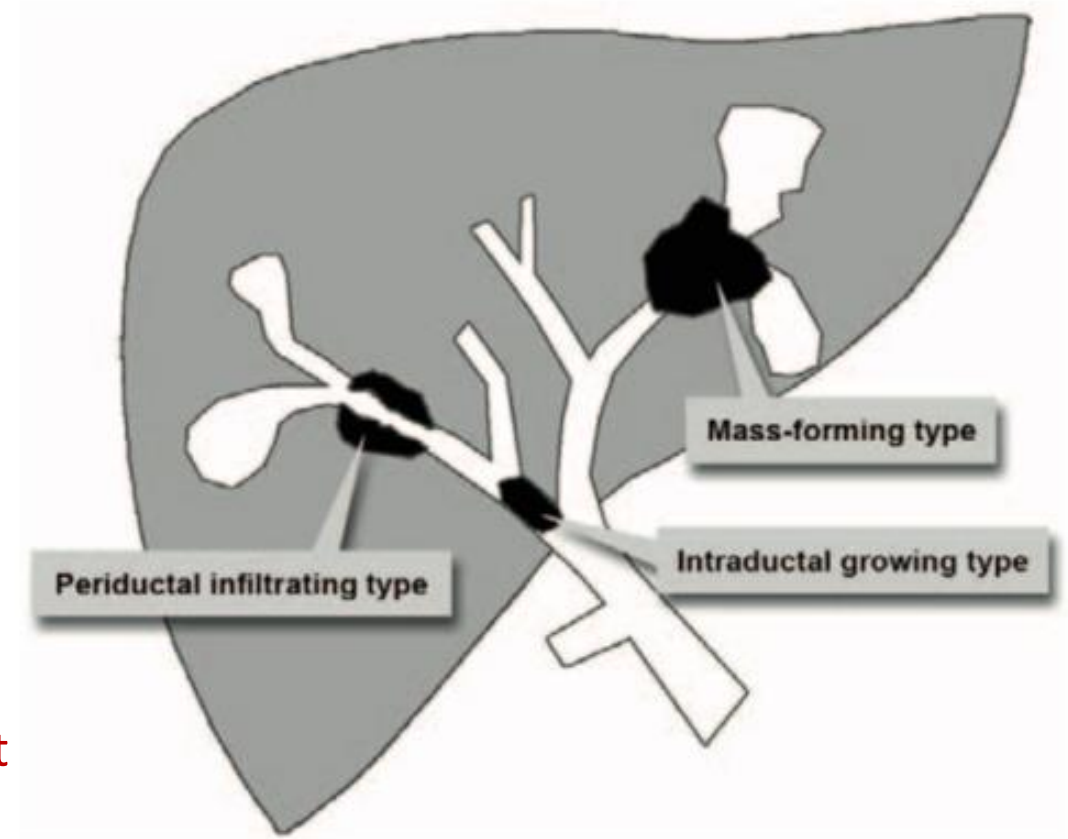
Cholangiocarcinoma

INTRAHEPATIC- PARENCHYMA

EXTRAHEPATIC- BILIARY TREE

Intrahepatic- ?? Easier

Extrahepatic-Significant Expertise, Need to interpret multimodality Imaging



Liver Cancer Study Group Japan

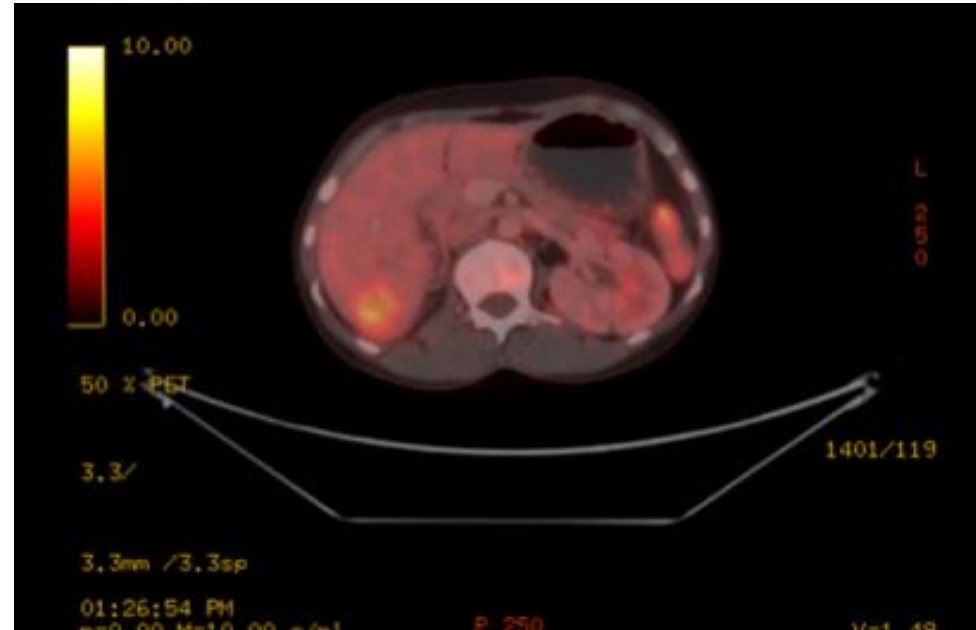
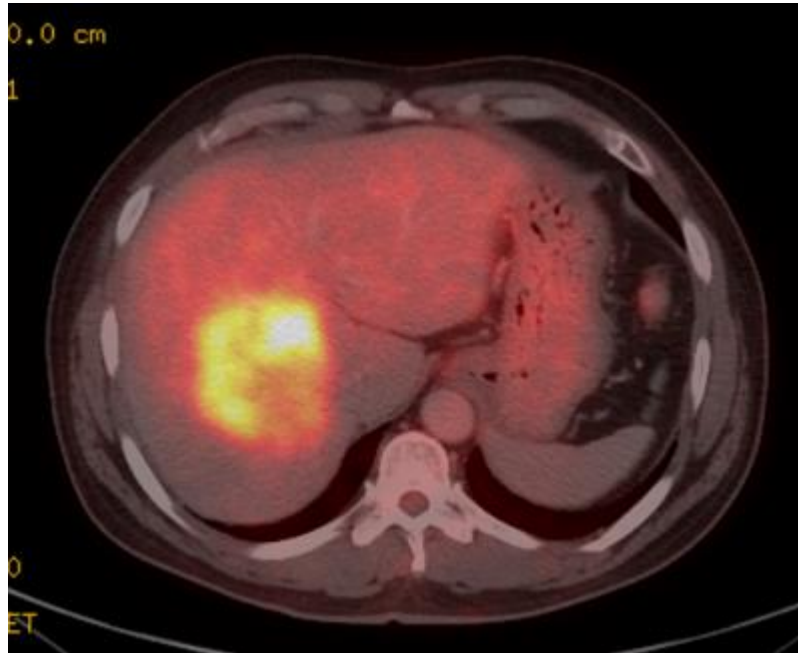
Imaging Modalities and Information

- Typically Patients have multiple Imaging data sets prior to visiting Radiation Oncology
 - Triphasic CECT with Delayed Scans (3 minutes)
 - ?PETCT
 - ERCP
 - PTC Gram
 - MRI+ MRCP Images

