PSC – Main Challenges

very heterogeneous disease; highly variable natural history; subtle changes over a long course of disease

1. Early detection and differentiation of changes (incl. sdPSC)

2. DD of benign versus malignant stricture (tumor)

3. Individual risk stratification / prognostication

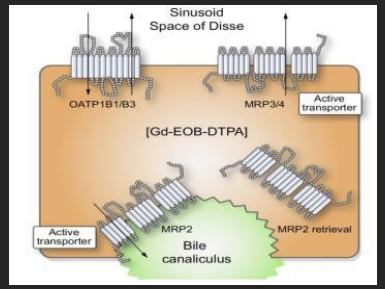
MRI (incl. MRCP) is mainstay in diagnosis and follow-up, but…

4. Technical challenges

high variability of protocols and image quality (not only among institutions)

PSC + MRI…more than bile duct changes !

e.g. using liver-specific contrast agents



Van Beers et al. J Hepatol 2012 (57):421-429

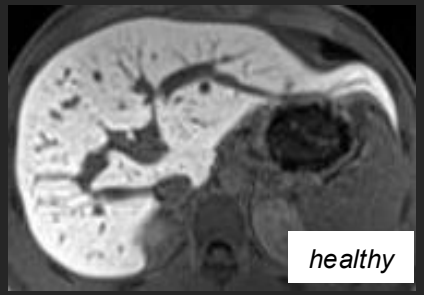
- hepatocellular uptake (OATP1)
- biliary secretion (MRP /cMOAT)

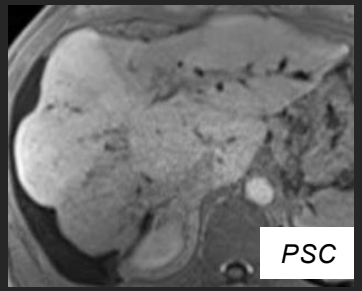
→ depends on liver function
(normal ~50% renal, 50% biliary)

Van Montfoort JE et al. J Pharmacol Exp Ther 1999;290:153-157
Takao H et al. Eur J Radiol 2011;77(2):325-329

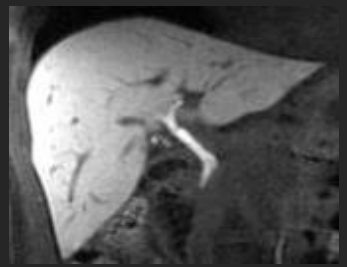
Hepatobiliary imaging (~15-20 min p.i.) in PSC

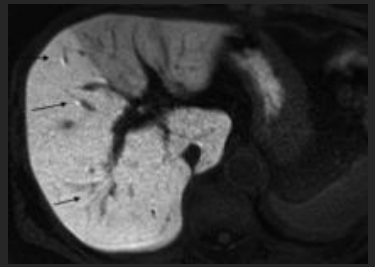
+ assessment of liver parenchyma (incl. quantification)

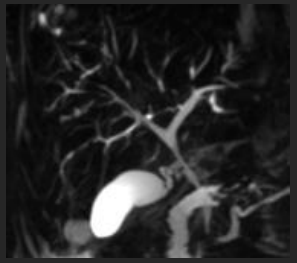




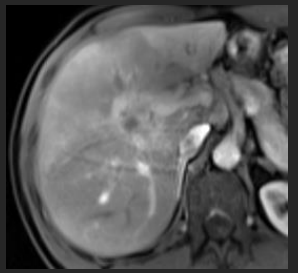
+ assessment of bile ducts (incl. quantification)



