Hepatic volume & vessels segmentation
R-VESSEL-X

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CHU Estaing – Clermont-Ferrand

Context

Development of a CT & MRI segmentation tool for the total liver and portal network

- **ANR project R-VESSEL-X**
- **Open-source software on 3D SLICER.**
- Very useful for surgeons (liver transplantation, partial hepatectomy…)
- Few solutions for liver segmentation of MRI images despite more and more indications

Objectives

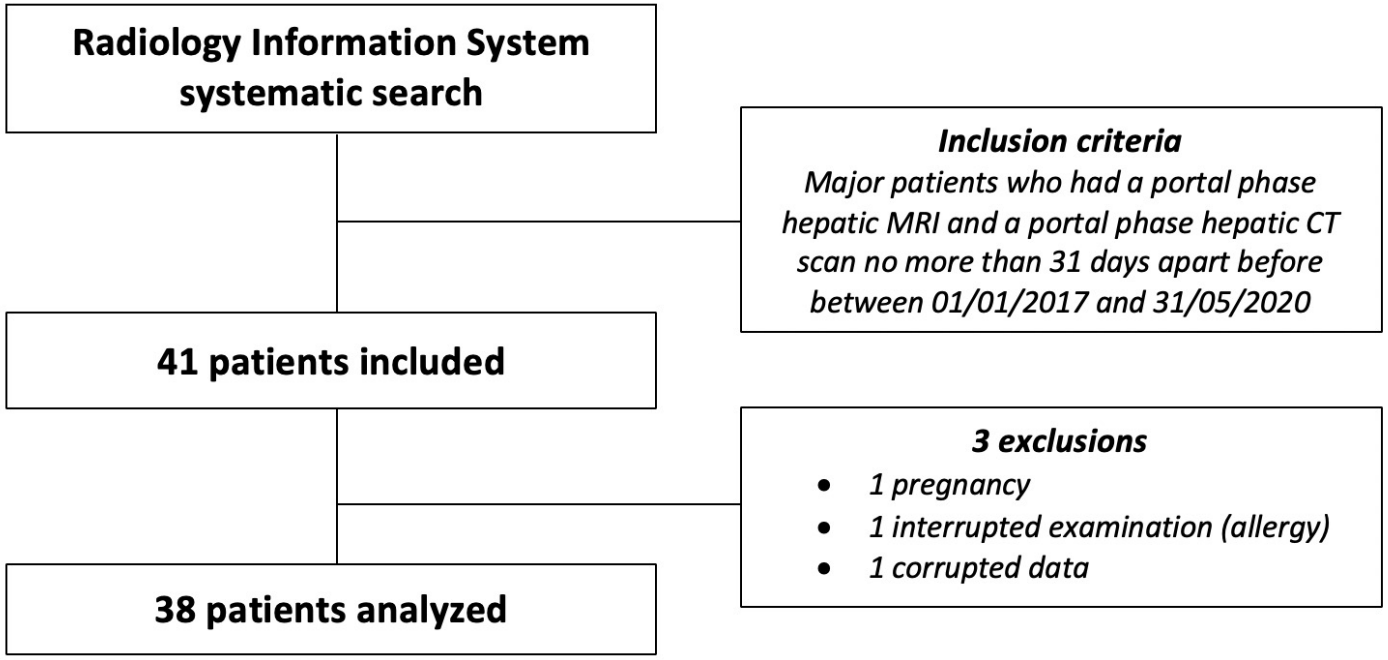
- **Main objective**
  - **Comparison of the performance of R-VESSEL-X (CT and MRI) vs HepaticVCAR (CT)**
    - Total liver volume
    - Segmentation time
    - Quality of segmentation
- **Secondary objectives**
  - Comparison of the performance of R-VESSEL-X vs HepaticVCAR
    - Dysmorphic livers
    - Difficult examinations

Data & flow-chart

Retrospectif monocentric study (University Hospitals Clermont-Ferrand)

CERIM accreditation, securised database

1 patient = 3 segmentation (HVCAR TDM, RVX TDM, RVX IRM)



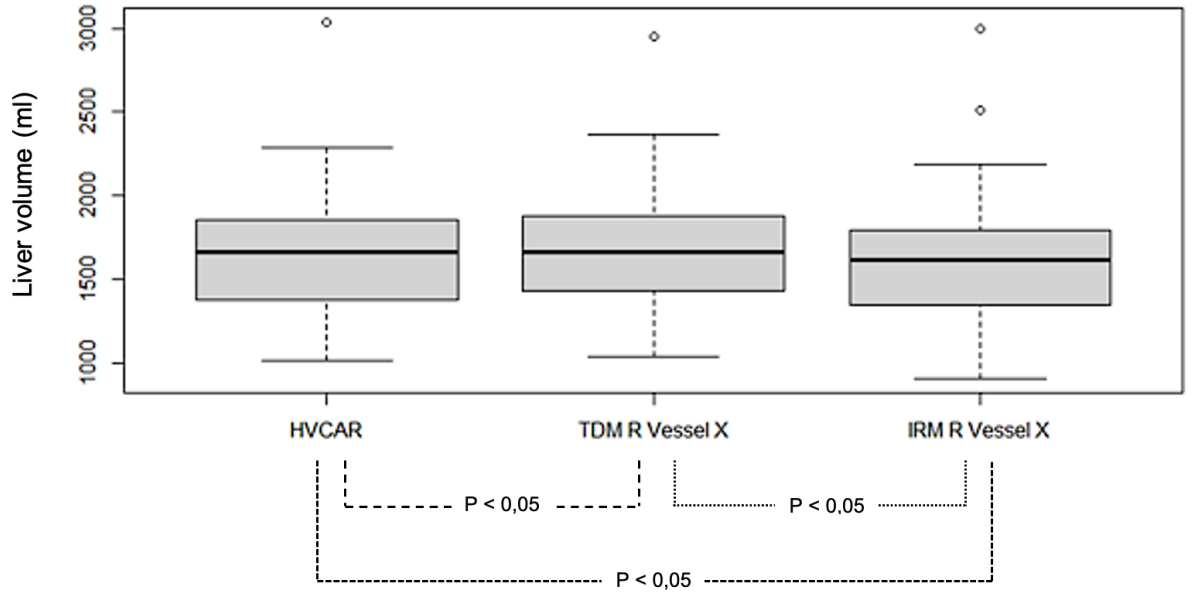
Population of study

- **Median age** : 66 [29-86] years
- **Sex ratio** : 3M/1W
- **Indications of study** :
  - Oncology (n= 35, 92%)
    - ❖ Metastasis (n = 19, 50%)
    - ❖ Hepatocellular carcinoma (n = 14, 37%)
    - ❖ Cholangiocarcinoma (n = 2, 5%).
  - Other (n = 3, 8%)
    - ❖ Encephalitis
    - ❖ Colitis (Clostridium Difficile)
    - ❖ Intra peritoneal effusion on sonography
- **Dysmorphic livers :** 16 (42%)
- **Difficult examens :** 12 (32%)

Results – Hepatic volume

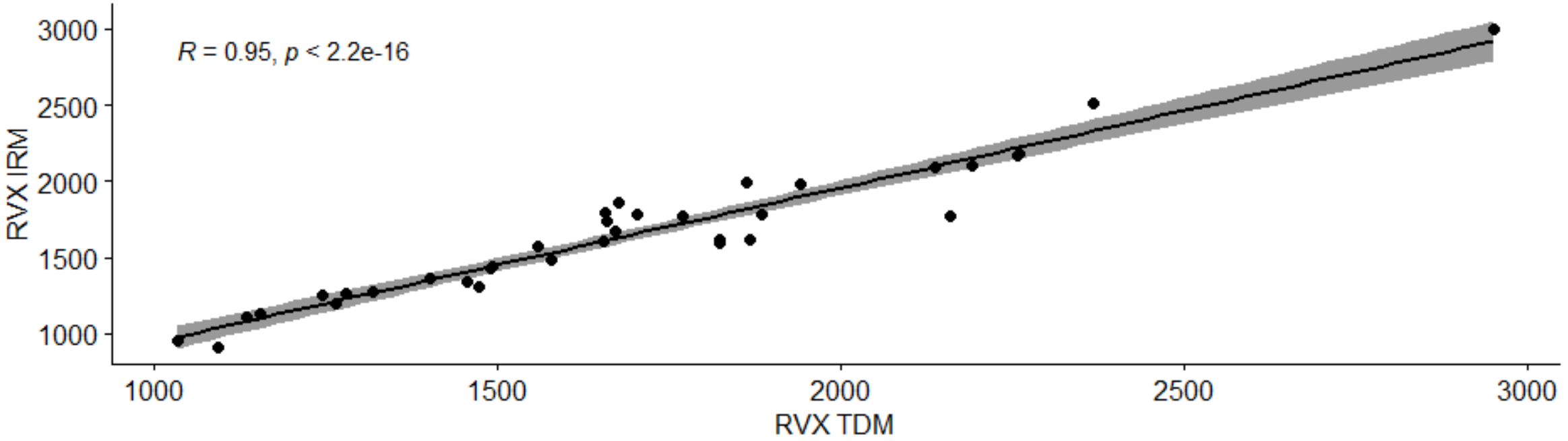
No significant difference between the 3 methods