Stent in situ/ Cholangitic Abscesses

Critical to review pre and post stent images

Intra-hepatic Cholangiocarcinoma



Worthwhile to combine with CECT for Edge Delineation

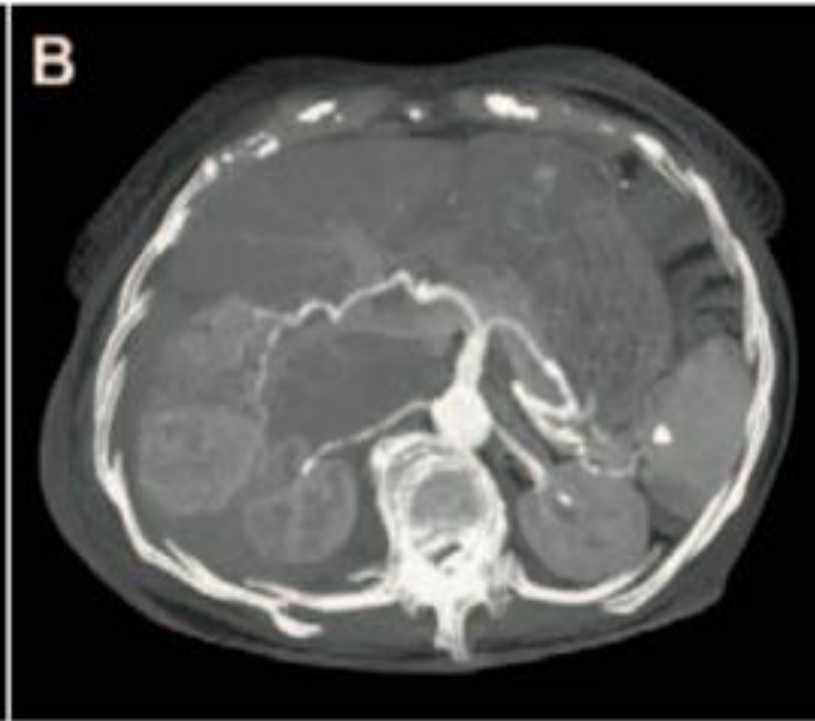
Encapsulated/ Infiltrative

Vascular Invasions

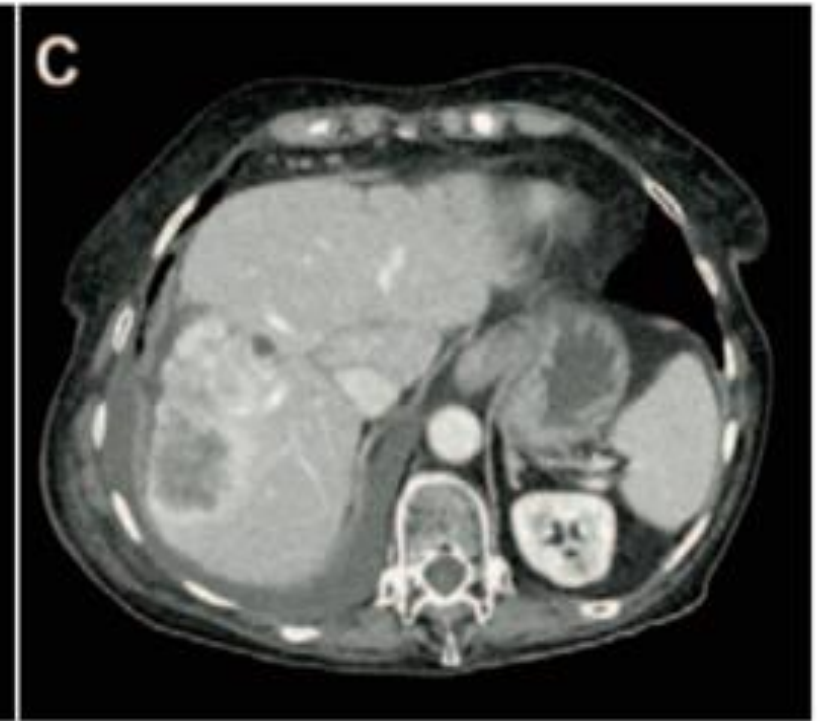
Triphasic CECT for Intrahepatic Cholangiocarcinoma



