Dedicated Drained Liver Volume Measurement after Percutaneous Biliary Drain Placement: A Personalized Three-Dimensional Volumetry Model

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Introduction

Malignant Bile Duct Obstruction (MBDO)

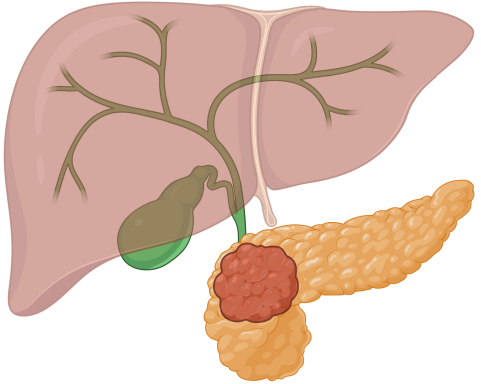
- Hyperbilirubinemia and improper bile excretion can affect administration of systemic chemotherapies[1,2]
- Intervention: Percutaneous Transhepatic Biliary Drainage (PTBD)

Physicians cannot accurately assess the probability of success for PTBD to reduce total serum bilirubin level below a threshold that allows for continuation of systemic chemotherapy.

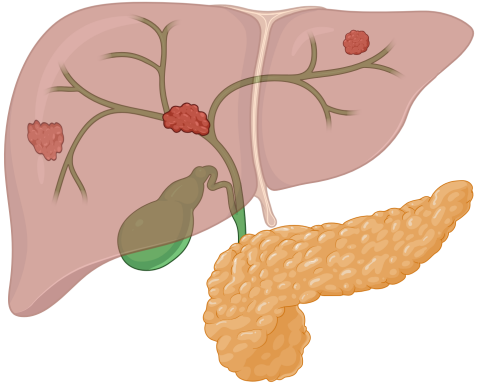
Proof-of-Concept Approach

- Train nnU-Net machine learning model to auto-segment CT scans into liver, biliary, and tumor segments[3]
- Validate biliary drainage volume in a sample of patients established to have increased likelihood of success: low obstruction with drained liver volume of 100%[1]

Low Obstruction

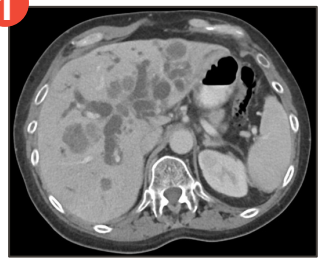


High Obstruction

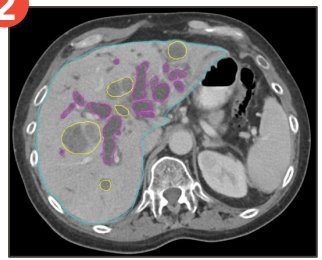


Methods

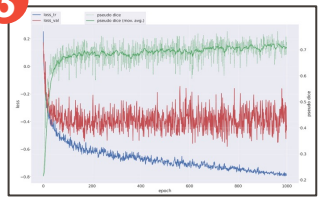
nnU-Net Training

1. 

   EMR patient search: PTBD January 2016 – May 2024

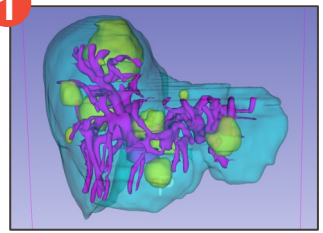
2. 

   Manual Segmentation to establish Ground Truth

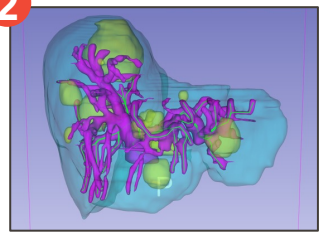
3. 

   nnU-Net algorithm trained to auto-segment CT scans into liver, tumors, and biliary tracts

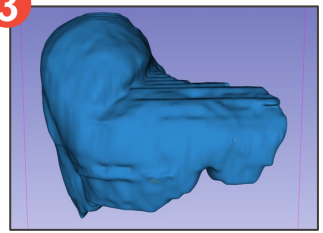
Biliary Drainage Volume Verification

1. 

   Ground Truth and nnU-Net 3D models input to 3D Slicer: SlicerLiver

2. 

   SlicerLiver: Add centerlines to identify biliary tract

3. 