	HVCAR	RVX TDM	RVX IRM	P-value (Kruskal-Wallis)
Volume (mL)	1721 ± 444	1722 ± 441	1648 ± 428	**0,82**



Results – Hepatic volume

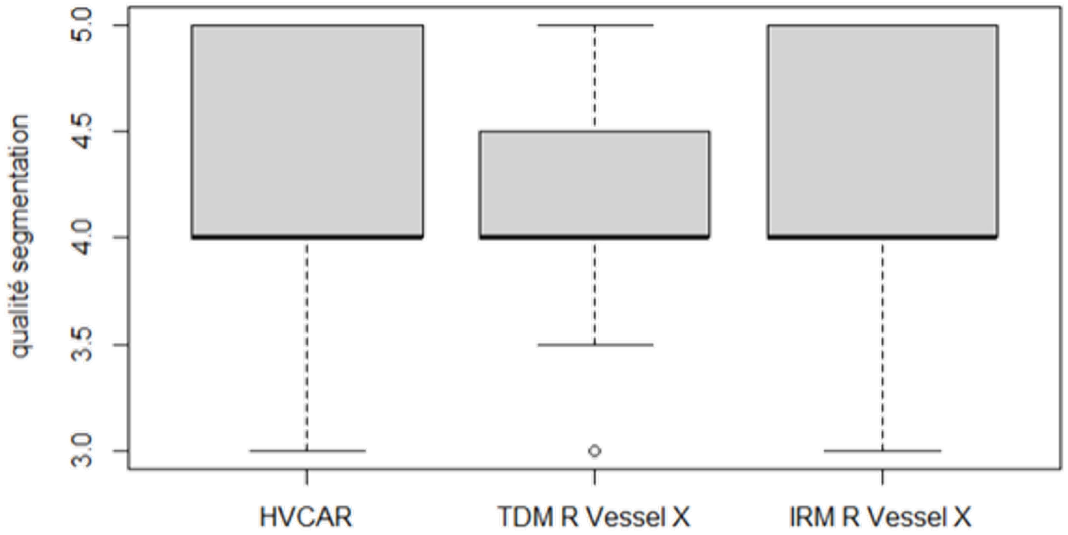
Very good correlations of liver volumes obtained between the 3 methods



Results - Quality

No significant difference between the 3 methods

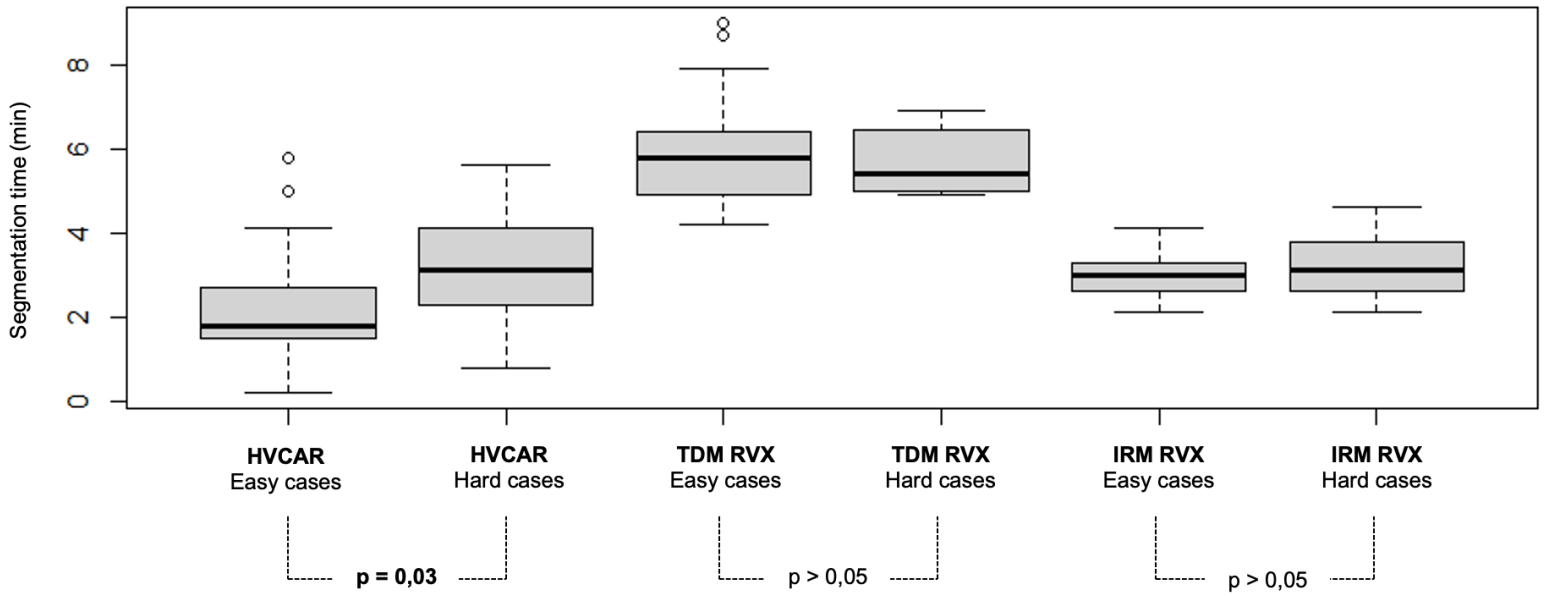
	HVCAR	RVX TDM	RVX IRM	P-value (Kruskal-Wallis)
Quality (1-5)	4,33 ± 0,64	4,19 ± 0,53	4,31 ± 0,59	**0,52**



Results – Segmentation time

Significant difference between TDM RVX and other methods

	HVCAR	RVX TDM	RVX IRM	P-value (Kruskal-Wallis)
Temps de segmentation (min)	2,69 ± 2,01	5,89 ± 1,16	3,05 ± 0,63	**< 0,05**