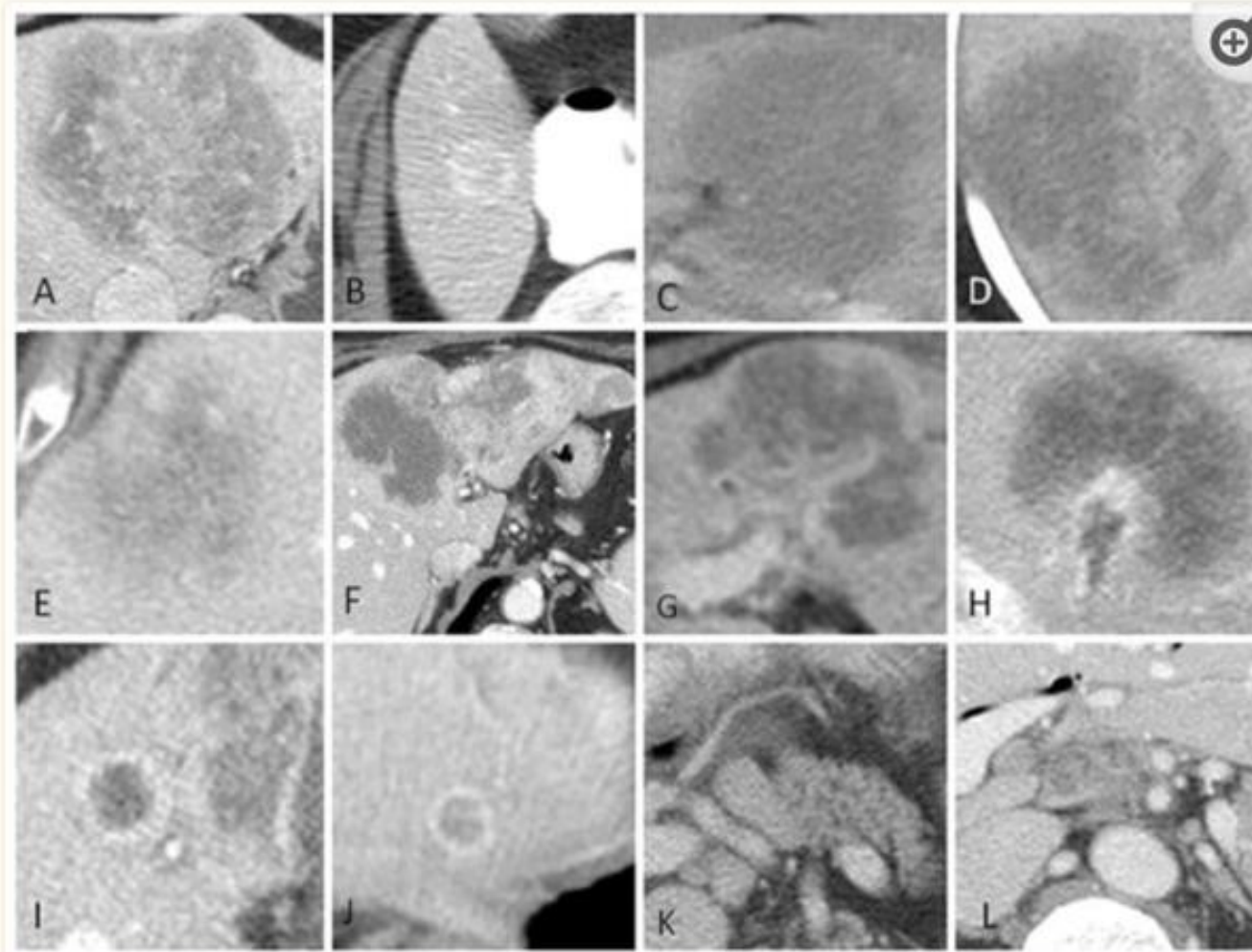
Non Contrast



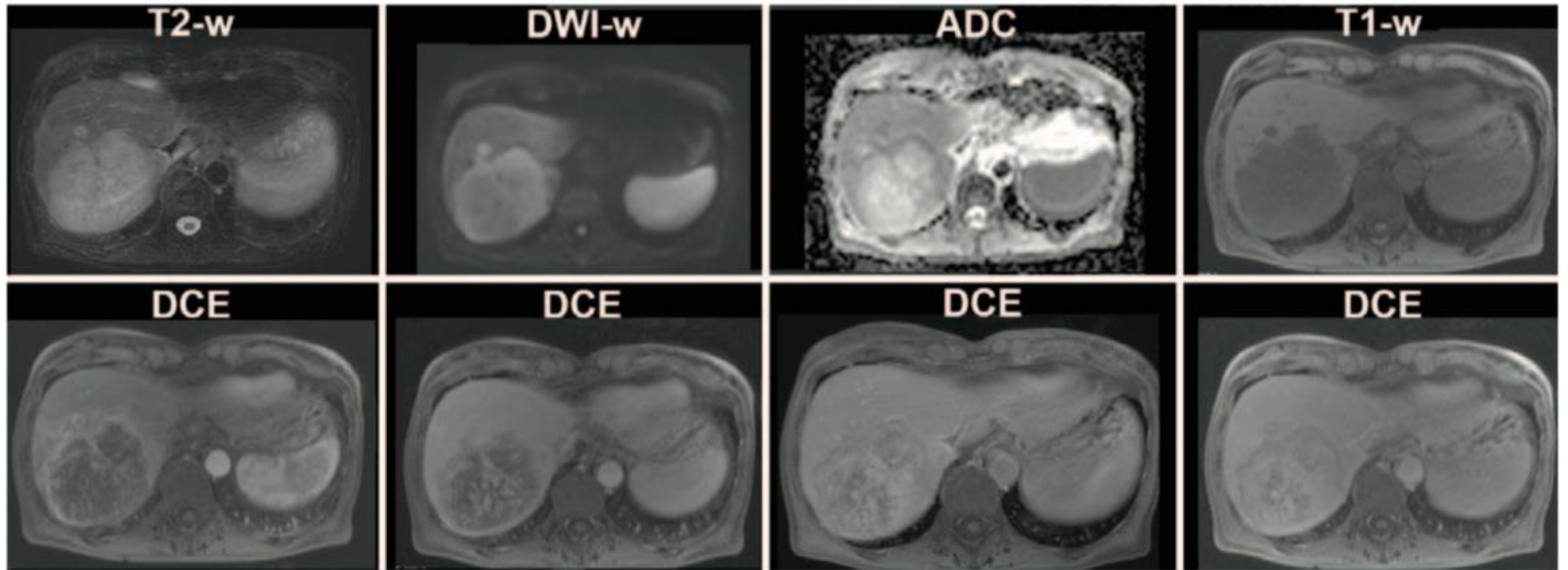
Arterial

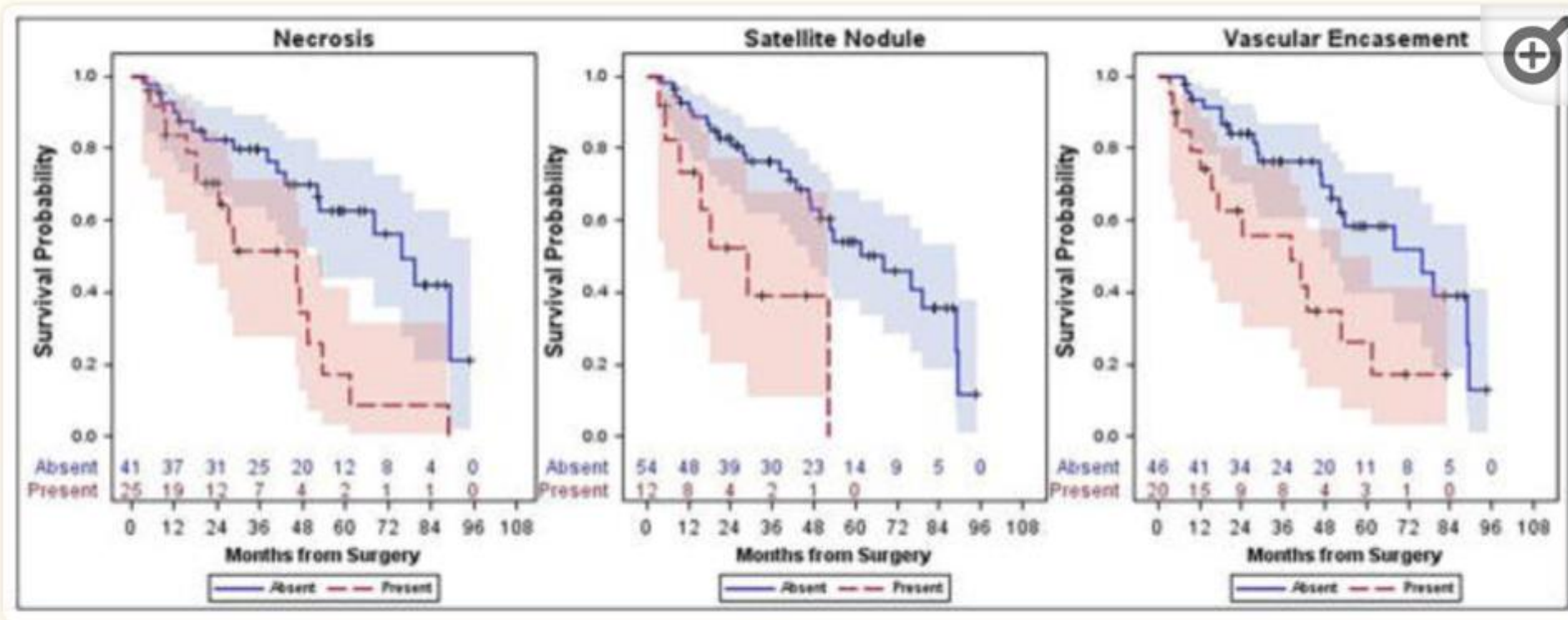


Portovenous



MRI Appearance of Intrahepatic Cholangiocarcinoma



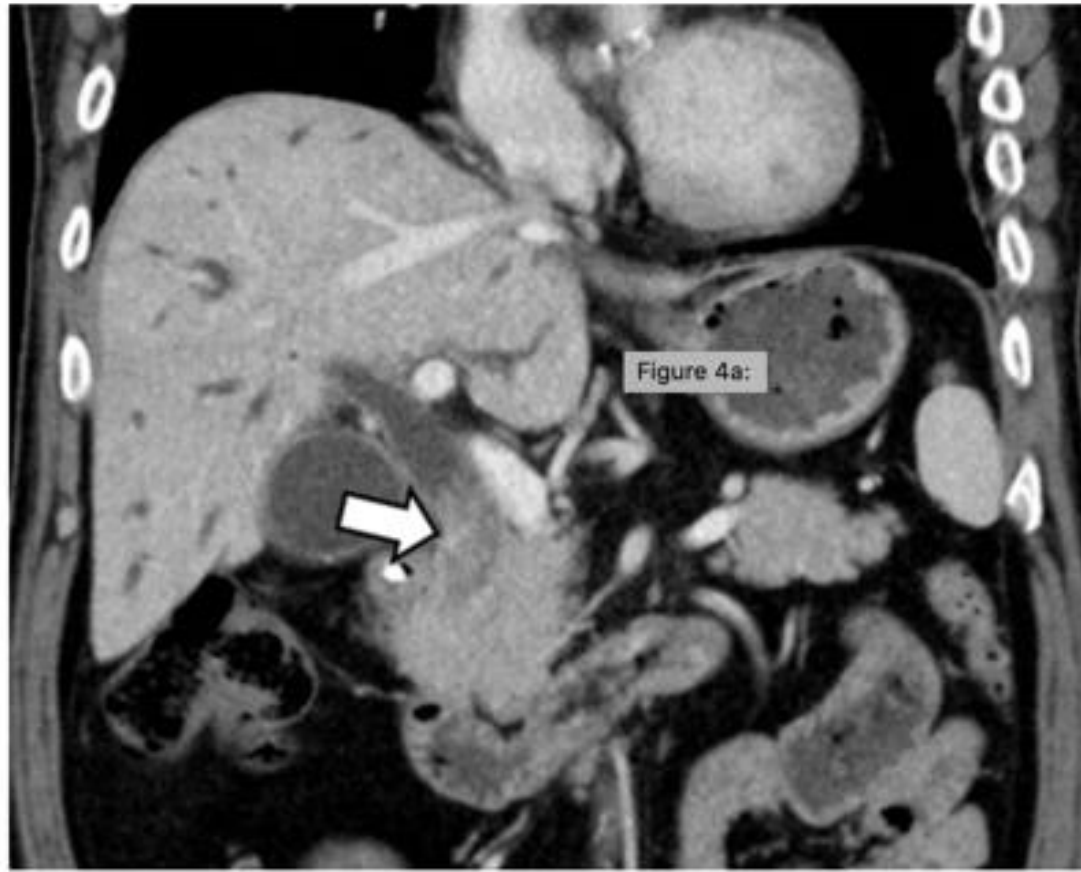


Disease Biology

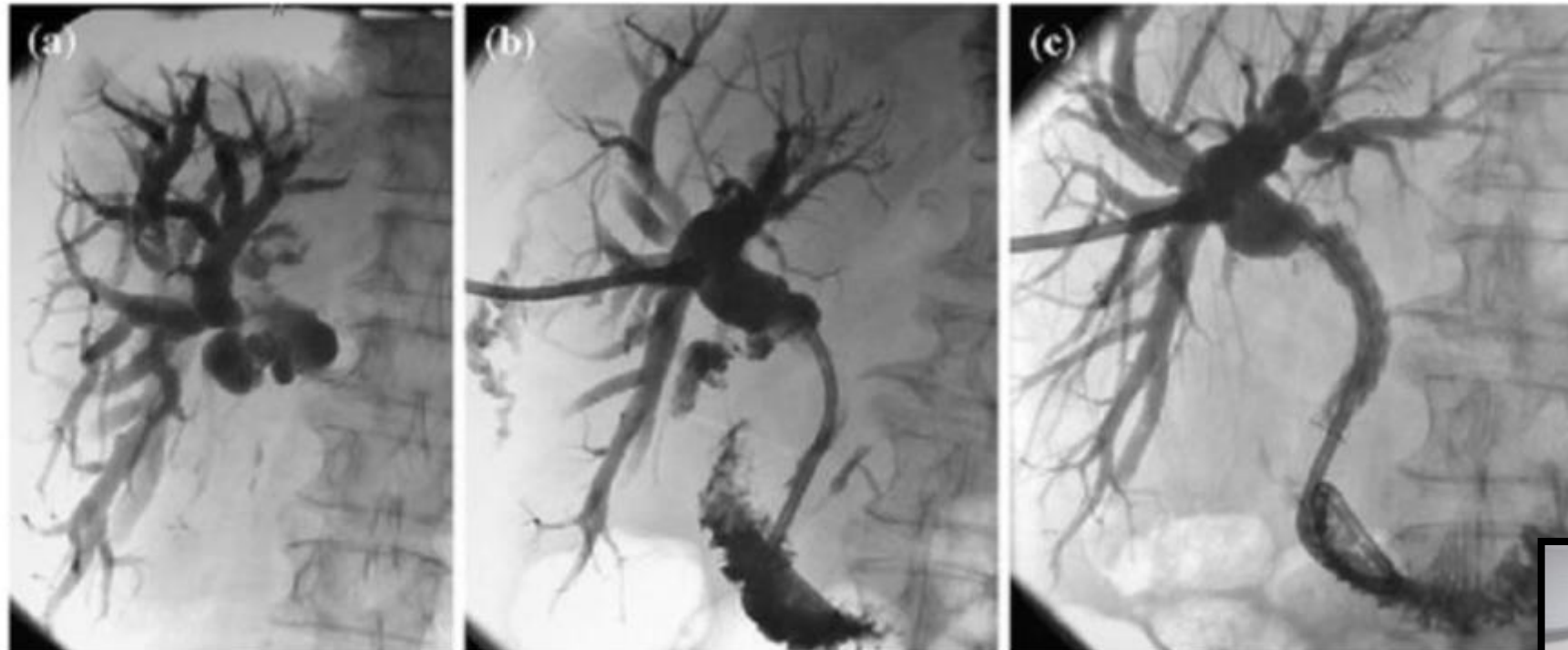
Adequacy of Target Delineation