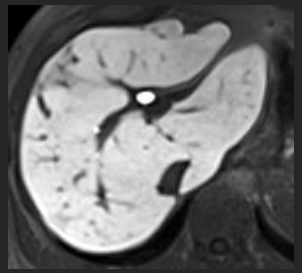




mutifocal strictures



e.g. signs of inflammation



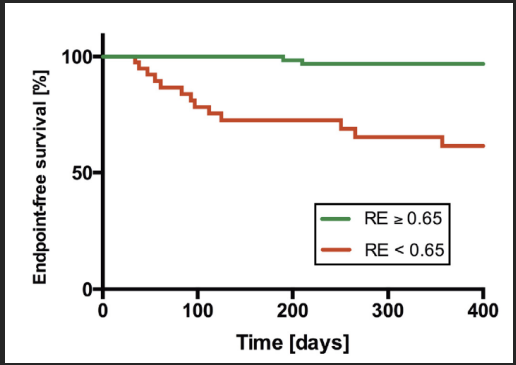
e.g. changes in liver morphology

PSC + MRI…more than bile duct changes !

e.g. using liver-specific contrast agents

→ correlation with disease severity, outcome, potential prognostic value in PSC…

Relative enhancement:
$(SI_{HBP})-(SI_{pre})) / (SI_{pre})$

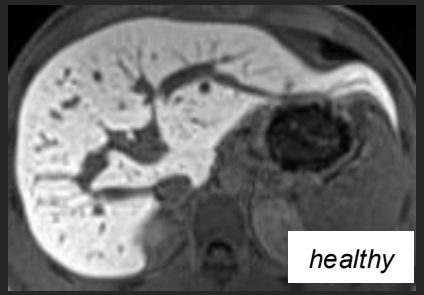


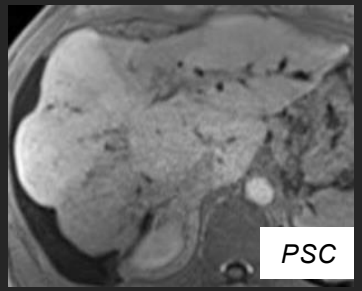
Manual or automatic measurements

Hinrichs H et al. Eur Radiol 2016;26(4):1116-1124
Schulze J et al. Clin Gastroenterol Hepatol 2019;17:192-199
Dornbusch S et al. Insights into Imaging, in press

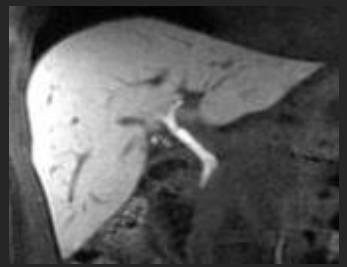
Hepatobiliary imaging (~15-20 min p.i.) in PSC

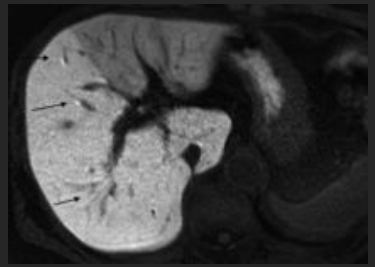
+ assessment of liver parenchyma (incl. quantification)

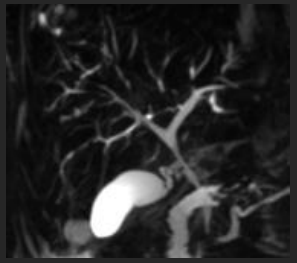




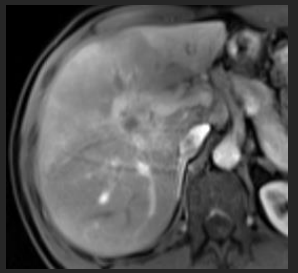
+ assessment of bile ducts (incl. quantification)



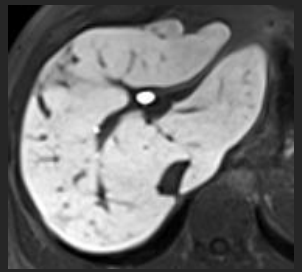




mutifocal strictures



e.g. signs of inflammation



e.g. changes in liver morphology

PSC and role of AI

European Radiology
https://doi.org/10.1007/s00330-020-07323-5

HEPATOBILIARY-PANCREAS

Fully automated detection of primary sclerosing cholangitis (PSC) -compatible bile duct changes based on 3D magnetic resonance cholangiopancreatography using machine learning