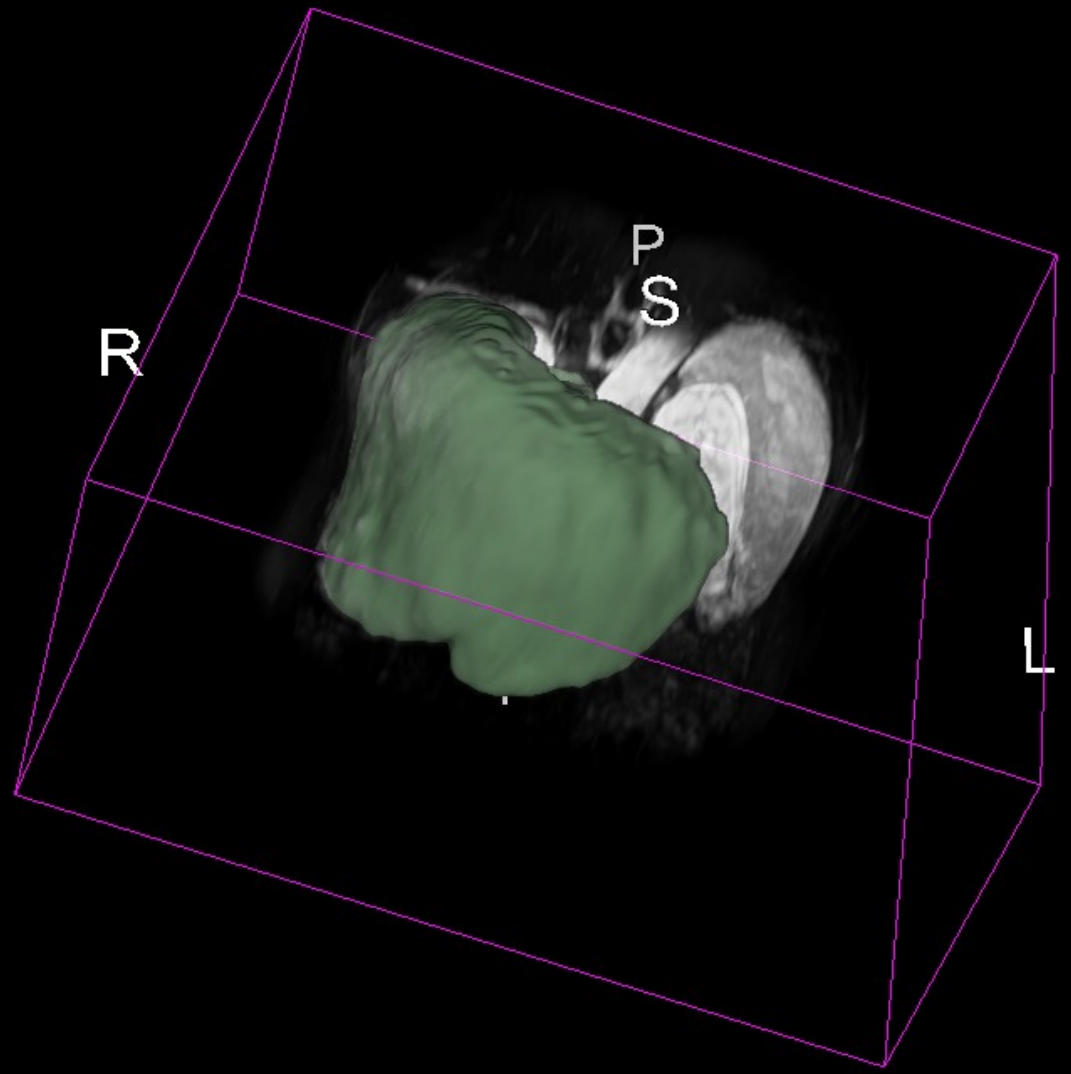


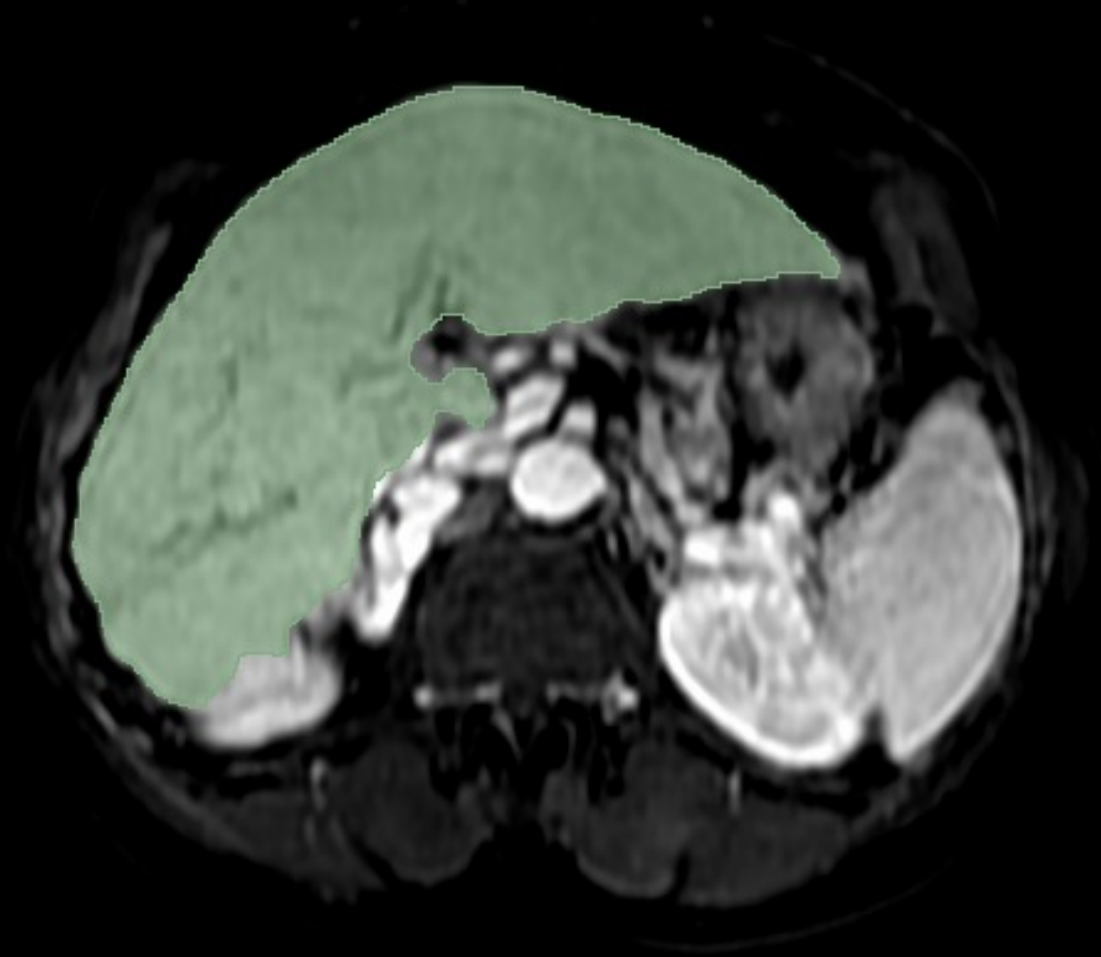
Results - secondary objectives

Same results as the main analysis for dysmorphic livers group and for non dysmorphic livers group.

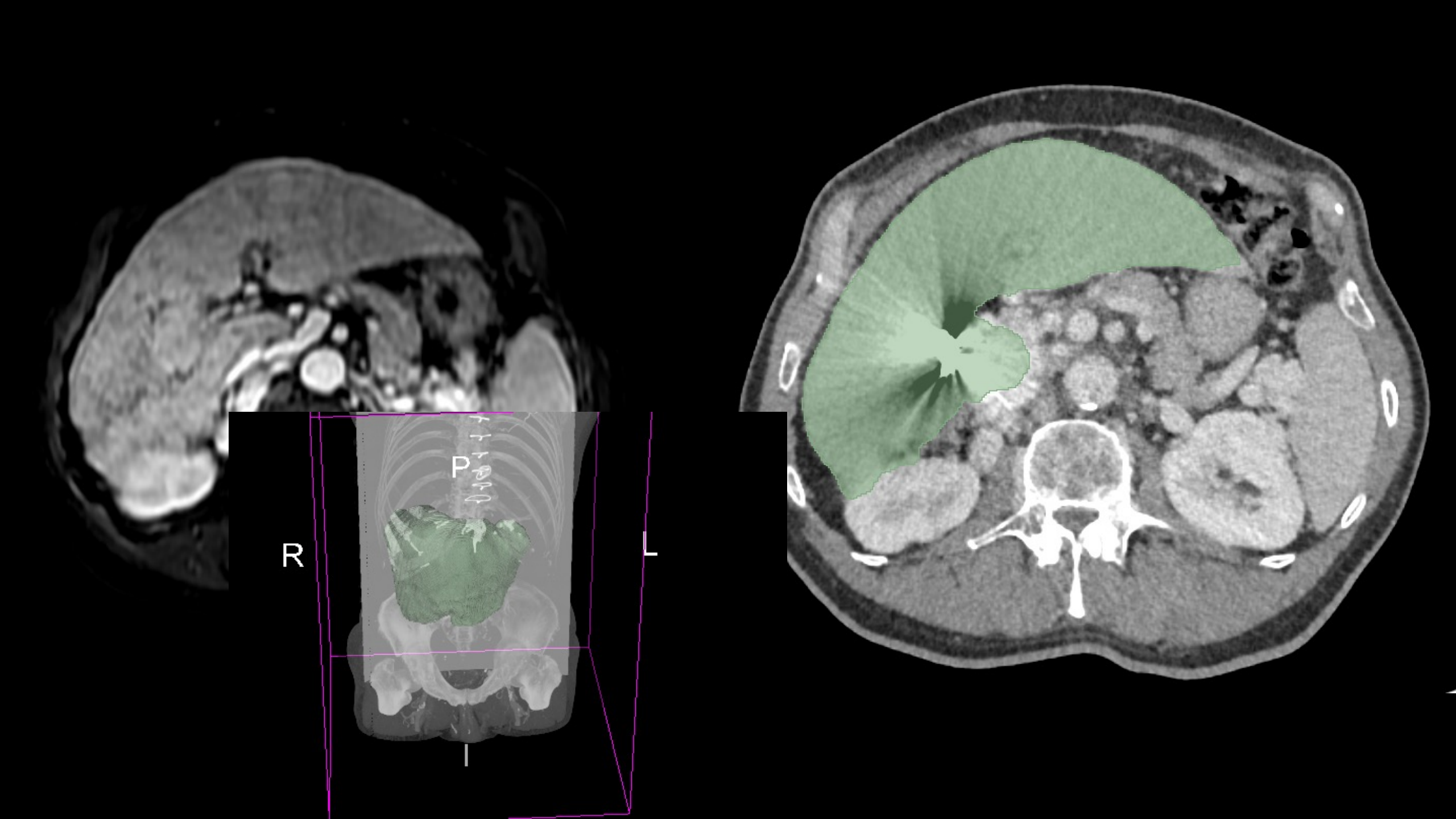
Quality of segmentation is statistically lower for dysmorphic livers compared to non-dysmorphic livers (p-value < 0.001).