   SlicerLiver: Calculate Biliary Drainage Territory Volume via shortest distance mapping to centerline(s)

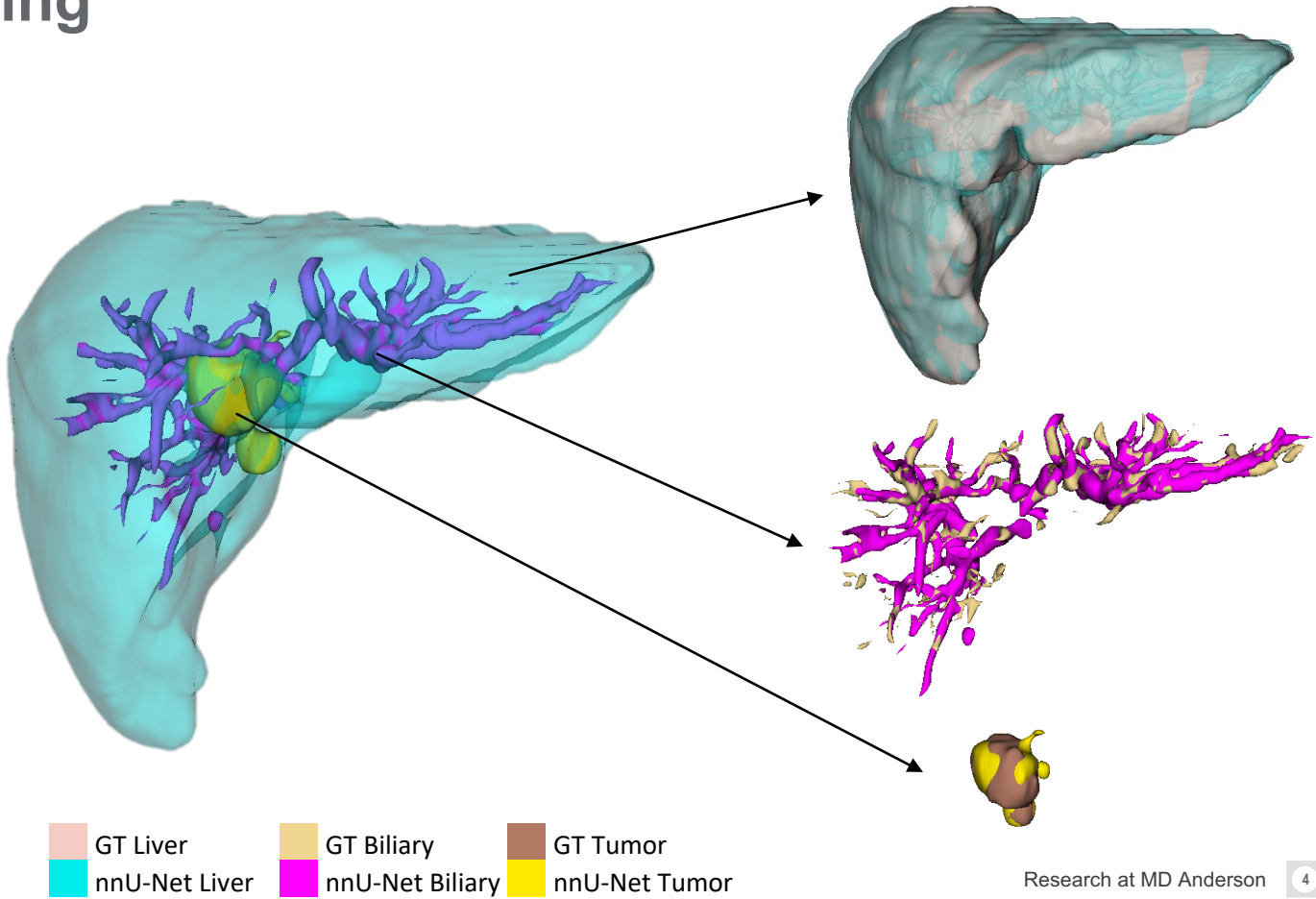
nnU-Net Training

nnU-Net Training

- Training Cases: 44
- Validation Cases: 11

Dice Scores

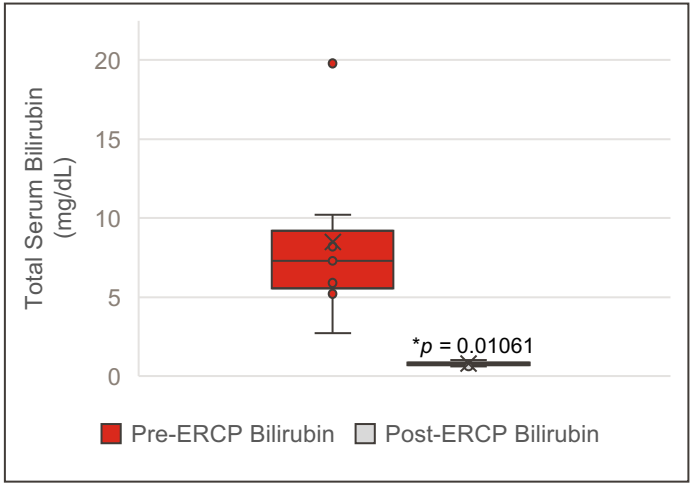
- Liver: 0.9154
- Biliary: 0.6338
- Tumor: 0.6051