Aherne, Abdominal
Radiology 2019

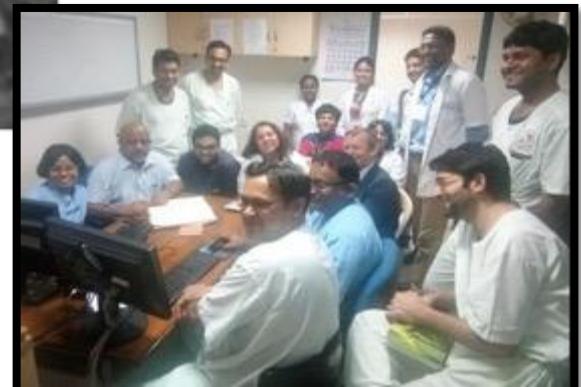
Intraductal Extrahepatic Bile duct cholangiocarcinoma



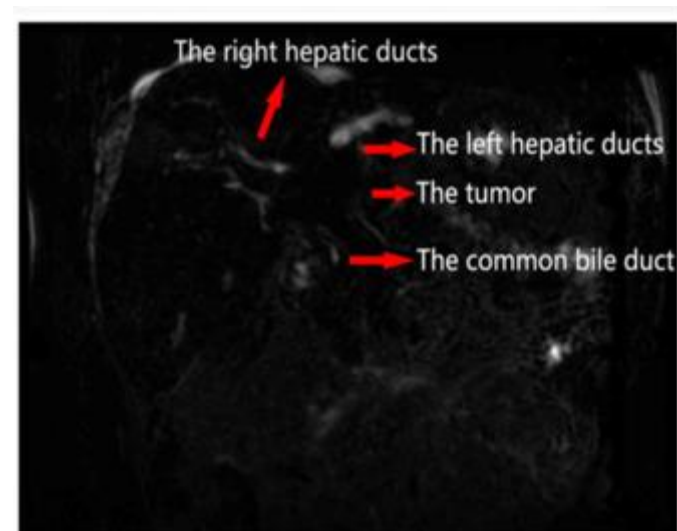
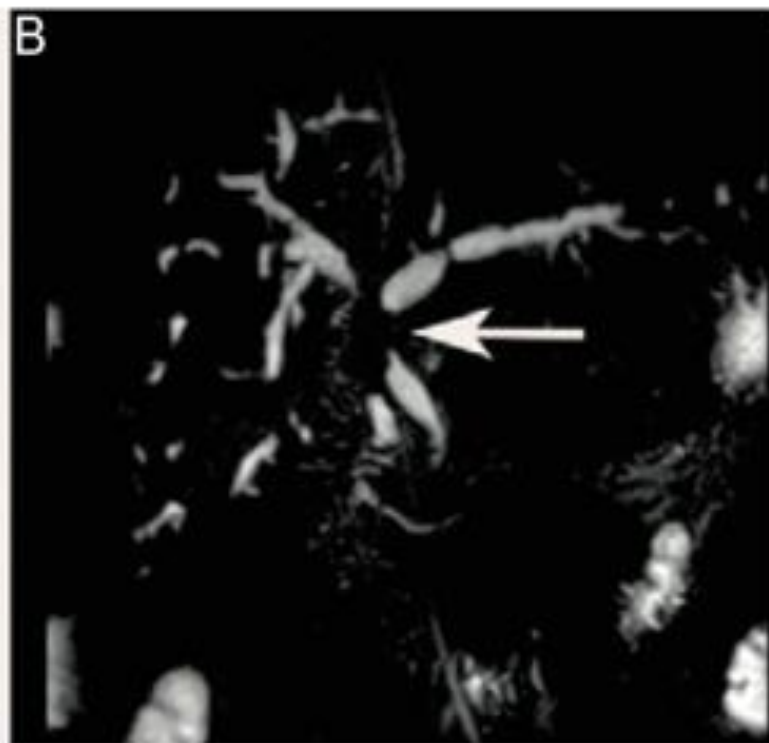
PTC Gram



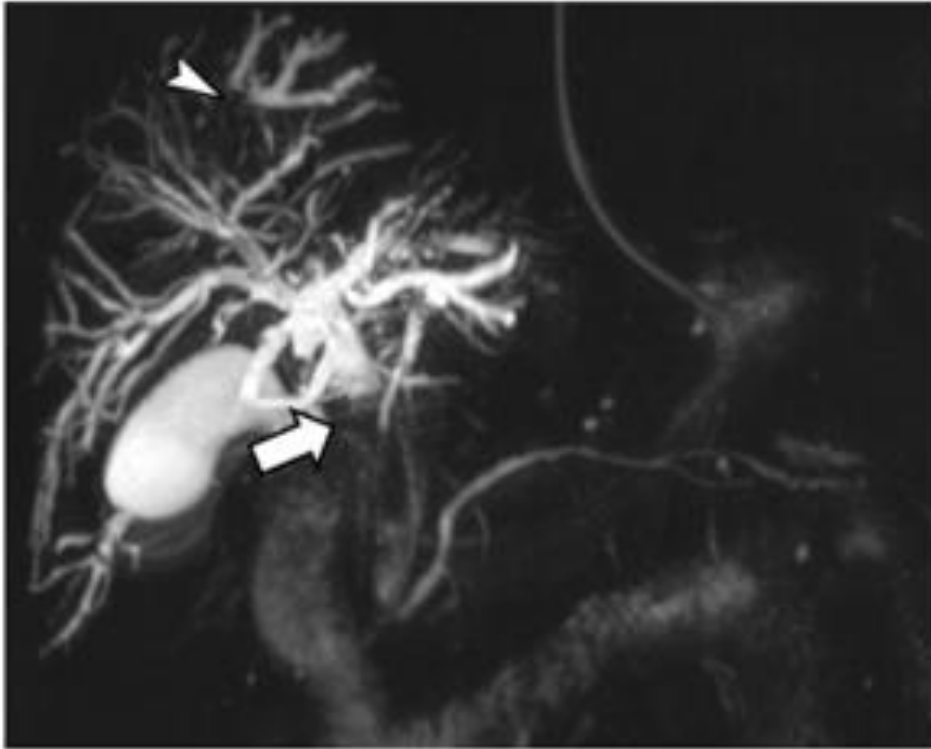
CHD Stricture; Level and Type of Block: III A/III B/IV