Wilcoxon p-value Dysmorphic liver vs non-dysmorphic liver	**HVCAR**	**RVESSEL X TDM**	**RVESSEL X IRM**
Segmentation time	0.35	0.18	0.18
Quality	**< 0.001**	**< 0.001**	**< 0.001**





Segmentation time : 4min20s
Dysmorphic liver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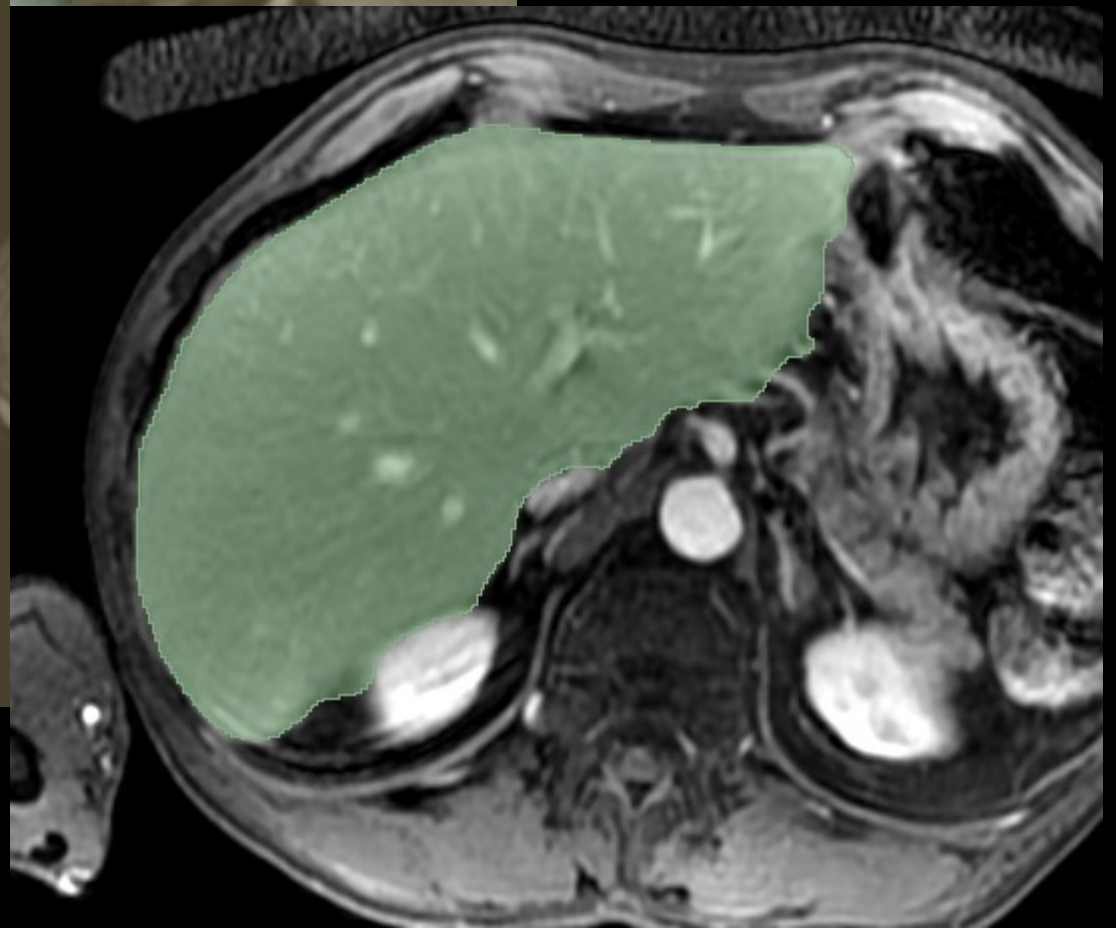


Discussion

- **Main hypothesis to explain the results: the thickness of slices**
  - IRM : 4-6mm
  - TDM : 0,6mm
    - → Longer calculation times for segmentation, shorter for MRI
- **Lack of user interactivity with HVCAR for corrections of automatic segmentations**

- **Benefits of the study**
  - New MRI and CT database on hospital patients
  - Innovative software
  - Similar performance between RVX MRI and commercial solution
  - No major impact a priori on dysmorphic livers and difficult exams.

- **Study flaws**
  - Several bias : single user, training and self-assessment bias
  - Software not integrated on PACS: extra time for data extraction
  - No manual reference segmentation: HVCAR as a substitute, but segmentation data not available.