Kristina I. Ringe[1] · Van Dai Vo Chieu[1] · Frank Wacker[1] · Henrike Lenzen[2,3] · Michael P. Manns[3] · Christian Hundt[4] · Bertil Schmidt[5] · Hinrich B. Winther[1]

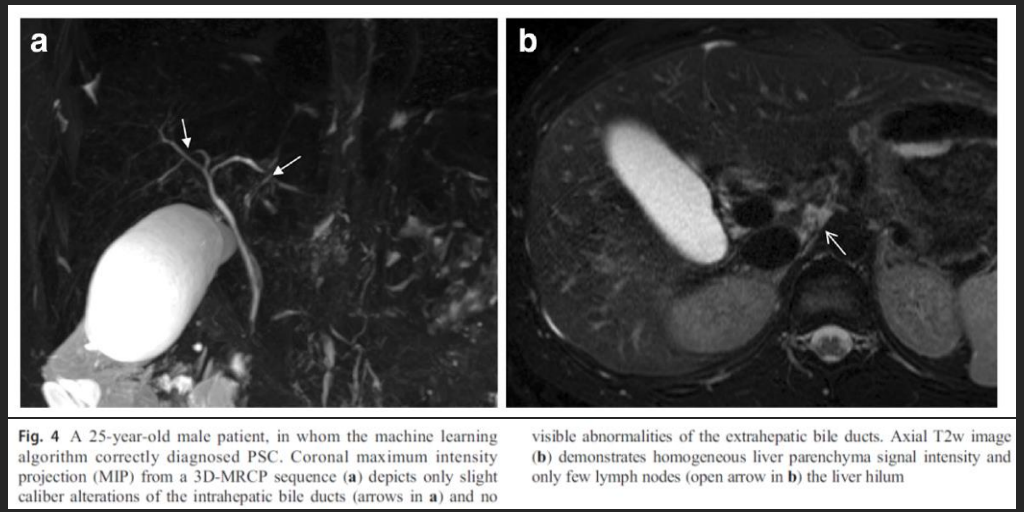


Fig. 4 A 25-year-old male patient, in whom the machine learning algorithm correctly diagnosed PSC. Coronal maximum intensity projection (MIP) from a 3D-MRCP sequence (**a**) depicts only slight caliber alterations of the intrahepatic bile ducts (arrows in **a**) and no visible abnormalities of the extrahepatic bile ducts. Axial T2w image (**b**) demonstrates homogeneous liver parenchyma signal intensity and only few lymph nodes (open arrow in **b**) the liver hilum

