



Dataset Segmentation in Surgical Planning *the Pancreas experience*

Marina Carbone





- ❑ EndoCAS – short description
- ❑ Background
- ❑ Material and Methods
- ❑ Cases studied
- ❑ Results
- ❑ Conclusion
- ❑ Future Developments

UNIVERSITÀ DI PISA



Consiglio Nazionale delle Ricerche

EndoCAS main partners :



Regione Toscana

Diritti Valori Innovazione Sostenibilità



microtech S.r.l.
Enabling technologies for
Minimally Invasive Surgery



Research and Education



- ❑ **EndoCAS Research** is an autonomous building of 250 m², consisting of **2 laboratories, a replica of a typical operating room**, a meeting room and some other service rooms.
- ❑ **EndoCAS Education**, the surgical training center, is a building of 250 m² communicating with EndoCAS Research, and equipped with **simulators for training** of physician and medical/surgical staff.

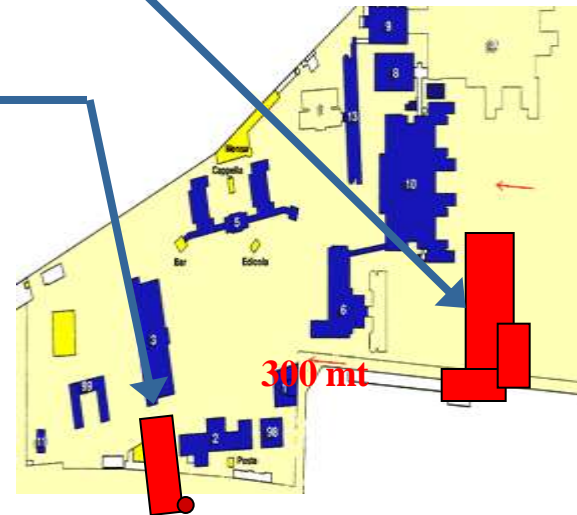


We are close to the surgeons...

- EndoCAS is located inside the Cisanello hospital structures, in close contact of the medical partners and the operating rooms.

Department of General Surgery and Transplantation

EndoCAS Center



- The Research team involves:
 - Scientists
 - Engineers
 - Surgeons
 - Radiologists
 - Medical Staff
 - Economists