Work in progress

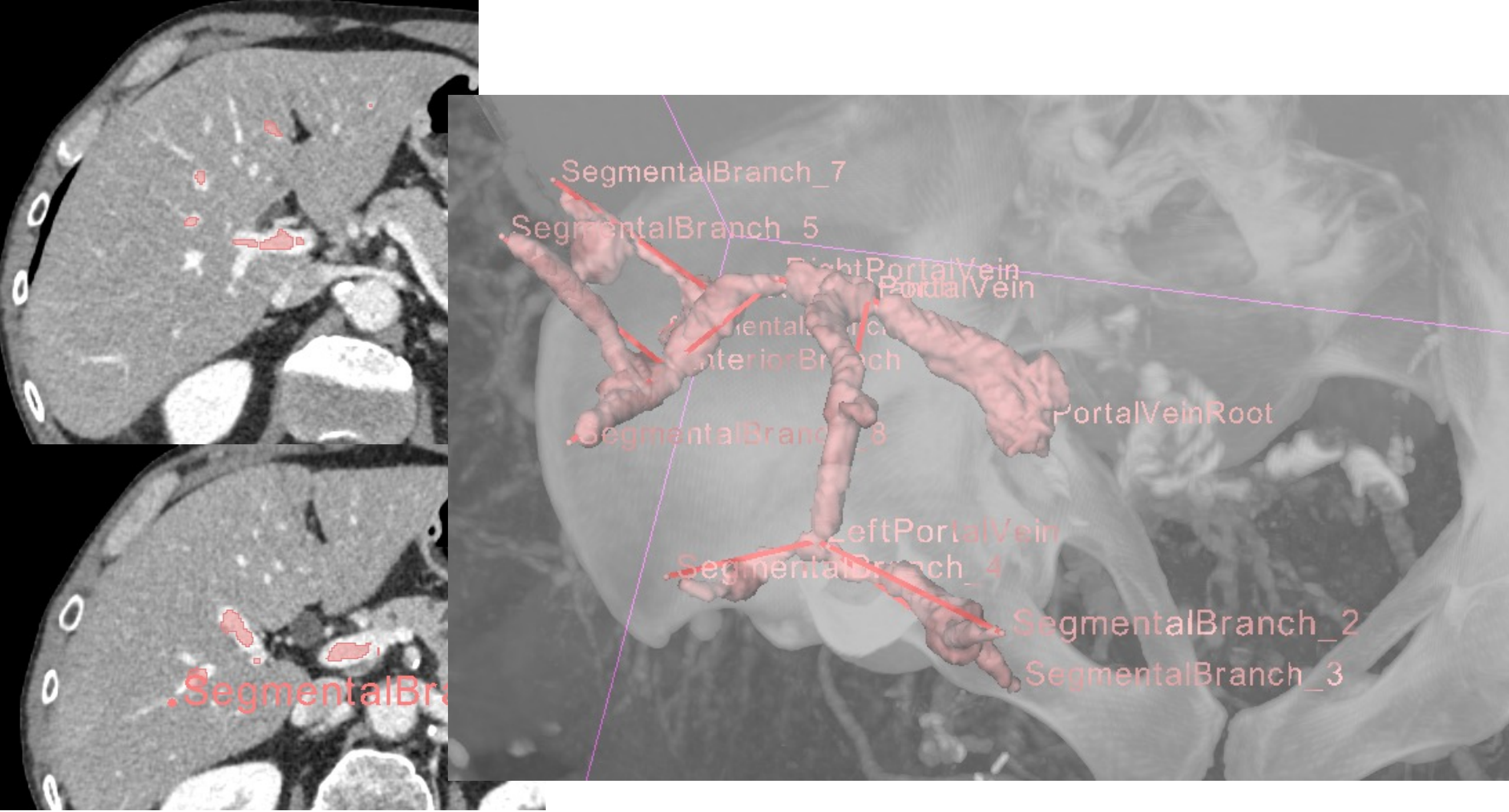
Segmentation of hepatic vessels

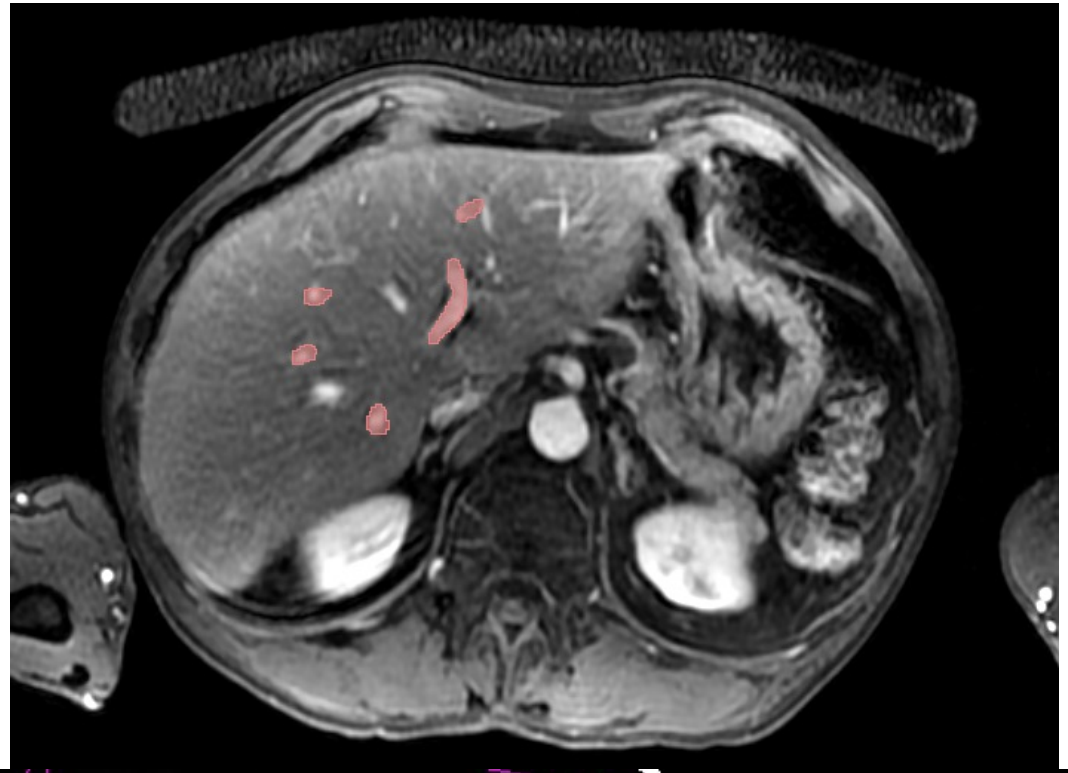
Liver vessels segmentation for what ?

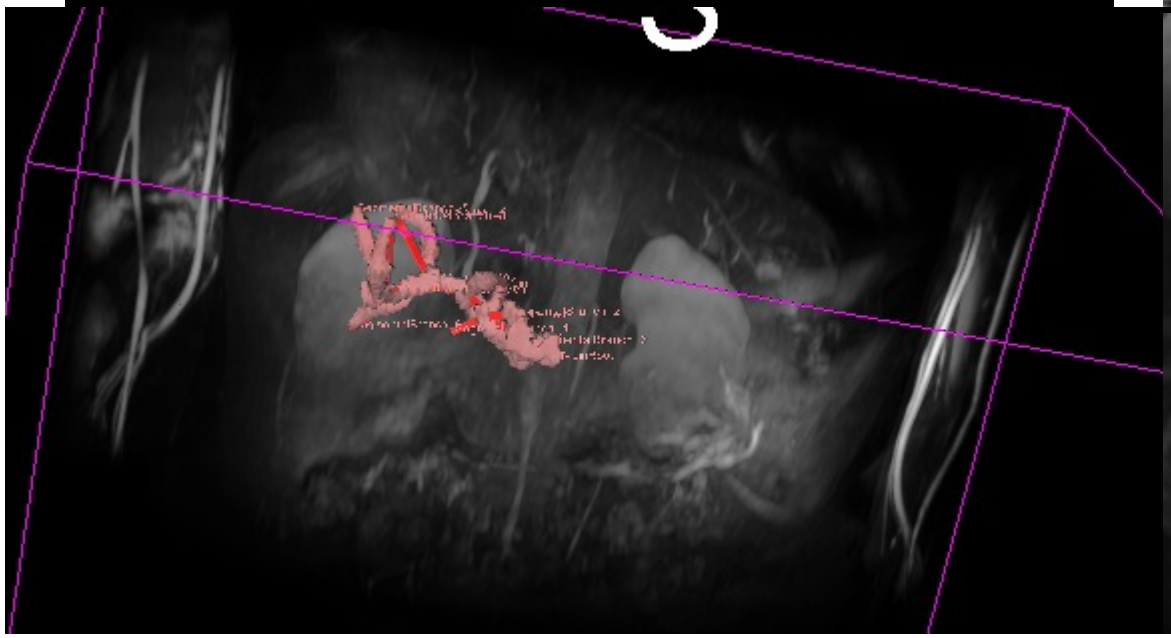
- Couinaud segmentation
- Pre-operative
- Modelization

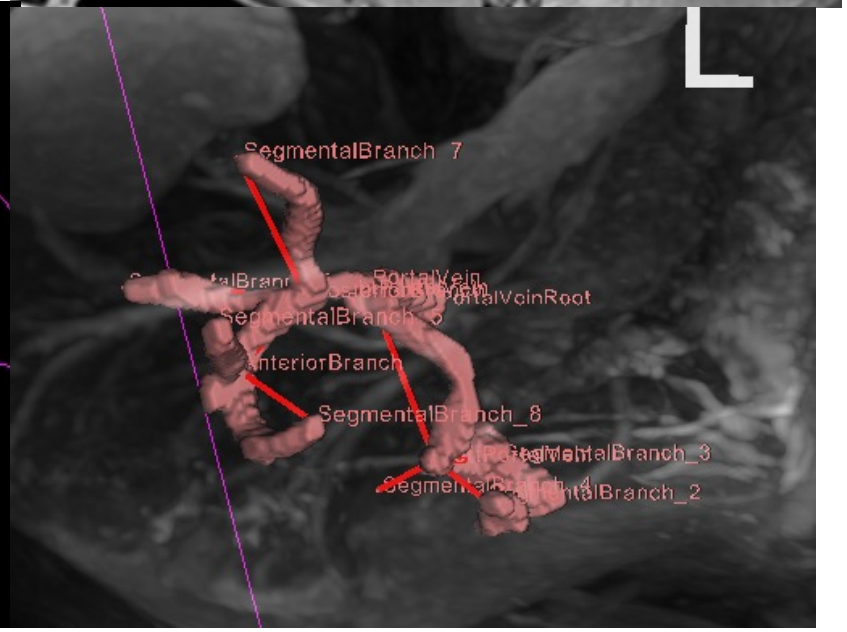
Hard challenge

- Less resolution on MRI
- Architectural modification for cirrhosis liver
- Good enhancement, no artefact


SegmentalBranch_7
SegmentalBranch_5
PortalVein
PortalVeinRoot
LeftPortalVein
SegmentalBranch_2
SegmentalBranch_3






SegmentalBranch_7
PortalVein
PortalVeinRoot
SegmentalBranch_8
SegmentalBranch_3
SegmentalBranch_2

Base de données (15/06/2023)

- **39 patients de la thèse → segmentation volume hépatique total & réseau porte & réseau veineux hépatique sur IRM par un utilisateur (G. LIENEMANN)**

- **Raphaël PERON → segmentation volume hépatique total & réseau porte & réseau veineux hépatique sur 9 patients aléatoires parmi les 39.**

- **Données partiellement inclues sur IBO**

Segmentations vasculaires

- **Deux facteurs principaux influant la qualité globale de la segmentation vasculaire**
  - Foie cirrhotique vs foie non cirrhotique
  - Qualité de l'examen (artefacts & qualité de l'injection)