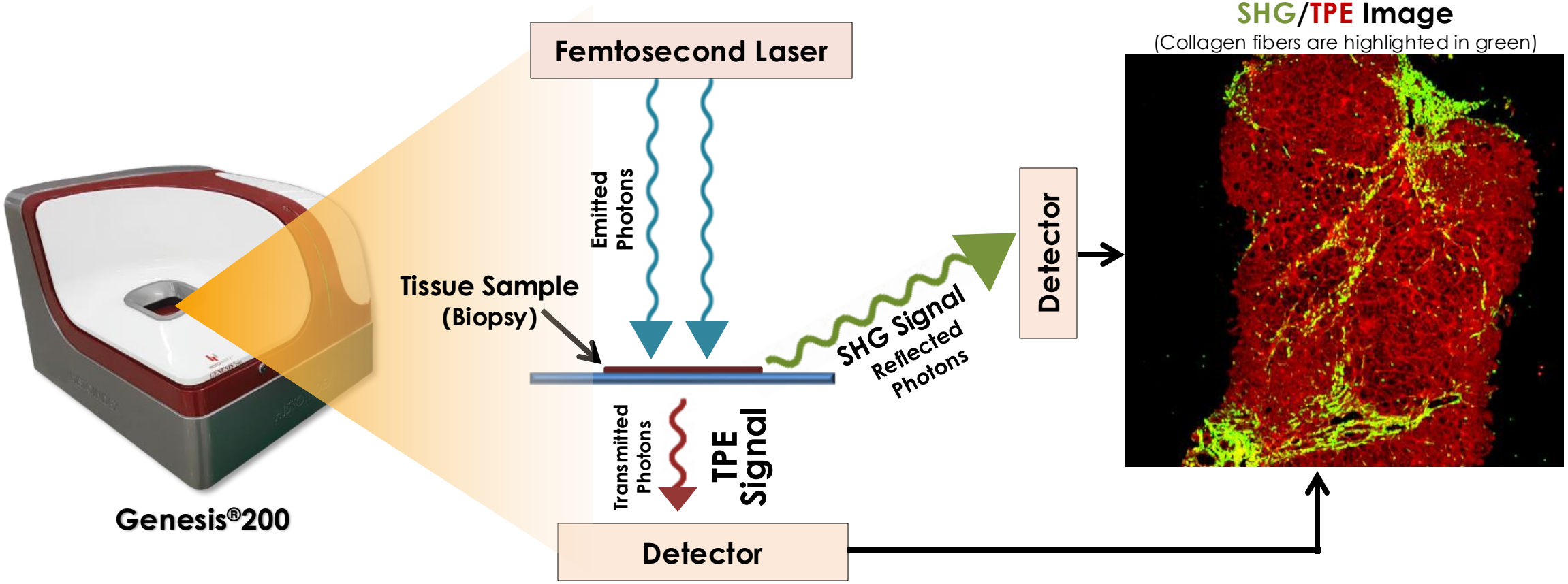
- DL-algorithm for detection of PSC compatible bile duct changes
- 428 patients (205 PSC, 223 non-PSC patients)
- generation of 2D projections (n=20) from 3D datasets, enabled implementation of an ensemble strategy to boost inference performance

- mean absolute error 7% (lowered from 21%)
- sensitivity: 95.0%
- specificity: 90.9%
- PPV: 90.5%
- NPV: 95,2%

PSC and role of AI – Challenges

- heterogeneity of datasets (image acquisition, image quality)
- large datasets needed (rare disease nature, few clinical end-points / long-follow-up needed)
- data-sharing (technical, governmental, regulatory issues…)

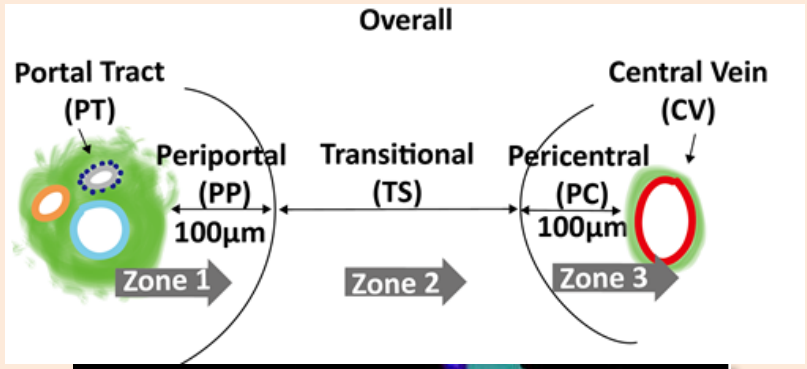
AI using Stain-free Digital Pathology highly reproducible quantitative assessment