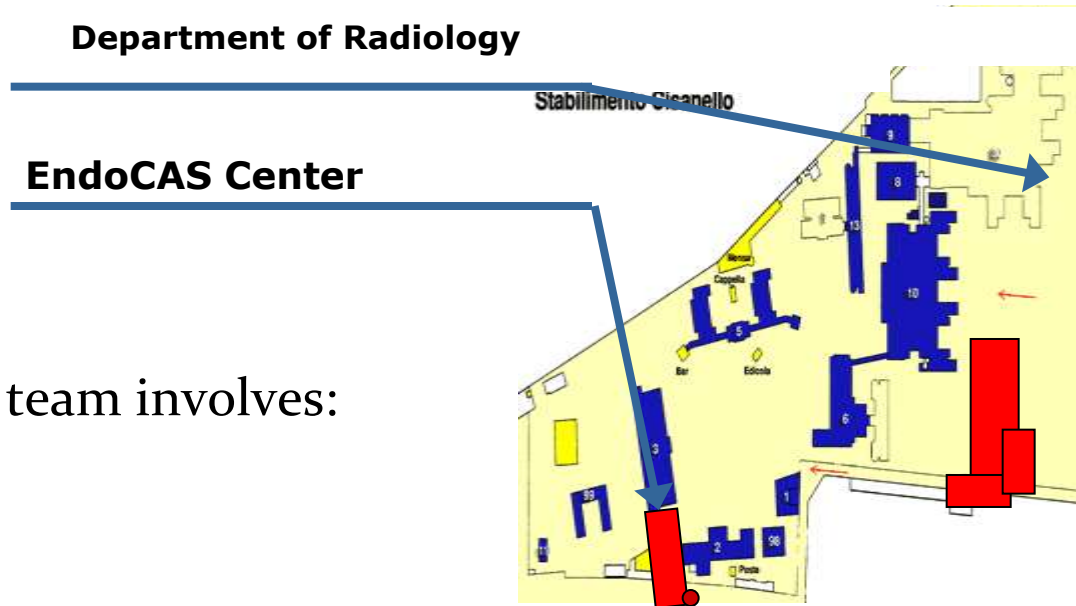


... and to the radiologists

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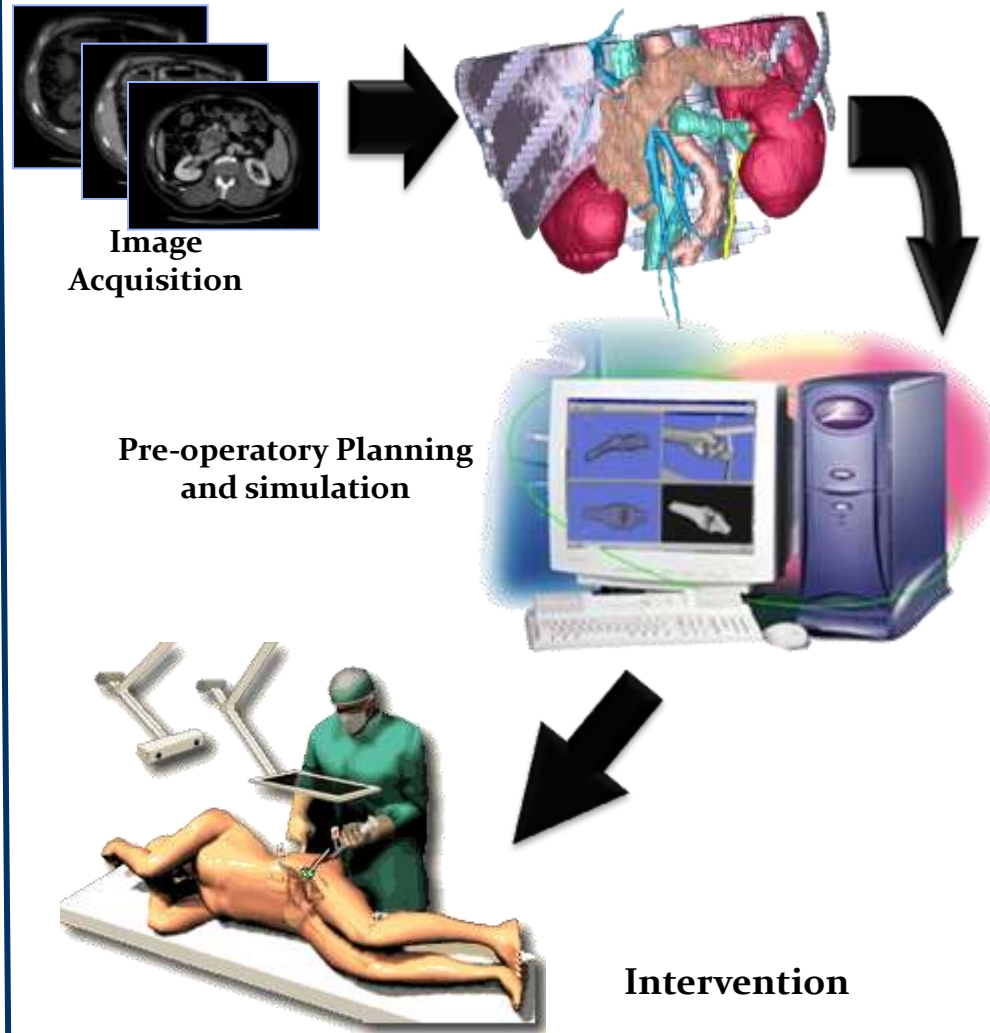
Mental Reconstruction



Diagnosis



Intervention





- Surgical Planning

- Surgical Simulation

- Surgical Navigation

- Surgical Training

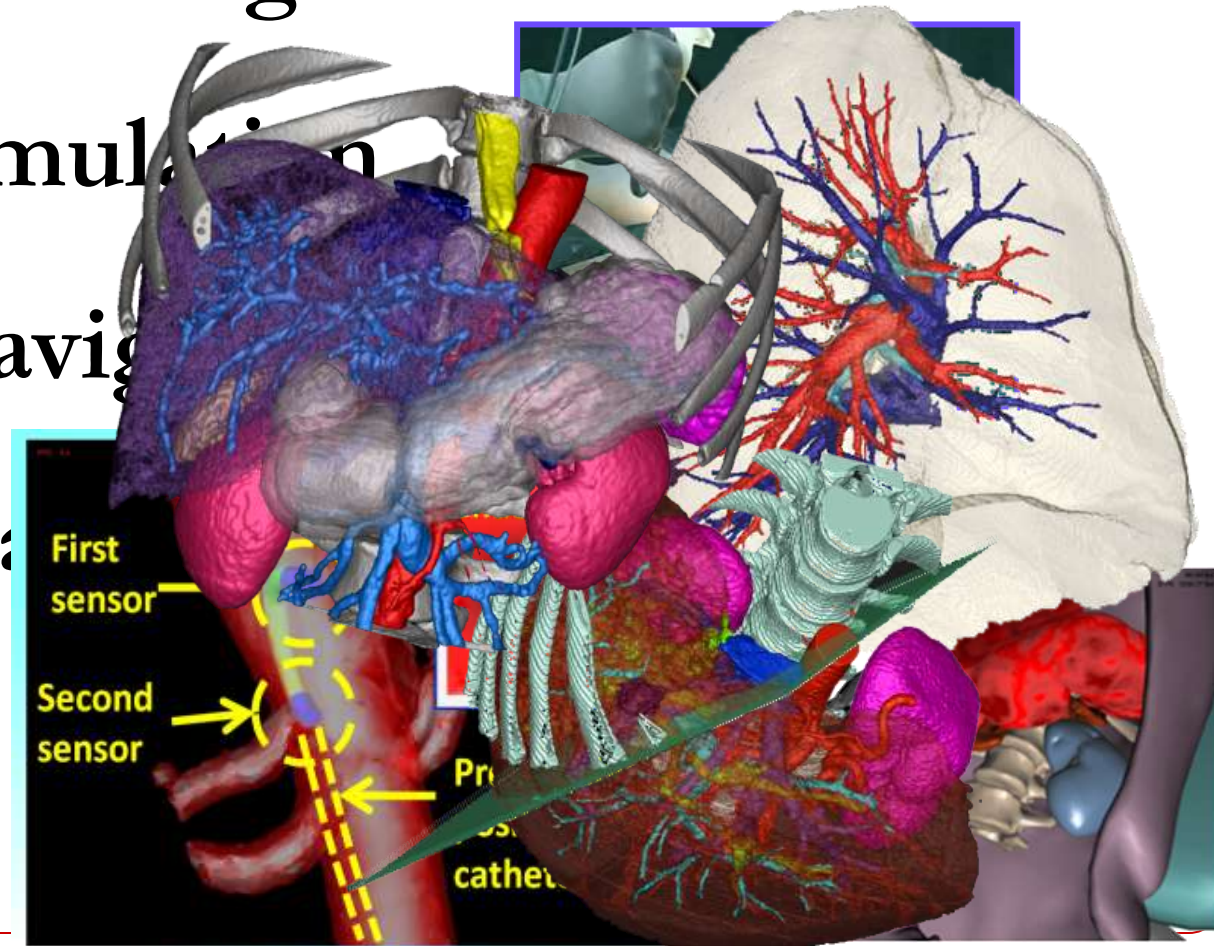
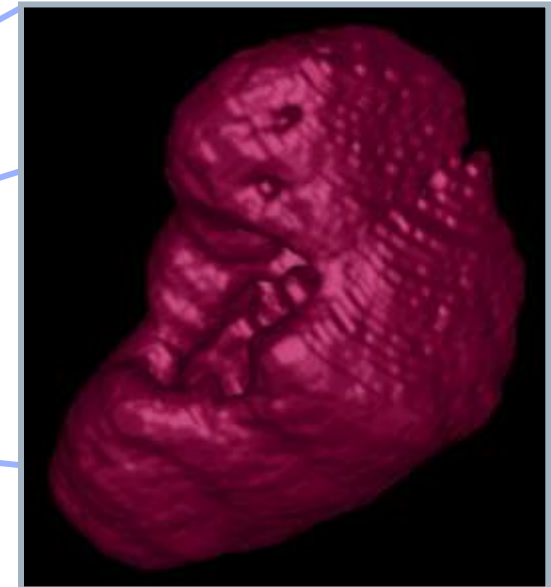
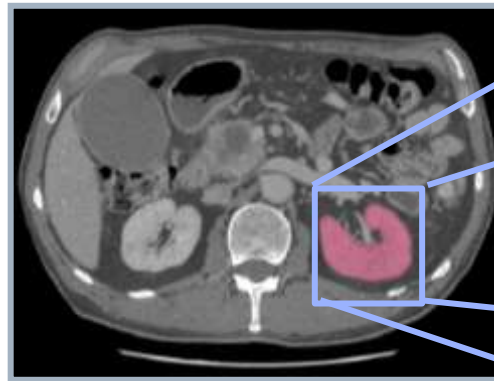