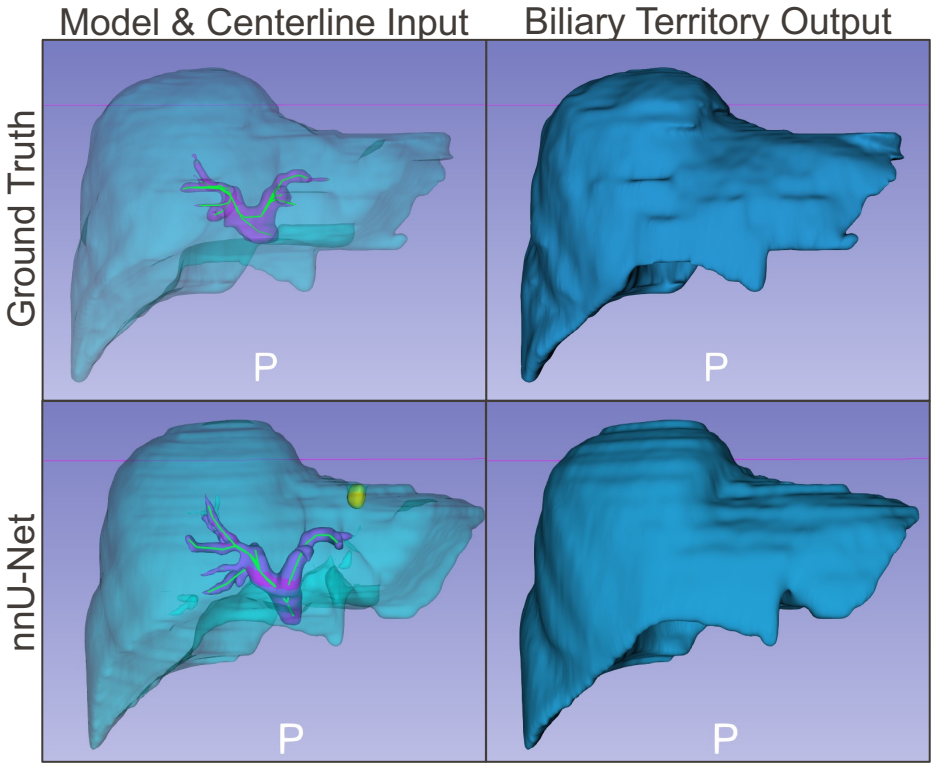
Low Obstruction Case Validation

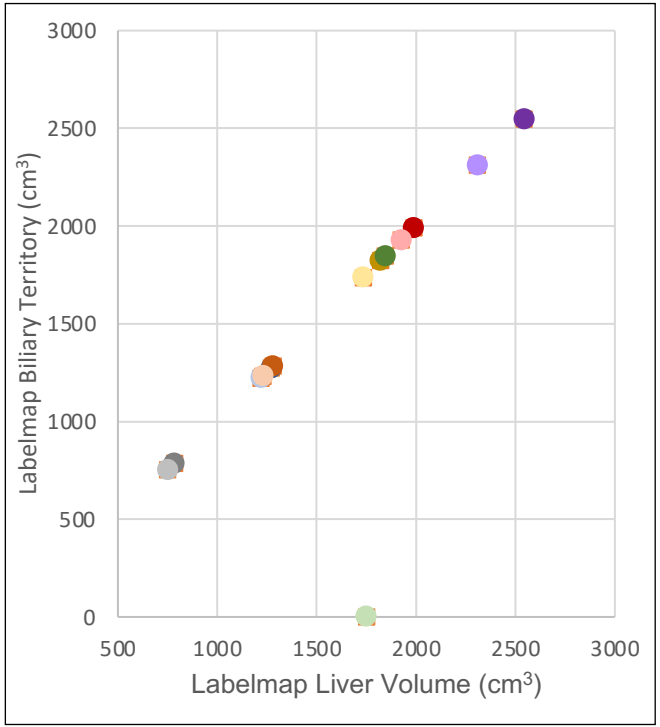
Variable	Value
Total Patients	7
Age	
Median	62
Range	54 - 70
Gender	
Male	3
Female	4
Pre-ERCP ECOG	
Not documented	2
0	1
1	3
2	1
Cancer Type	
Pancreatic	6
Cholangiocarcinoma	1
Post-ERCP Total Bilirubin <1.2 mg/dL	
Yes	7
No	0
Days to Post-ERCP Total Bilirubin <1.2 mg/dL	
Median	69
Range	29 - 109

- Low obstruction with drained liver volume of 100%
- ERCP resulted in total serum biliary normalization for all patients



Low Obstruction Case Validation



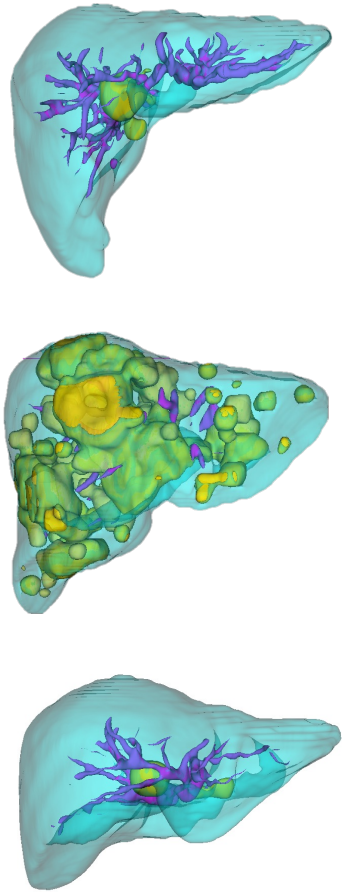


Conclusions

- nnU-Net machine learning algorithm trained to auto-segment liver, biliary, and tumor segments from abdominal CT scans. Further training for biliary and tumor segments is needed to improve accuracy.

- Utilized nnU-Net auto-segmented 3D models to verify 100% drained liver volume in small sample of patients with low level MBDO.