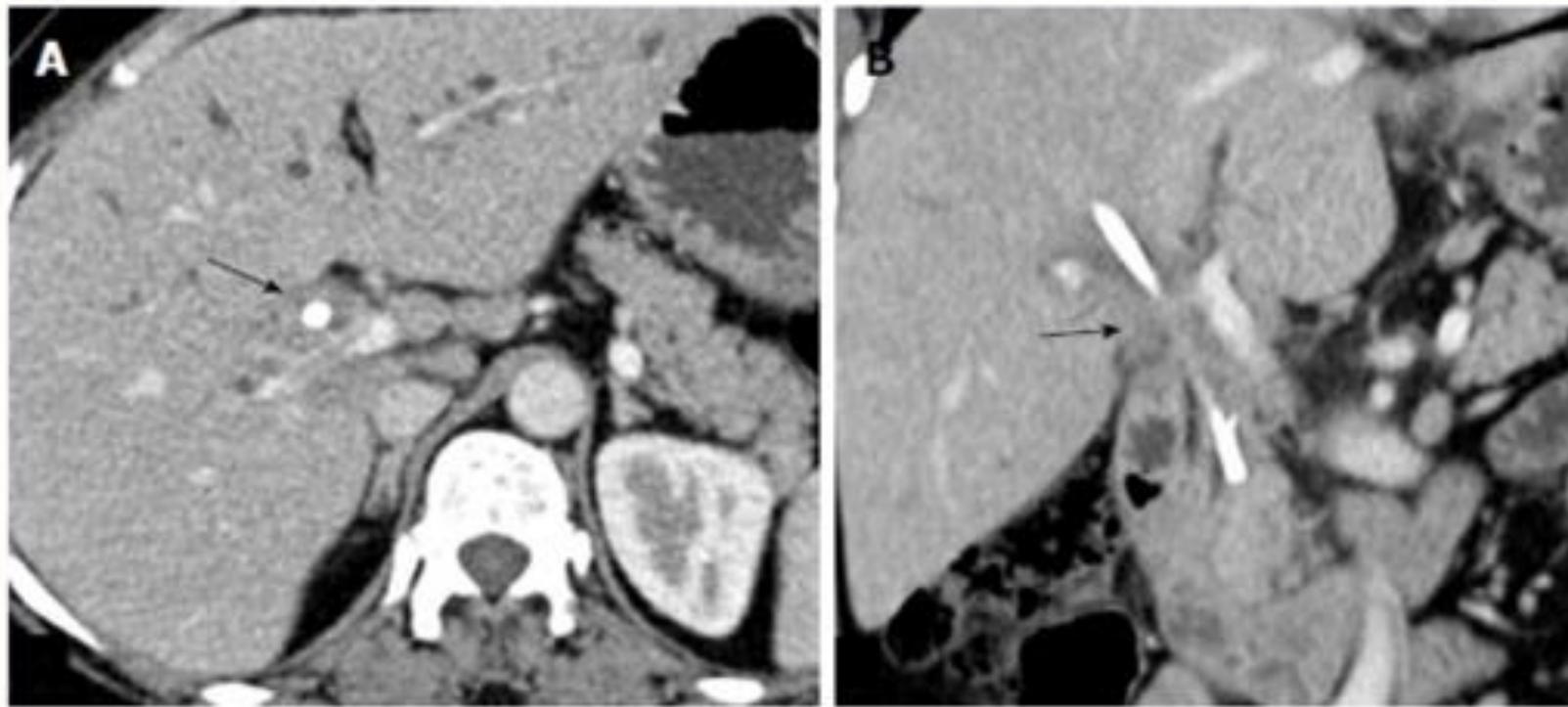
MRI Cholangiopancreatography



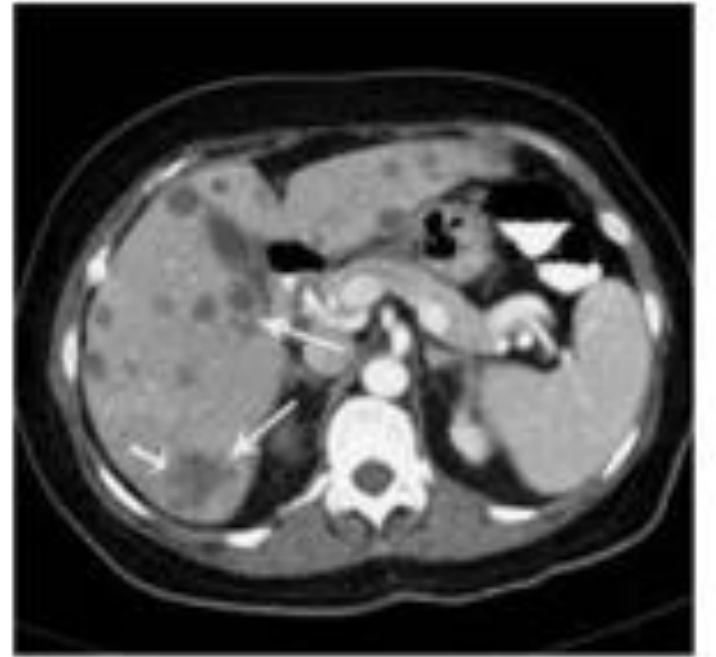
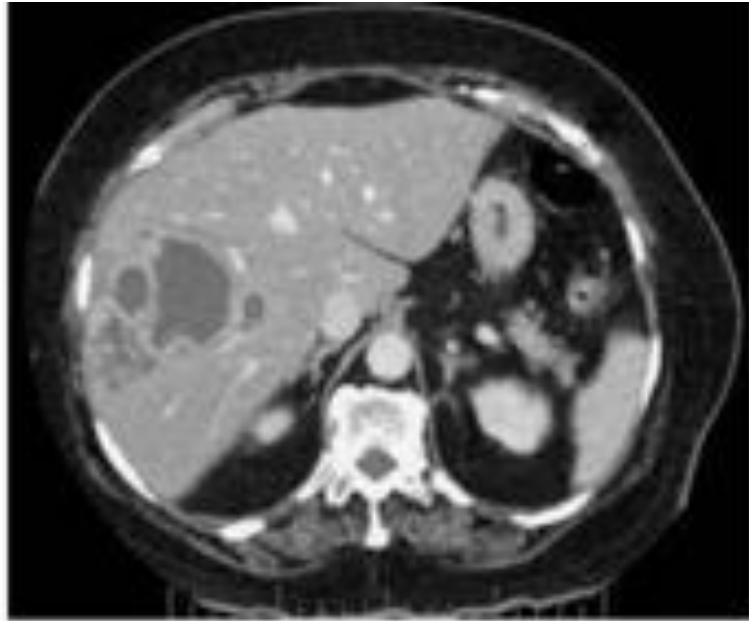
Imaging Pathology Correlation



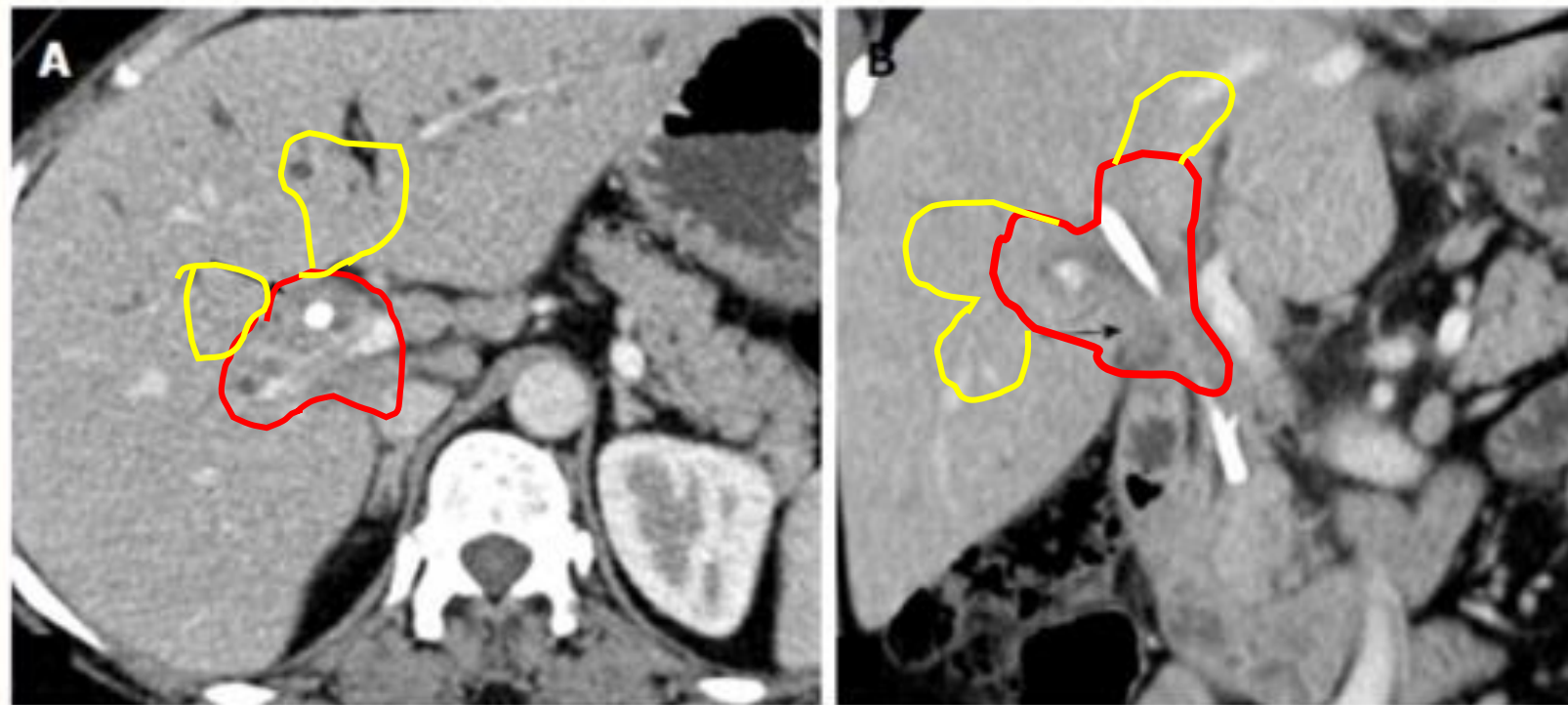
Post Stenting Target Delineation



Cholangitic Abscesses



Post Stenting Target Delineation



Summary: Target Delineation for Cholangiocarcinoma

- Challenging
- Knowledge of Biliary System Critical
- Integration of all Imaging needed
- Important to understand that classical expansion of volumes along biliary tract
- What's not seen is extremely important in target delineation.
- Important to exclude cholangitic abscesses.
- “Educated imagination with help of baseline scans” of disease extent after stents are placed.