Image segmentation is an important part of computer based medical applications for diagnosis and analysis of anatomical data



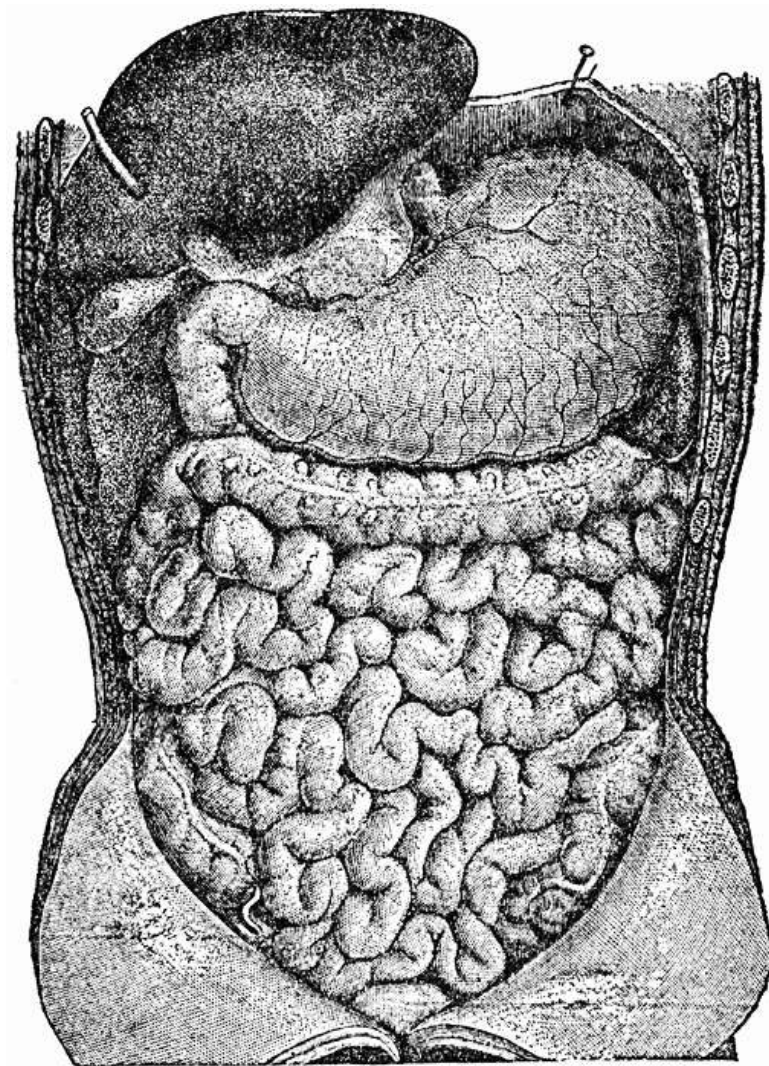
Partitioning an image in its “salient” pieces, that means to delimitate regions, “**segments**” with correlated content.