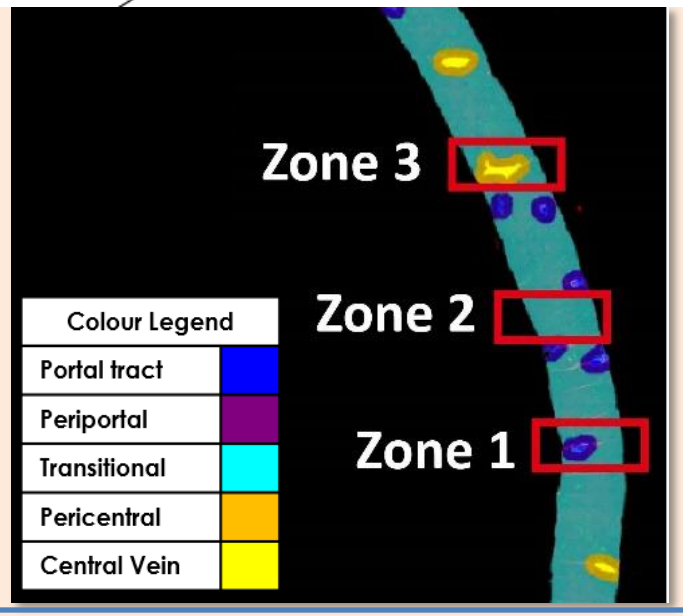


Reference: Sun W, Chang S, Tai D C, et al. Nonlinear Optical Microscopy: Use of Second Harmonic Generation and Two-photon Microscopy for Automated Quantitative Liver Fibrosis Studies[J]. Journal of Biomedical Optics, 2008, 13(6):7-0.