- Future: use unified computational tool to measure dependent liver volume from pre- and post-PTBD CT scans to correlate drained liver volume to total serum bilirubin levels post-PTBD.



Acknowledgements

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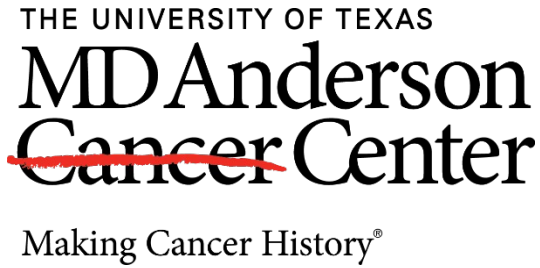
References

1. Thornton RH, Ulrich R, Hsu M, Moskowitz C, Reidy-Lagunes D, Covey AM, Brody LA, Robson PM, Sofocleous CT, Solomon SB, Getrajdman GI, Brown KT. 2012. Outcomes of Patients Undergoing Percutaneous Biliary Drainage to Reduce Bilirubin for Administration of Chemotherapy. J Vasc Interv Radiol. 23(1):89-95. https://doi.org/10.1016/j.jvir.2011.09.022
2. Thornton RH, Covey AM. Management of Malignant Biliary Tract Obstruction. In: Image-Guided Interventions: Expert Radiology Series. 3rd ed. Philadelphia (PA): Elsevier; c2021. p.749-760.
3. Isensee F, Jaeger PF, Kohl SAA, Petersen J, Maier-Hein KH. 2021. nnU-Net: a self-configuring method for deep learning-based biomedical image segmentation. Nat Methods. 18(2):203-211. https://doi.org/10.1038/s41592-020-01008-z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