Segmentation in medical imaging is generally considered a difficult problem, especially when it has to be carried on abdominal anatomical structures

This difficulty mainly arises due to the sheer size of the datasets coupled with the complexity and variability of the anatomic organs

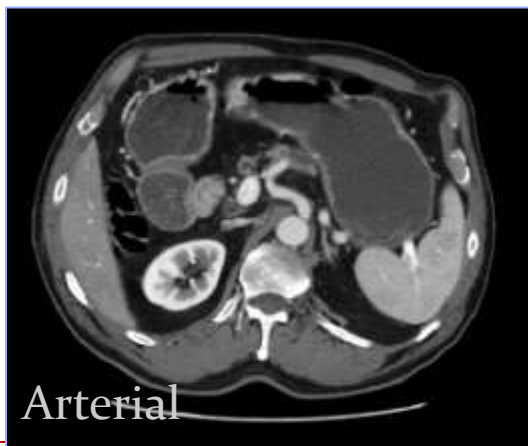
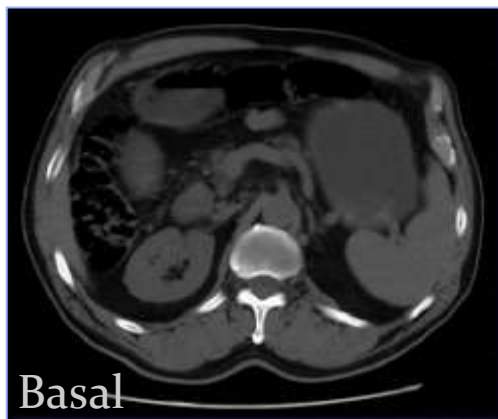
Situation is worsened by the shortcomings of imaging modalities (sampling artefacts, noise, low contrast etc.) which cause the boundaries of anatomical structures to be indistinct and disconnected



PlugIn tailored on the extraction of upper abdominal structures from a volumetric radiological datasets

⚡ **MDCT images:** several acquisition after contrast medium injection in order to capture each anatomical structure in its maximum enhancement instant

⚡ **“EndoCAS segmentation pipeline”:** developed on the top of the opensource platform deploying opens ource libraries: ITKSnap, ITK, VTK, FLTK





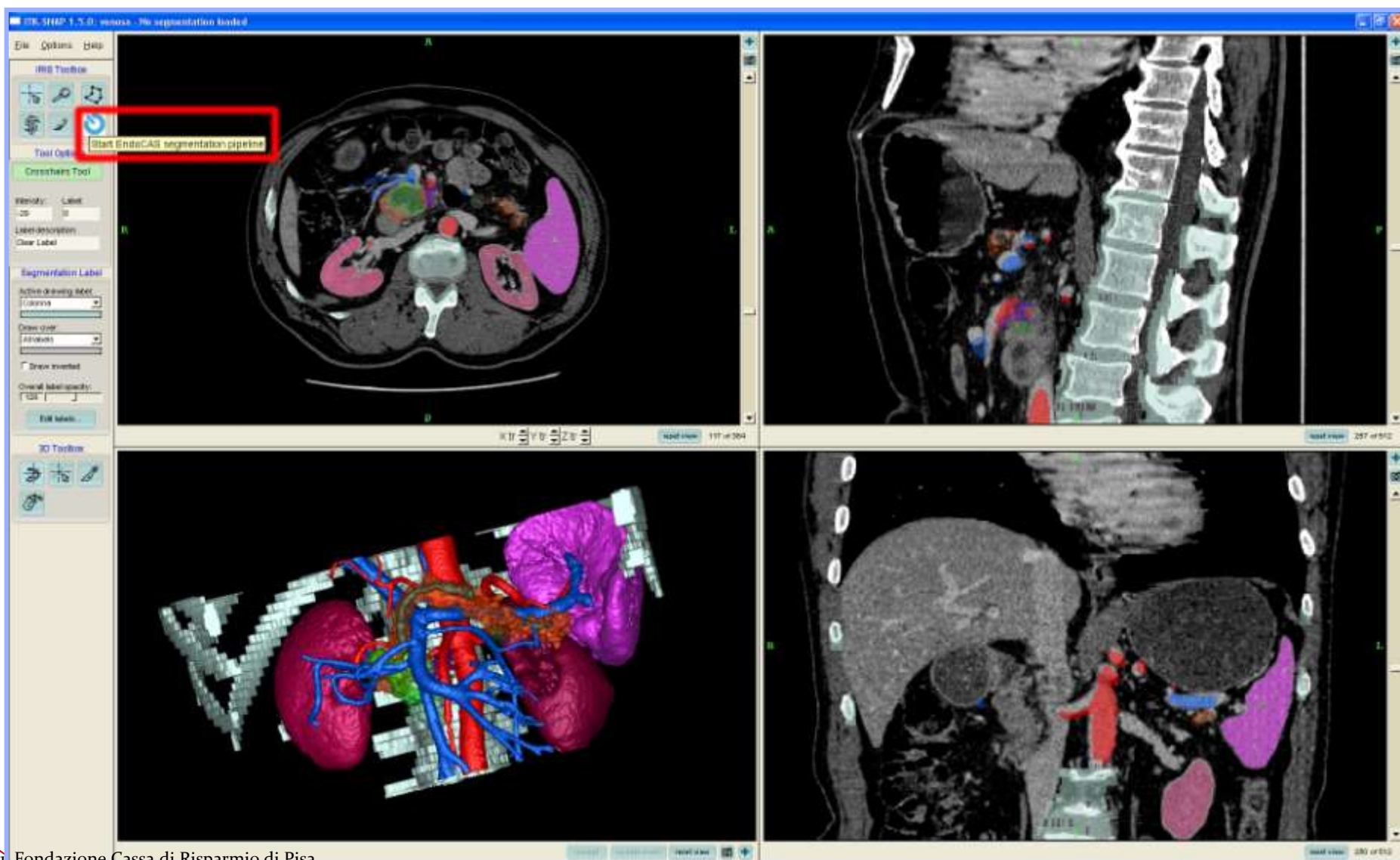
The same libraries are shared by ...