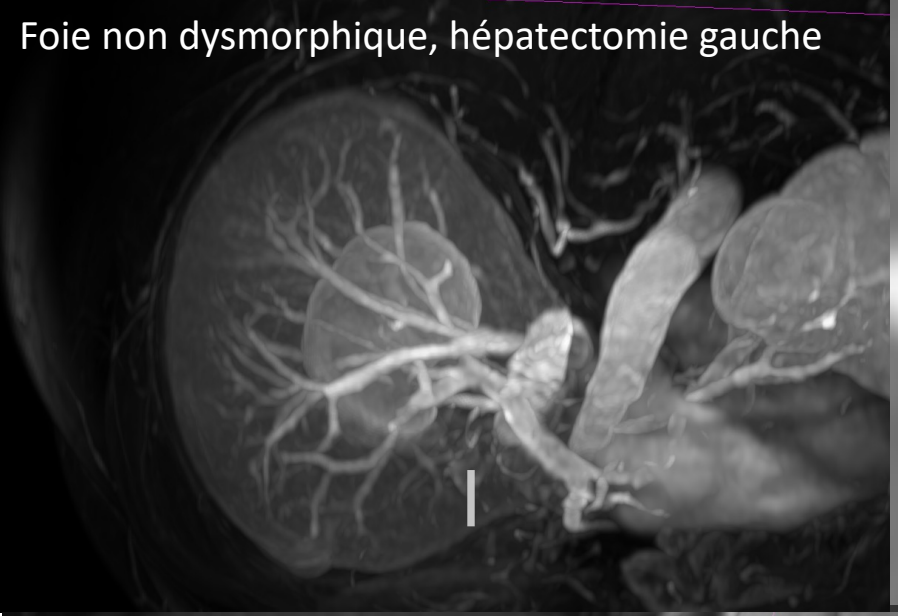
- **De bons (voir très bons) résultats pour les branches segmentaires du réseau porte et du réseau veineux**

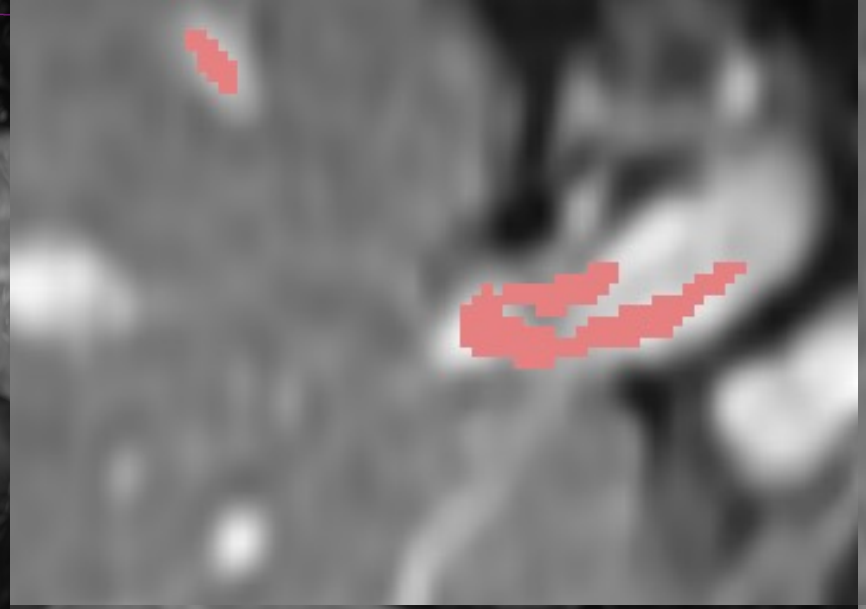
- **De moins bons résultats concernant les gros troncs (tronc porte, veine cave inférieure)**

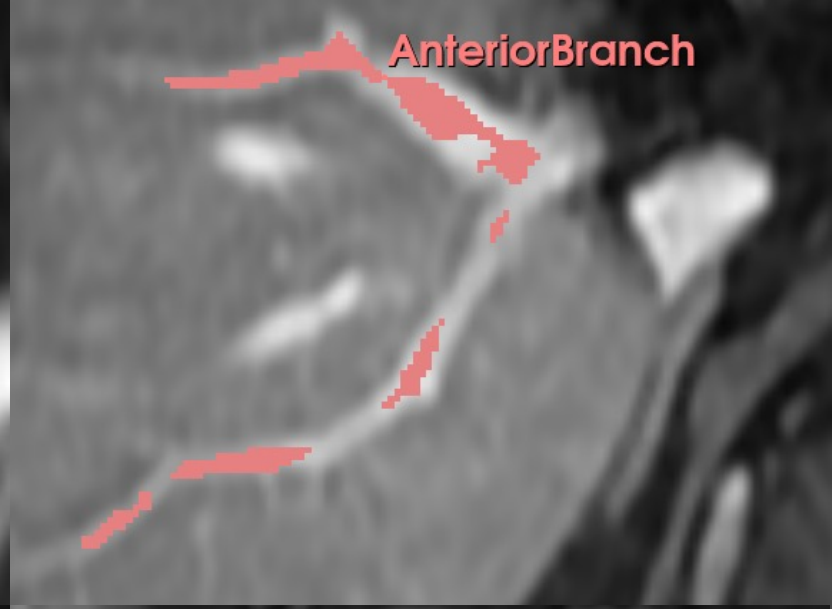
- **Discontinuités dans les vaisseaux**

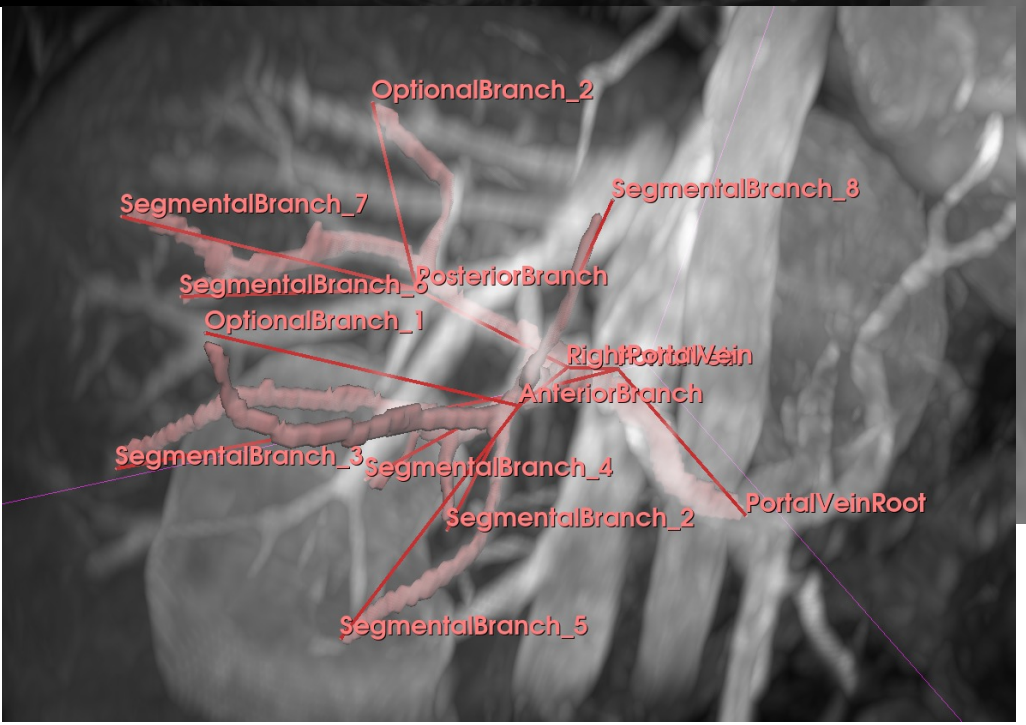
- **Temps estimé pour les segmentations vasculaires : entre 10 min et 30 min**

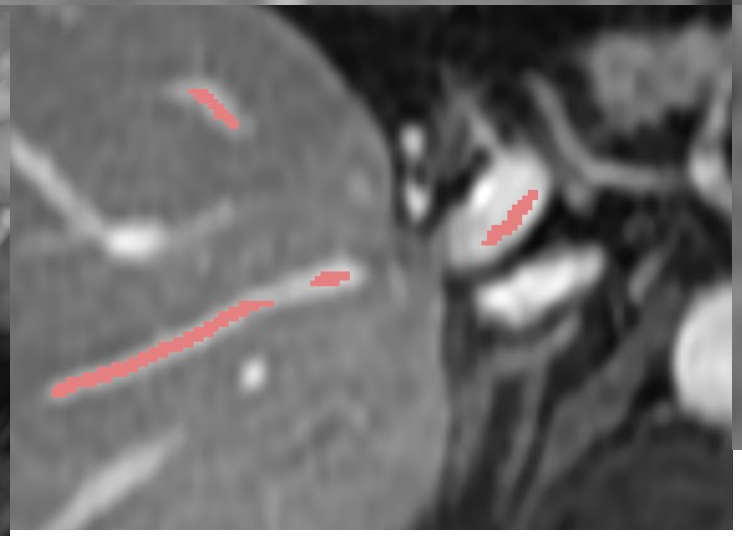
Foie non dysmorphique, hépatectomie gauche