qFibrosis: Definitions

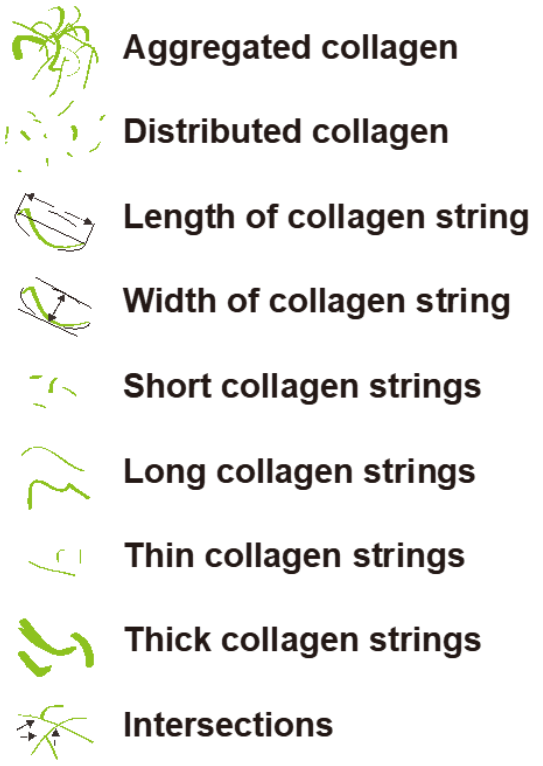
AI identified zones





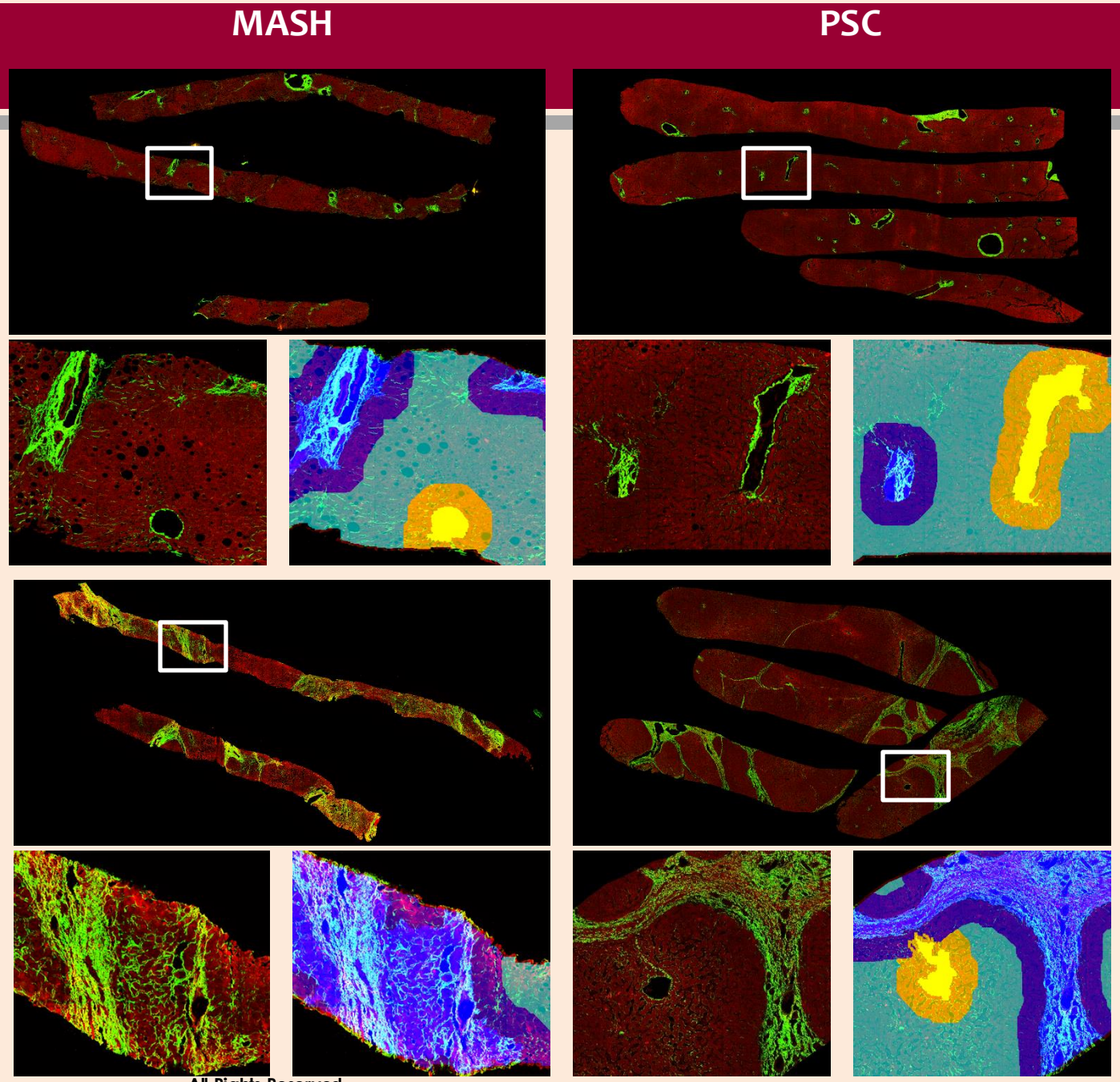
28 Knowledge-based fibrosis parameters were quantified in each zone

No.	Fibrosis Parameters
1	Percentage of collagen
2	Percentage of aggregated collagen
3	Percentage of distributed collagen
4	Number of collagen strings
5	Number of short collagen strings
6	Number of long collagen strings
7	Number of thin collagen strings
8	Number of thick collagen strings
9	Area of collagen strings
10	Length of collagen strings
11	Width of collagen strings
12	Number of aggregated collagen
13	Number of short and aggregated collagen
14	Number of long and aggregated collagen
15	Number of thin and aggregated collagen
16	Number of thick and aggregated collagen
17	Area of aggregated collagen strings
18	Length of aggregated collagen
19	Width of aggregated collagen
20	Number of distributed collagen
21	Number of short and distributed collagen
22	Number of long and distributed collagen
23	Number of thin and distributed collagen
24	Number of thick and distributed collagen
25	Area of distributed collagen strings
26	Length of distributed collagen
27	Width of distributed collagen
28	Number of intersections in collagen strings



Differences in MASH vs PSC

- Similar fibrosis patterns in early stages
- Significant differences patterns in late stages
  - Extensive fibrosis around bile ducts
  - Periductal concentric fibrosis - "onion-skin" fibrosis