- ☐ VolView
- ☐ 3D-Slicer
- ☐ Seg3D
- ☐ SCIRun
- ☐ ImageVis 3D
- ☐ 3DMed
- ☐ 3D-Doctor
- ☐ ParaView
- ☐ Osirix (MAC platform)

and so on...



ITK-Snap 1.5 + EndoCAS Segmentation Pipeline ¹



¹ Fondazione Cassa di Risparmio di Pisa



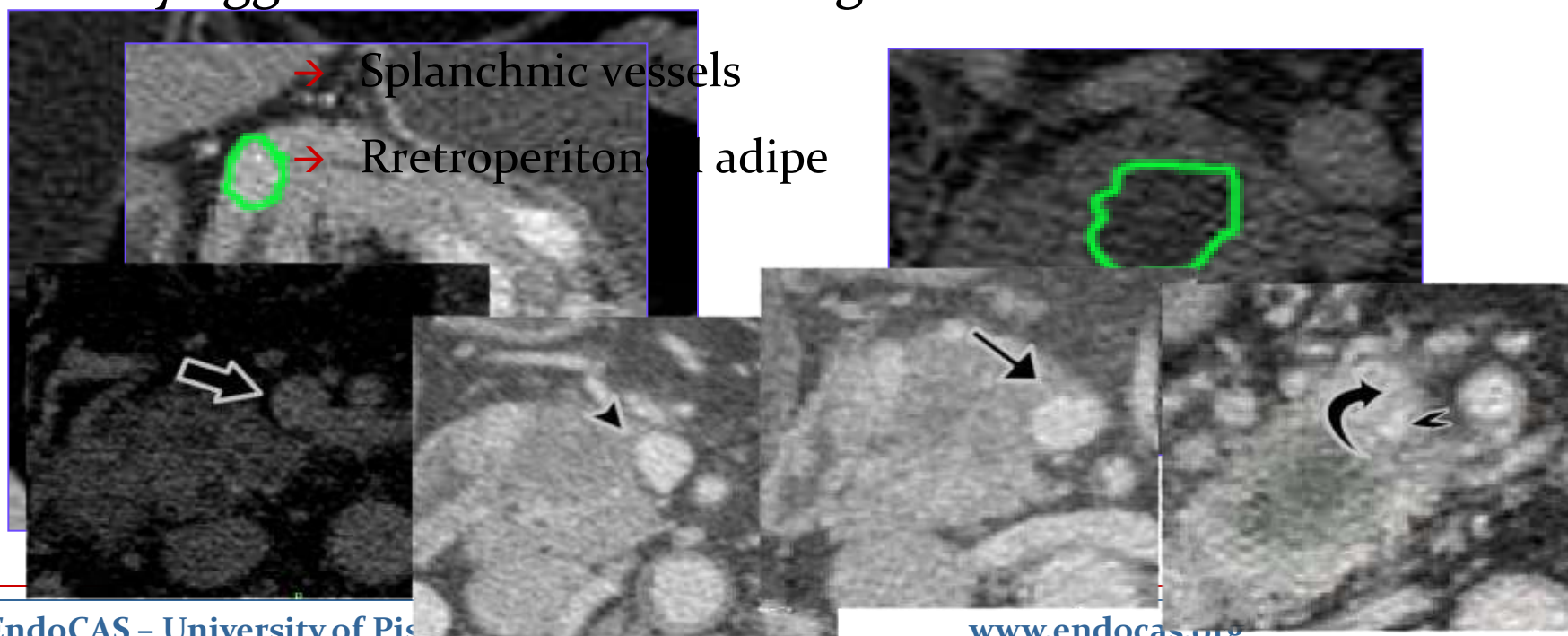
The tool is tailored to extract abdominal structures but it showed itself useful for thoracic and orthopaedic application too

Within last year we started on interesting in **pancreas segmentation** for surgical planning of tumors surgical treatment