Liver Metastasis



Liver metastases

- Peripheral arterial enhancing.
- IV contrast enhanced scans in portal venous phase.
- Hypervascular metastases occur in breast, renal cell, thyroid, and neuroendocrine cancers and may be better imaged in the arterial phase.
- For other metastasis lesions are often best seen in the portal venous phase and appear hypodense in relation to the liver parenchyma.
- PETCT should be utilized.
- Review of diagnostic imaging to determine the best phase for delineating the tumor should be performed before simulation.

Dutch Belgian Registry > 500 patients

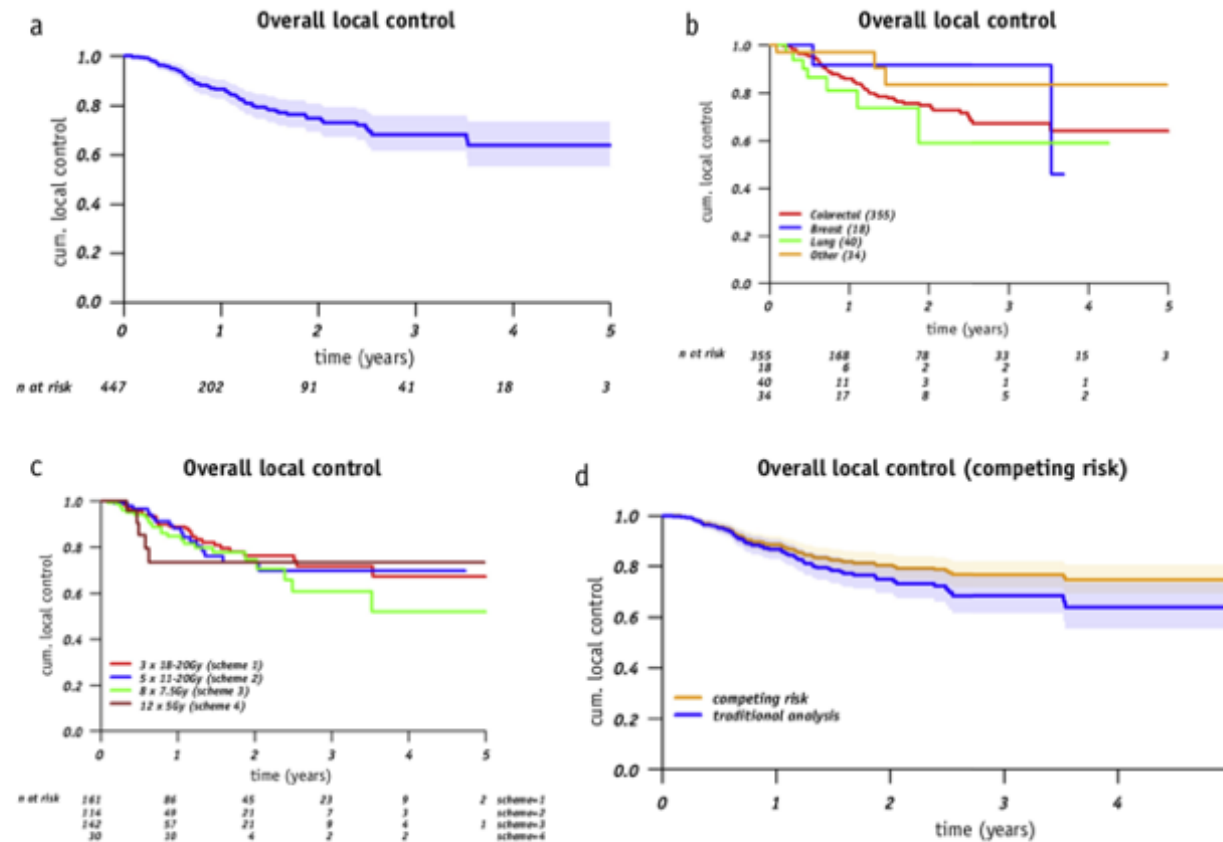
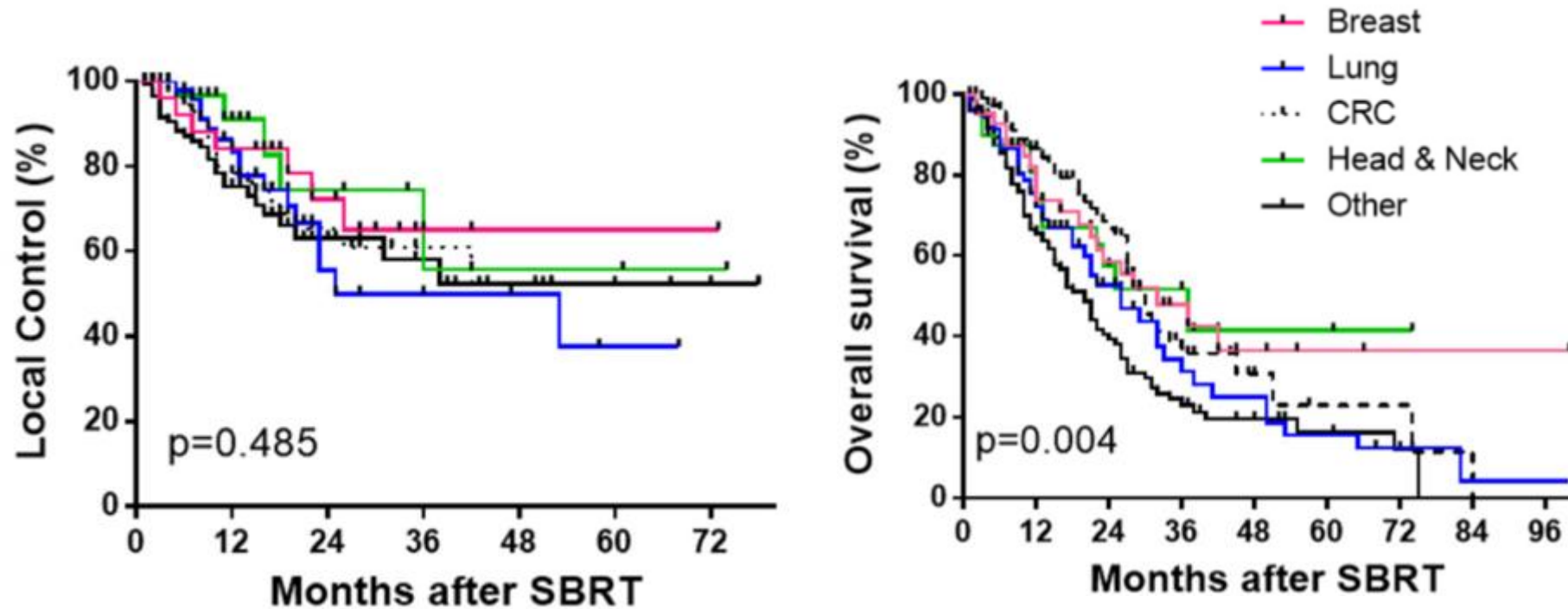


Fig. 1. (a) Overall local control. (b) Overall local control; metastases from different primary tumors. (c) Overall local control; various fractionation schemes applied to treat liver metastases. (d) Overall local control; competing risk method.