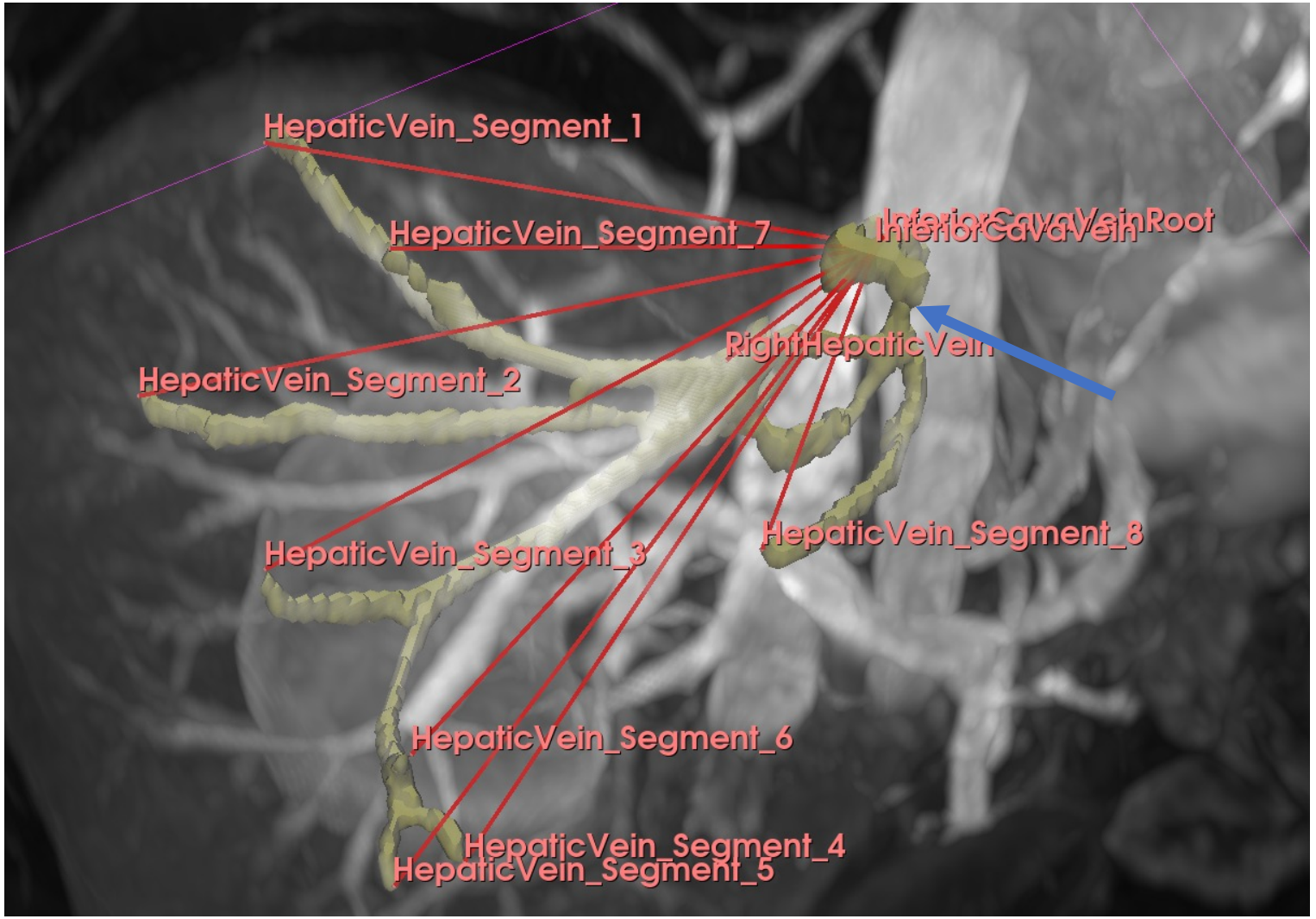


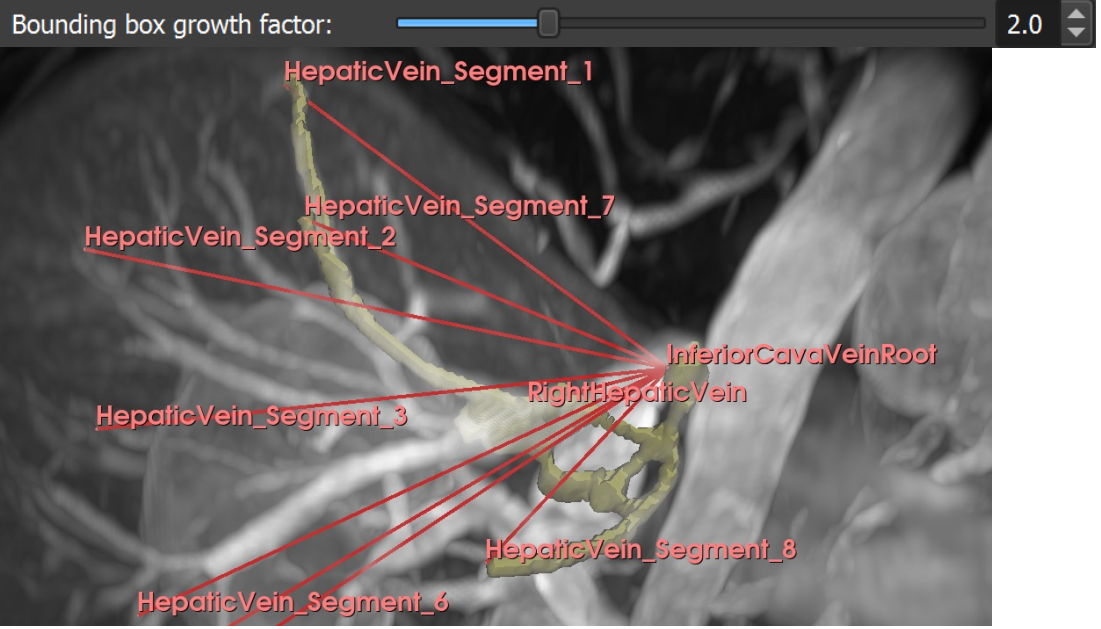
▼ Vesselness Filter Options

Use VMTK Vesselness:	☐
Use bounding box:	☑
Bounding box growth factor:	1.2
Min Bounding Box extent:	20
Sato Hessian Sigma:	2.00
Sato Alpha 1:	0.50
Sato Alpha 2:	2.00
Restore default filter parameters:	Restore
Show vesselness volume:	☐

▼ LevelSet Segmentation Options

Inflation:	0
Curvature:	70
Attraction to gradient:	50
Iterations:	10
Segmentation strategy:	One vessel per branch
Segmentation initialization:	Colliding Fronts
Segmentation method:	Geodesic

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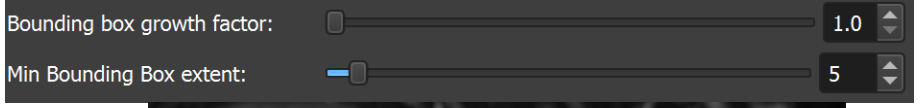
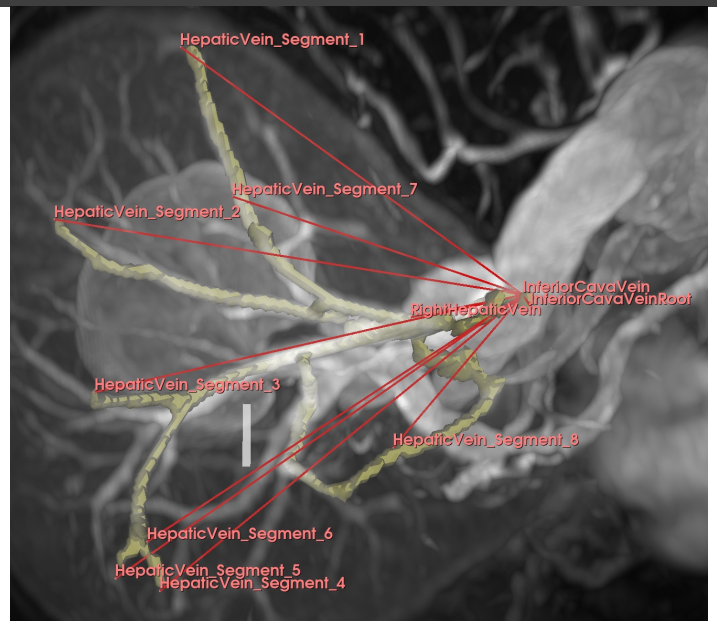
2.0
HepaticVein_Segment_1
HepaticVein_Segment_7
HepaticVein_Segment_2
InferiorCavaVeinRoot
RightHepaticVein
HepaticVein_Segment_3
HepaticVein_Segment_8
HepaticVein_Segment_6