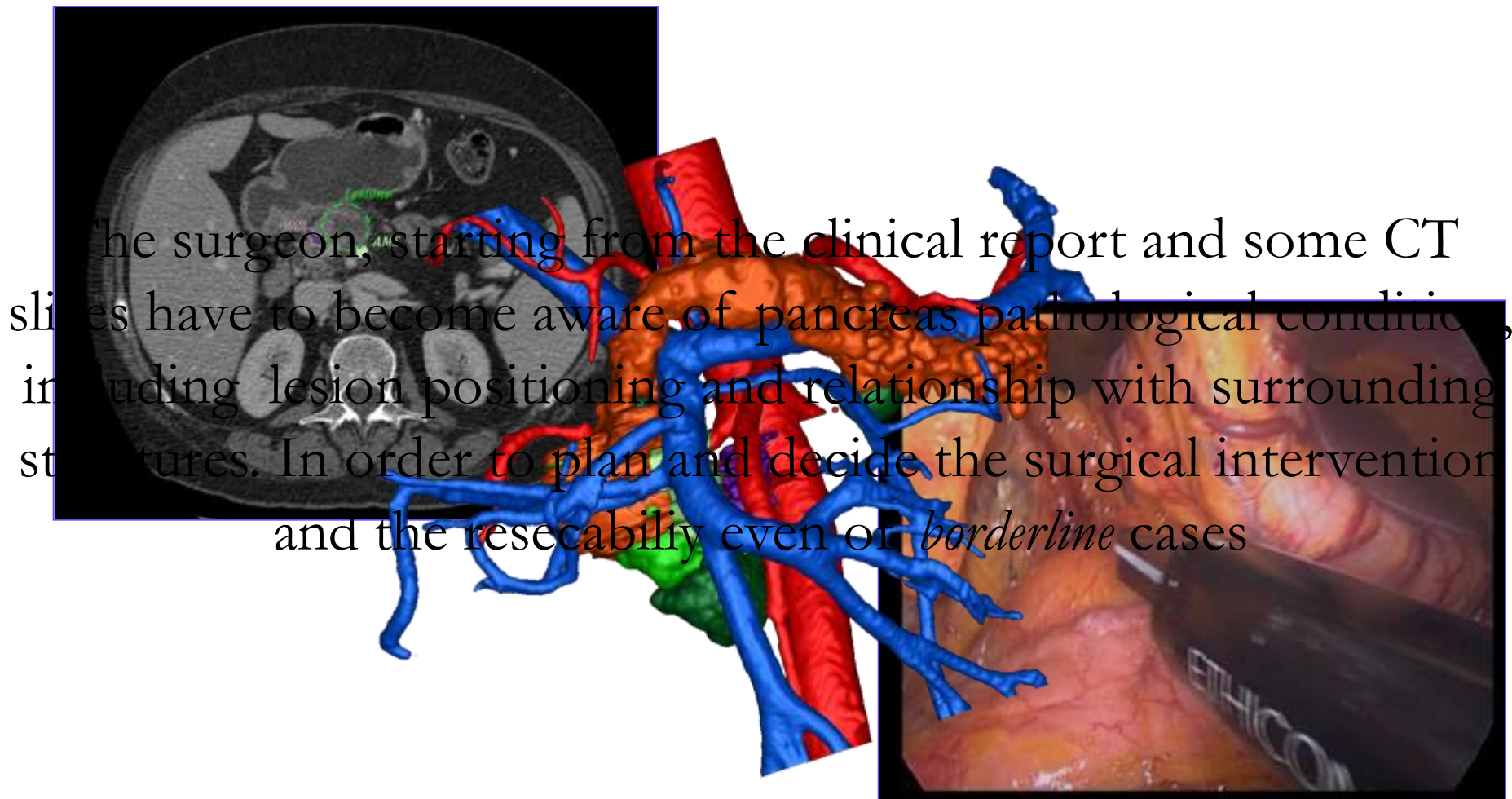
The segmentation pipeline required some add-ons and furthermore the introduction of some manual steps

Pancreas Tumors – a diagnostic challenge

- Neoplastic tissue is shadowed and non homogeneously contrasted
- No standard enhancement → IF contrasted can both be *iper* or *ipo*
- Early aggression of surrounding anatomical structures