GTV+ 5 mm PTV
Margins

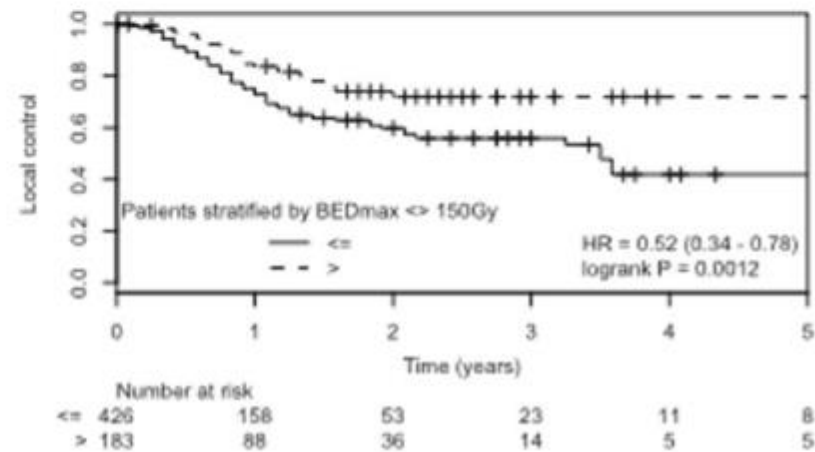
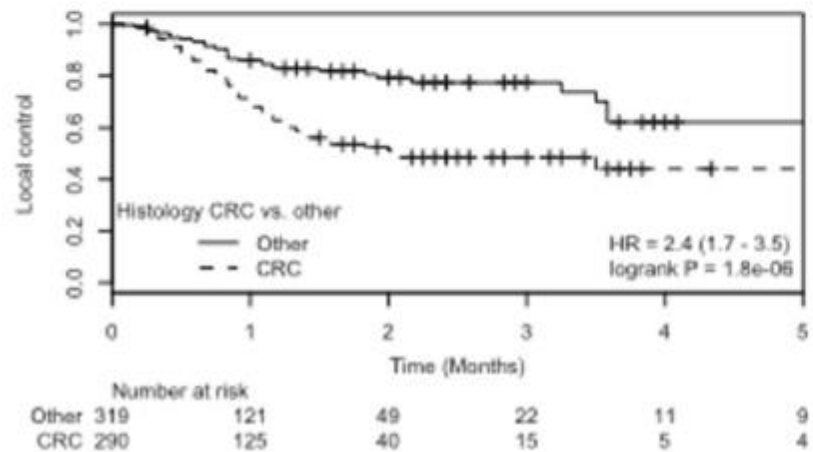
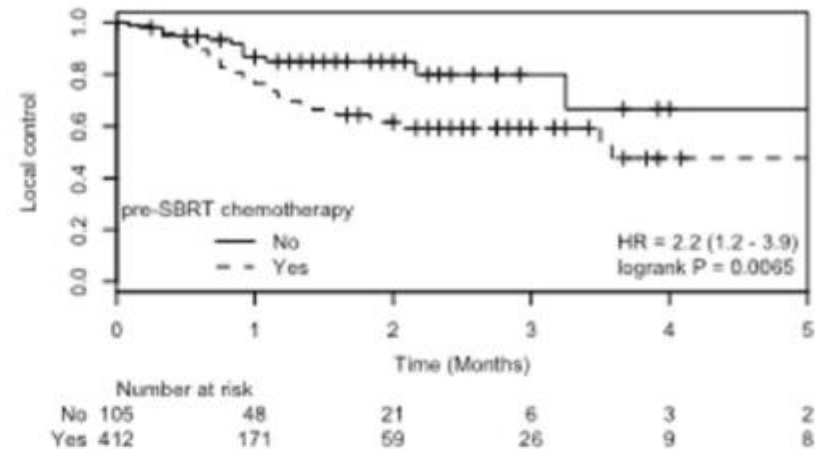
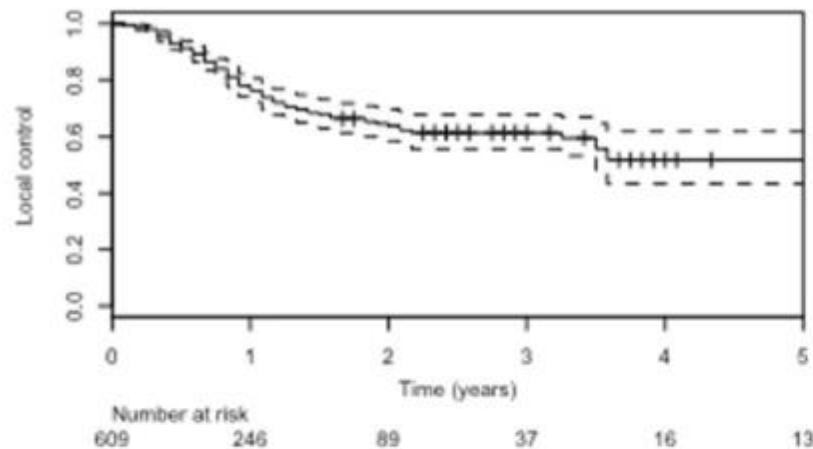
CECT/PET

Impact of Tumour Histology on overall outcomes



Multi-institutional database; 702 pts.

DEGRO Study (N=623 Liver Mets)

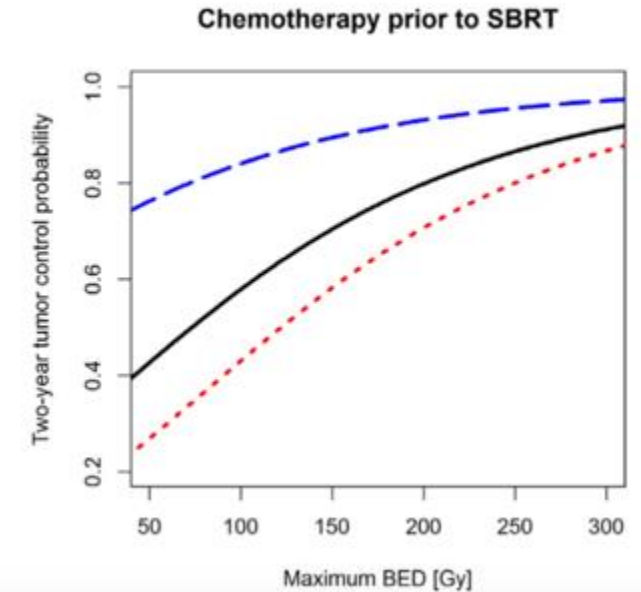
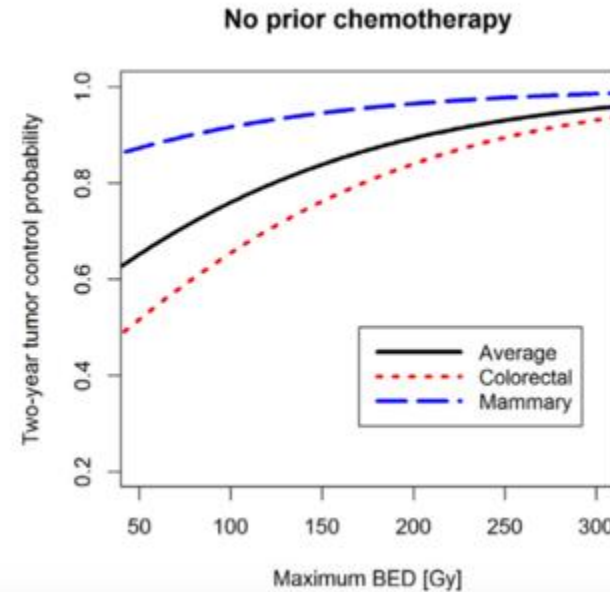
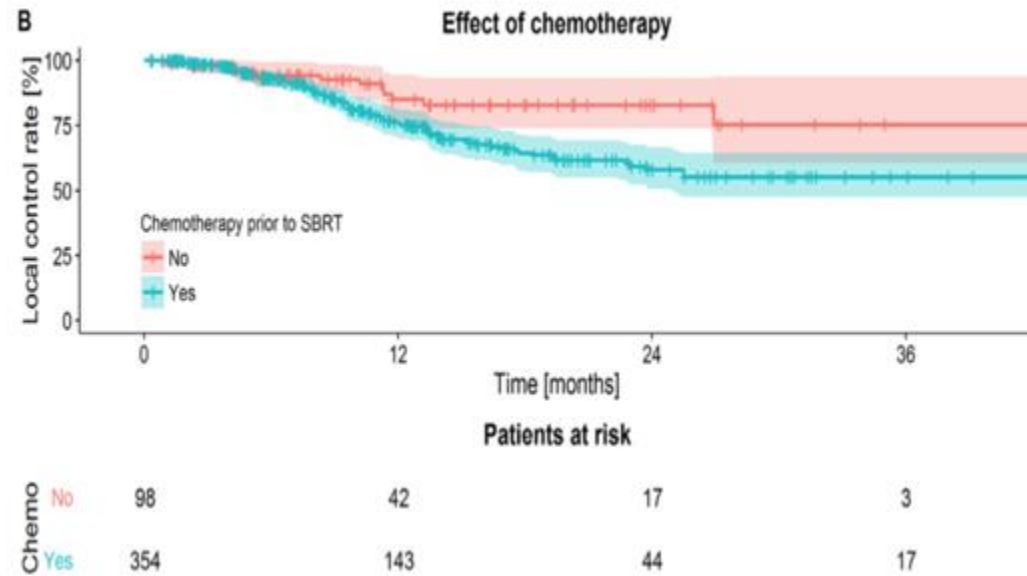