Bounding box growth factor:
1.0
Min Bounding Box extent:
5


HepaticVein_Segment_1
HepaticVein_Segment_7
HepaticVein_Segment_2
InferiorCavaVein
InferiorCavaVeinRoot
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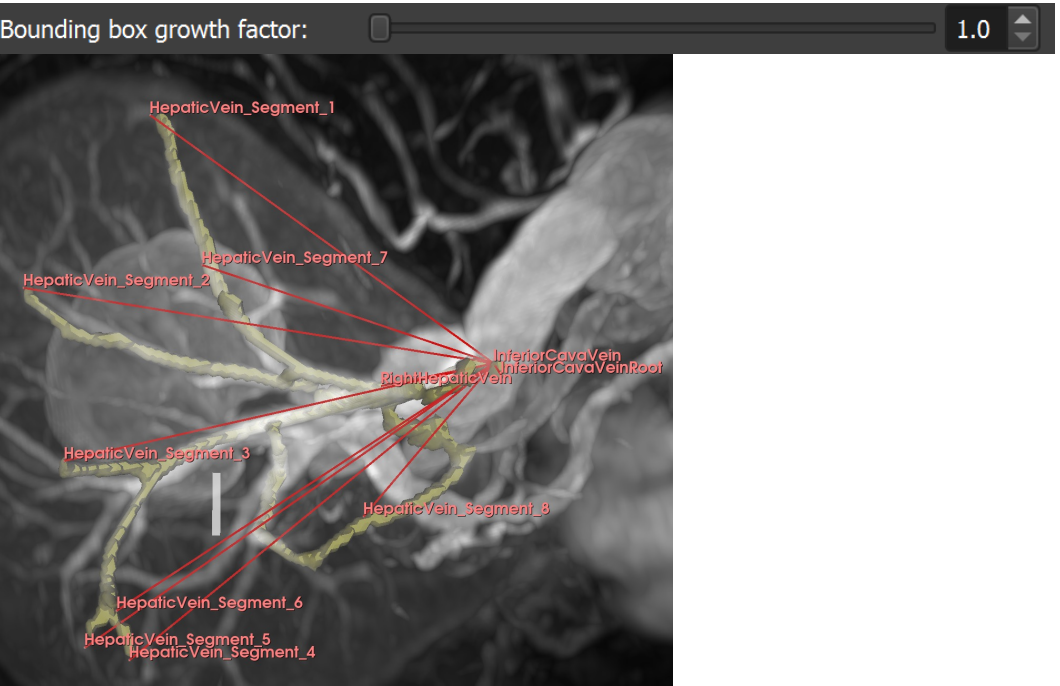
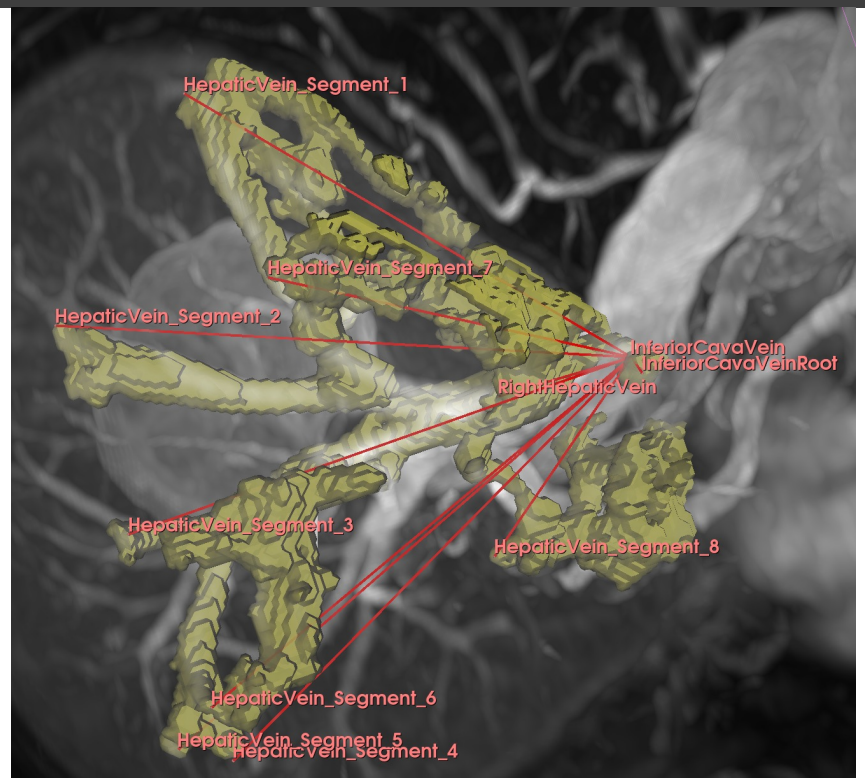
HepaticVein_Segment_3
HepaticVein_Segment_8
HepaticVein_Segment_6
HepaticVein_Segment_5
HepaticVein_Segment_4


Bounding box growth factor:
1.0
HepaticVein_Segment_1
HepaticVein_Segment_7
HepaticVein_Segment_2
InferiorCavaVein
InferiorCavaVeinRoot
RightHepaticVein
HepaticVein_Segment_3
HepaticVein_Segment_8
HepaticVein_Segment_6
HepaticVein_Segment_5
HepaticVein_Segment_4

Vesselness Filter Options

Use VMTK Vesselness:	✓
Use bounding box:	
Bounding box growth factor:	1.0
Min Bounding Box extent:	5
Minimum vessel diameter:	1 voxels
Maximum vessel diameter:	7 voxels
Vessel contrast:	0
Suppress plates:	50 %
Suppress blobs:	50 %
Restore default filter parameters:	Restore
Show vesselness volume:	



Vesselness Filter Options

Use VMTK Vesselness:	✓
Use bounding box:	
Bounding box growth factor:	1.0
Min Bounding Box extent:	5
Minimum vessel diameter:	1 voxels
Maximum vessel diameter:	7 voxels
Vessel contrast:	15
Suppress plates:	60 %
Suppress blobs:	60 %
Restore default filter parameters:	Restore
Show vesselness volume:	

Failed to extract vessels

An error happened while extracting vessels.Please try to adjust vesselness or levelset parameters.
Failed to extract vessel tree from vesselness volume.

Traceback (most recent call last):
File "C:\Users\Guillaume\AppData\Local\NA-MIC\Slicer 4.13.0-2022-03-07\NA-MIC\Extensions-30679\RVesselX\lib\Slicer-4.13\qt-scripted-modules\RVXLiverSegmentationLib\VesselWidget.py", line 511, in _extractVessel
self.vesselSegmentationChanged.emit(self._vesselVolumeNode, self._vesselBranchWidget.getBranchNames())
File "C:\Users\Guillaume\AppData\Local\NA-MIC\Slicer 4.13.0-2022-03-07\NA-MIC\Extensions-30679\RVesselX\lib\Slicer-4.13\qt-scripted-modules\RVXLiverSegmentationLib\RVXLiverSegmentationUtils.py", line 549, in emit
slot(*args, **kwargs)
File "C:\Users\Guillaume\AppData\Local\NA-MIC\Slicer 4.13.0-2022-03-07\NA-MIC\Extensions-30679\RVesselX\lib\Slicer-4.13\qt-scripted-modules\RVXLiverSegmentationLib\VesselSegmentEditWidget.py", line 117, in onVesselSegmentationChanged
self._importLabelMap(vesselLabelMap)
File "C:\Users\Guillaume\AppData\Local\NA-MIC\Slicer 4.13.0-2022-03-07\NA-MIC\Extensions-30679\RVesselX\lib\Slicer-4.13\qt-scripted-modules\RVXLiverSegmentationLib\VesselSegmentEditWidget.py", line 128, in _importLabelMap
raise ValueError("Failed to extract vessel tree from vesselness volume.")
ValueError: Failed to extract vessel tree from vesselness volume.

OK