Pancreas tumors: from diagnosis to Operatory Room



The registration Issue

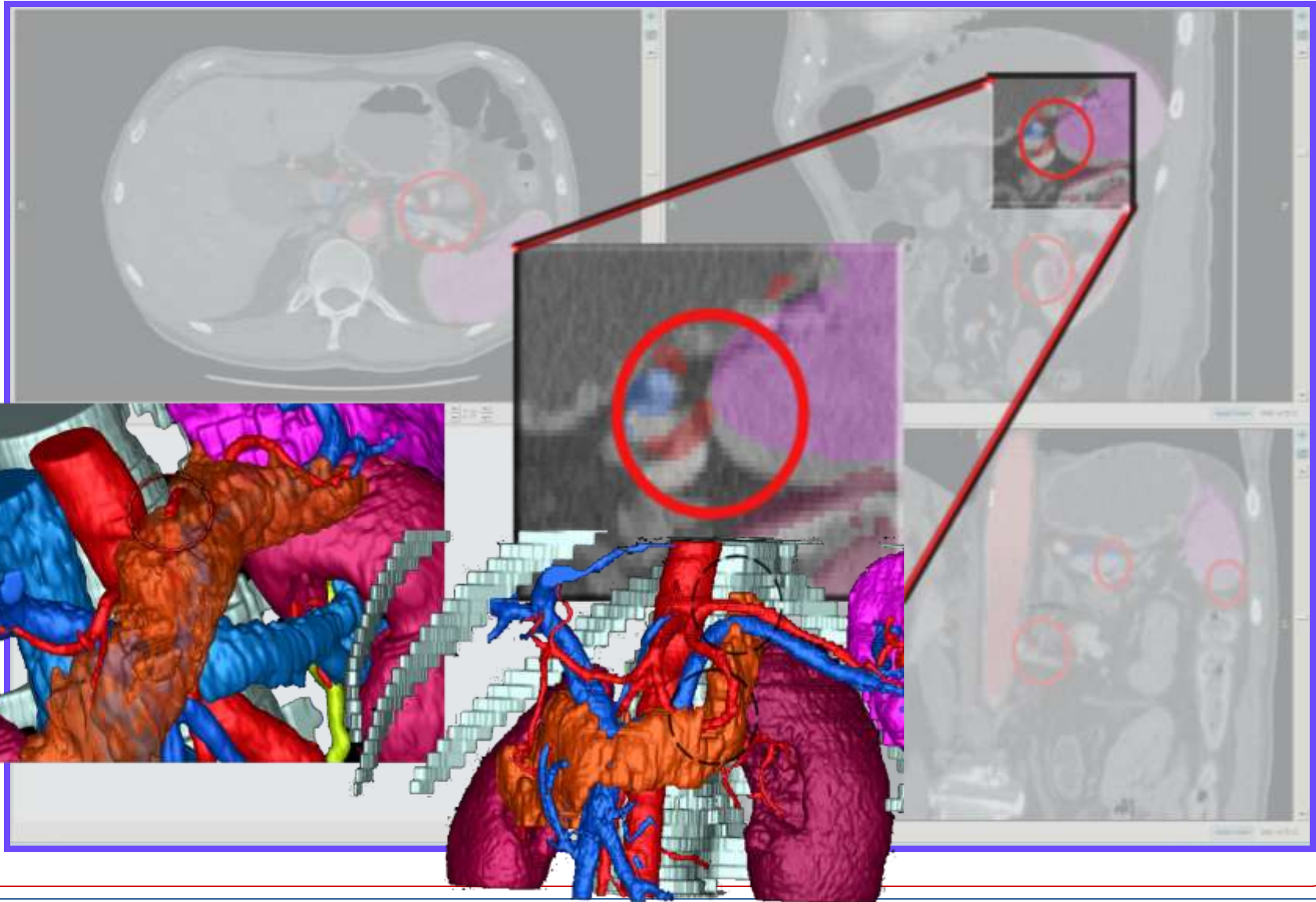
Segmentation quality (that means planning efficacy) relies strongly on the quality of the starting dataset to be segmented

During image acquisition several patient scans are acquired
→ breathing movements cause misregistration

But, as the software works according to an algorithm that means without human brain elasticity, voxel stability is of outmost importance