Poor Local Control of CRC Subtype and if Previous Chemotherapy Use is There

? Development of Chemoresistant Subclones or ? Progression on Systemic Chemotherapy

DEGRO Study
Andrataschke, BMC
Cancer 2018

Impact of Timing of Systemic Chemotherapy prior to SBRT



? Treatment to reduced tumour Volume

Chemoresistant Clones

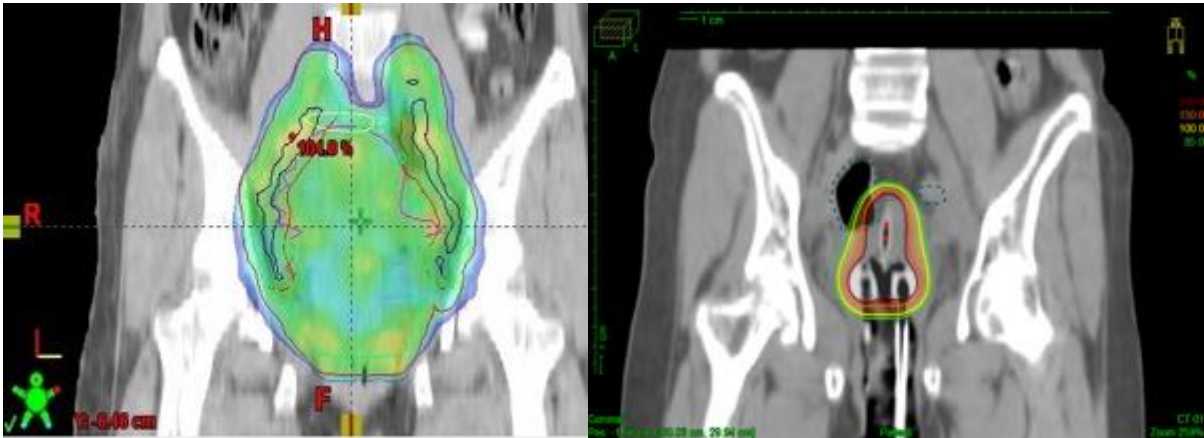
Similar observations also there for lung oligometstasis

Multicourse SBRT for Liver Metastasis

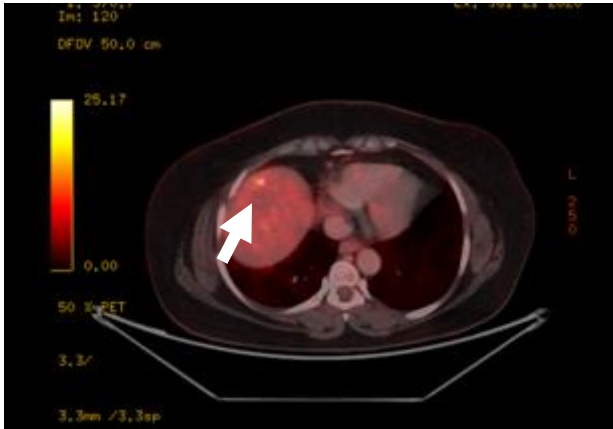
- RG diagnosed with locally advanced cervical cancer in March, 2020 with solitary liver metastasis (segment VIII).
- Chemotherapy could not be offered due to medical reasons.
- Received EBRT and BT. In between 2 fractions of Brachytherapy she received Liver SBRT 45 Gy/3#: May, 2020
- In June, 2021 she came with a new lesion in a nearby region. FNAC=Metastatic Squamous carcinoma and was planned for 54 Gy/6#.
- In 2021 as she already had rib pain and liver hypo-intensity corresponding to 20 Gy SBRT volume from course 1.
- Avoid Rib of major dose and spilled dose from SBRT 2 corresponded to region of liver hypointensity while saving dose spillage in new normal regions of liver.

M1 at Presentation (Solitary Liver)

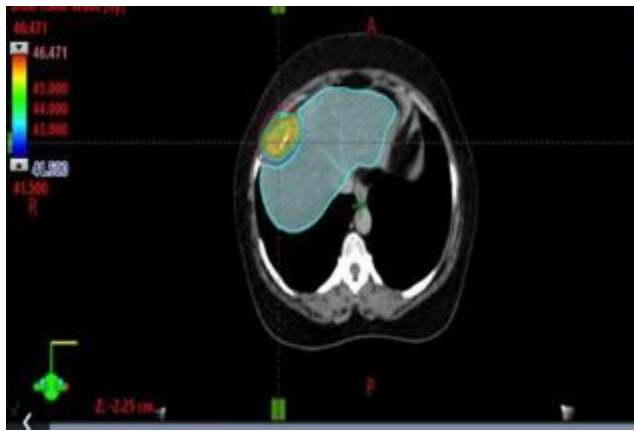
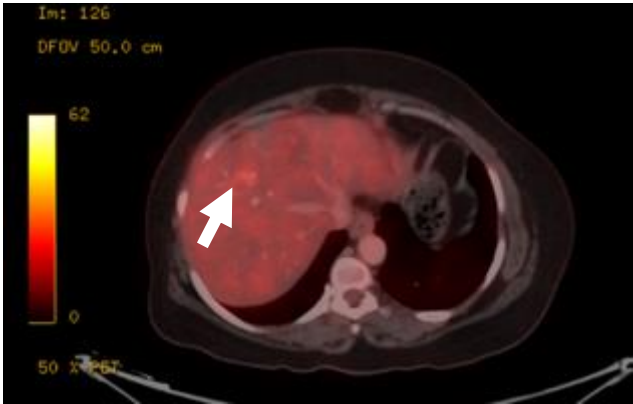
RT alone+ BT / SBRT Liver 45/3 (May,2020)



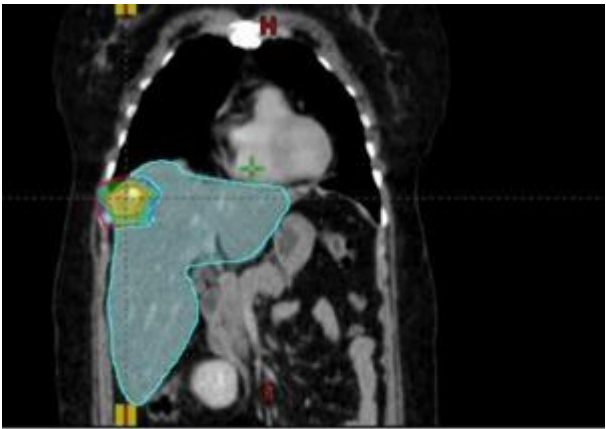
May,2020



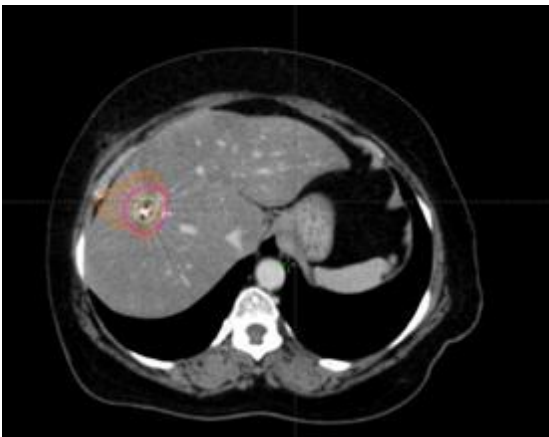
June,2021



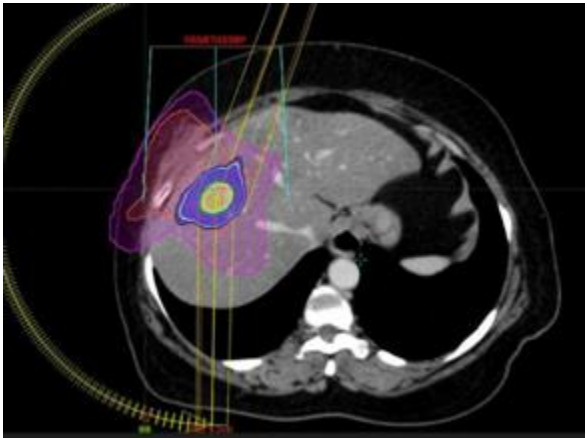
May,2020



May,2020



June,2021 54 Gy/6#



Thank you