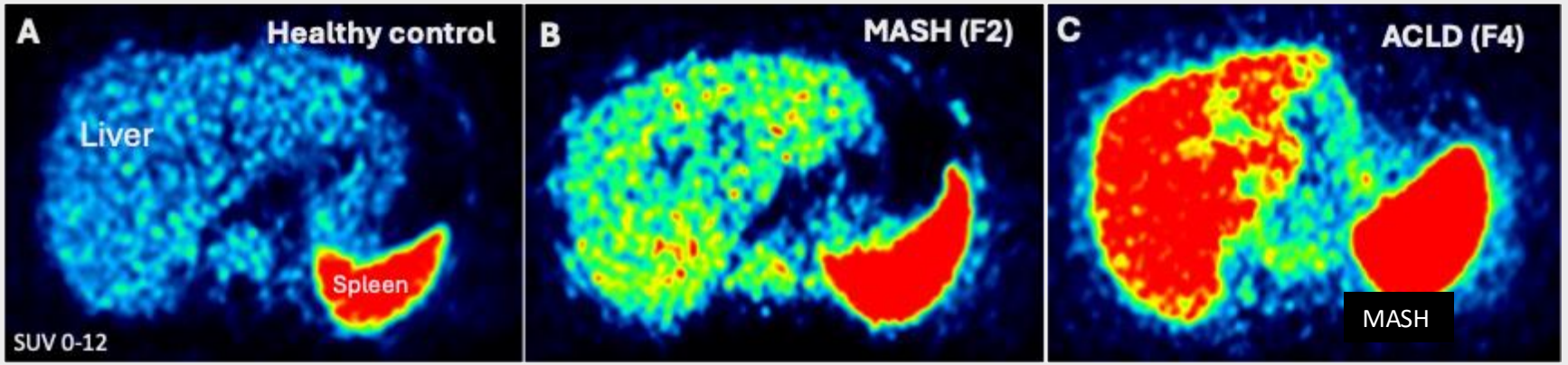


Fibrogenesis imaging with PDGF-receptor-β PET probe in MASH and PSC

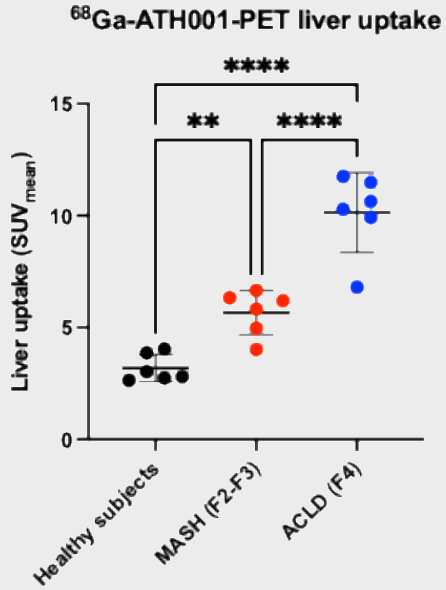
Lars Johansson, CSO Antaros Medical

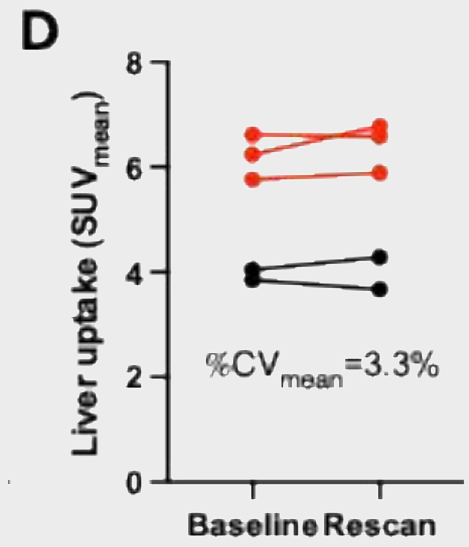
Antaros Medical

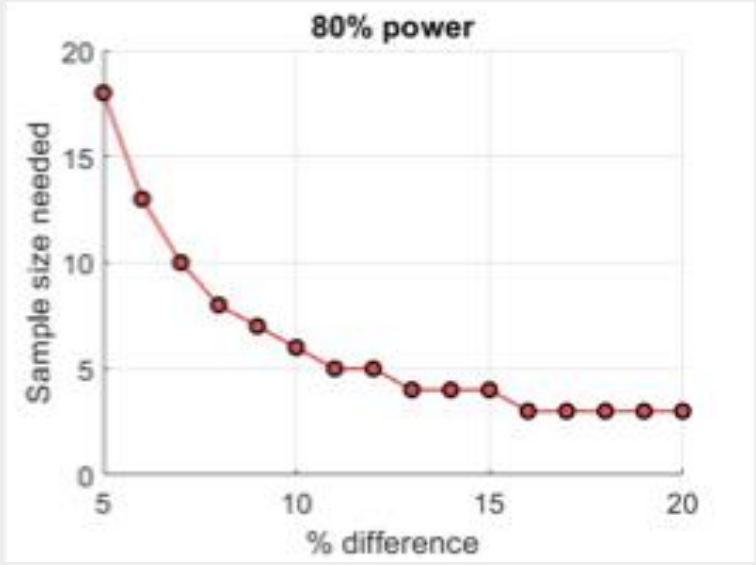
PDGFRβ-PET in MASH dynamic range and repeatability



Healthy subjects (n=6) ProC3>12.6 (n=6) TE > 12 kPa (n=6)



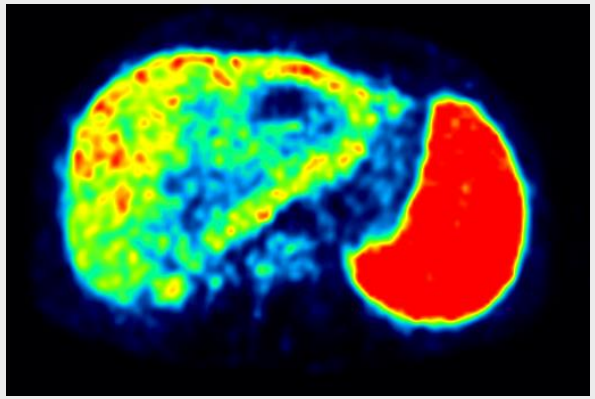




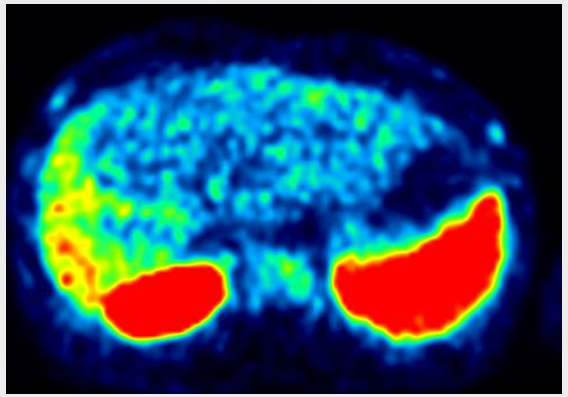
Antaros Tracer

PDGFRβ-PET in Primary Sclerosing Cholangitis (PSC)

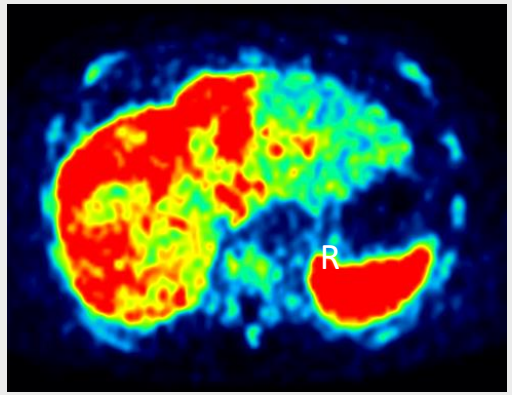
24.5 kPa



7.5 kPa



14.7 kPa



SUV 0-10

Marked heterogeneity in liver uptake compared to MASH etiology patients

Antaros Tracer