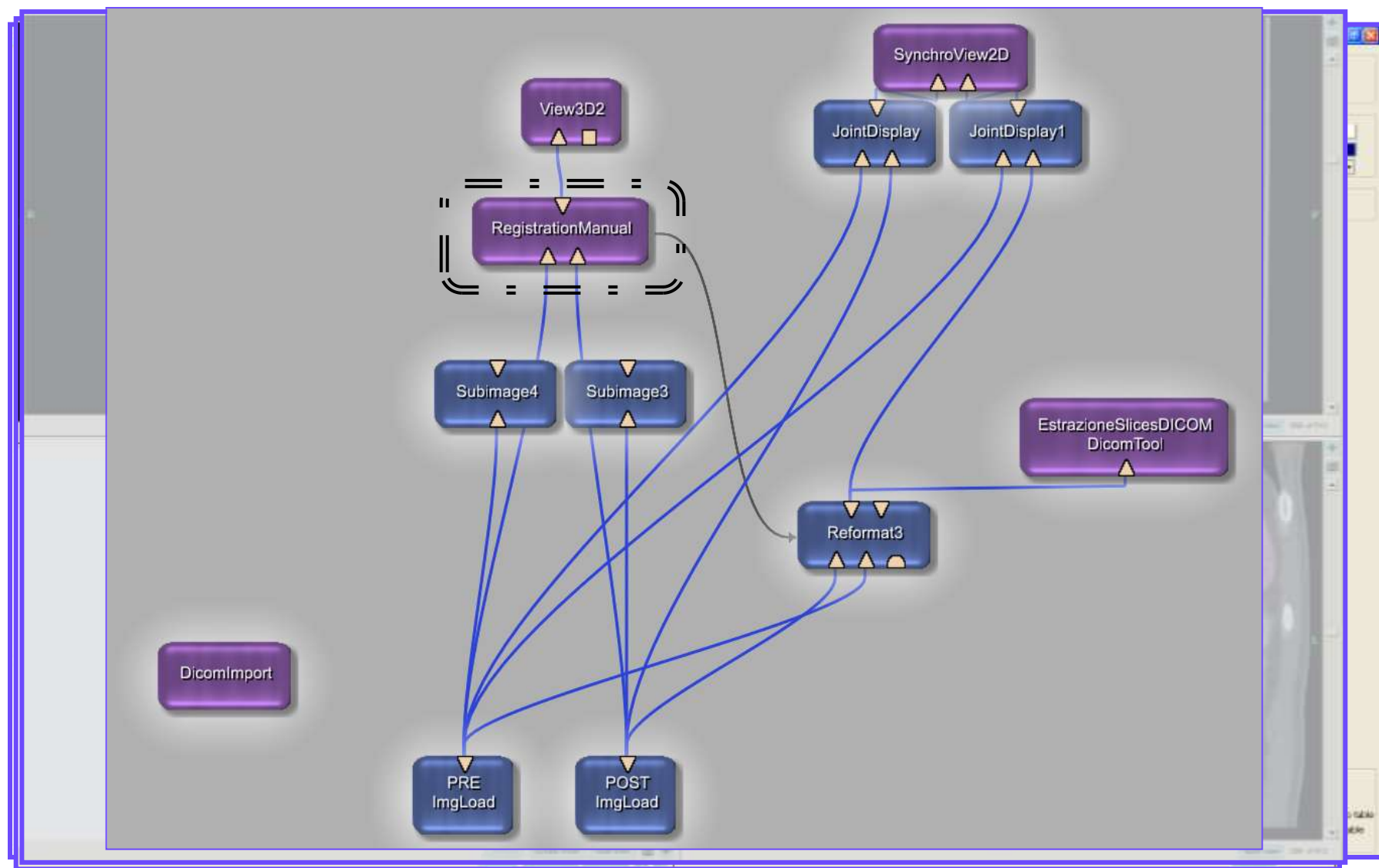


The registration Issue



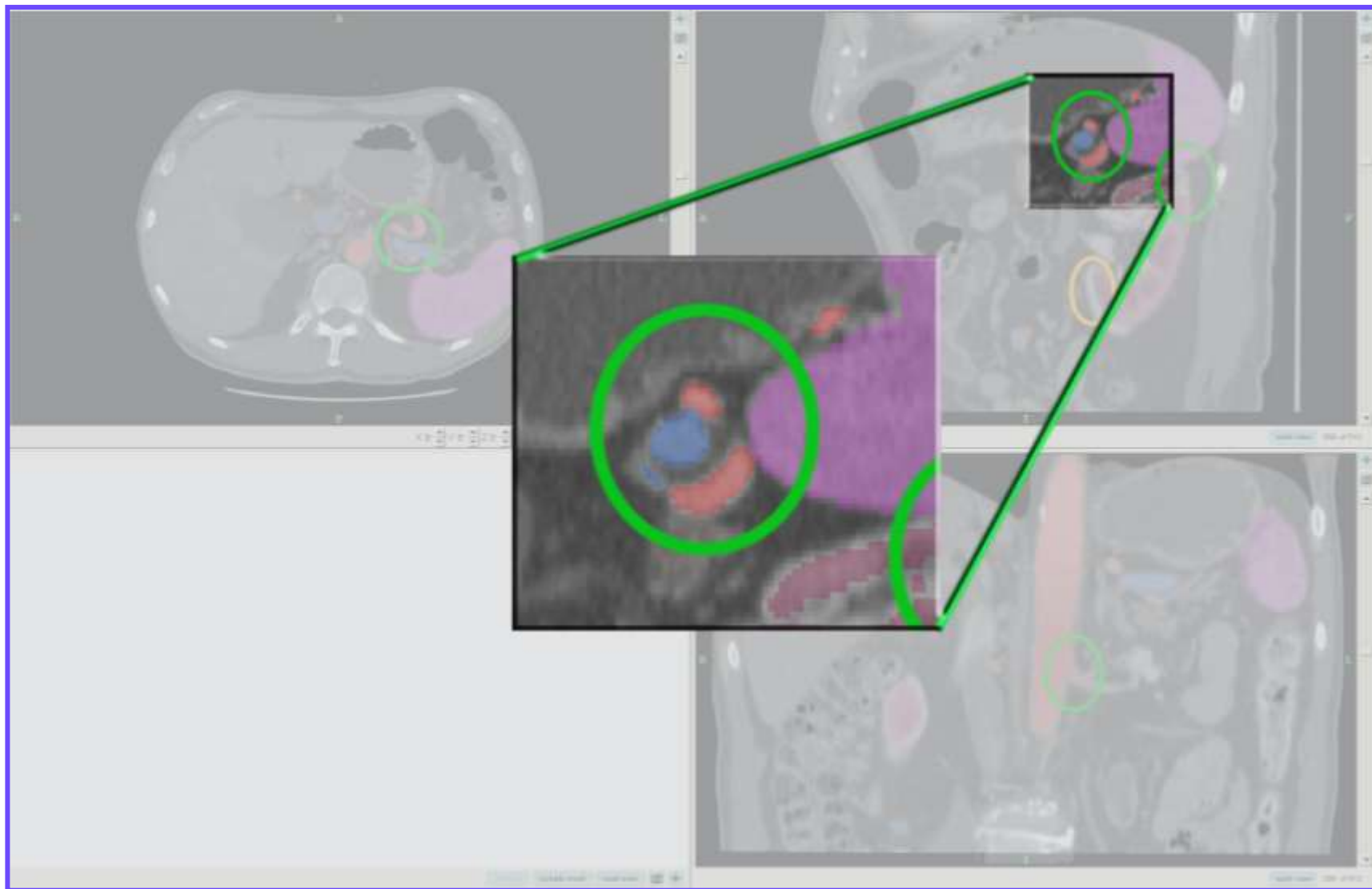


MevisLab – Manual Registration

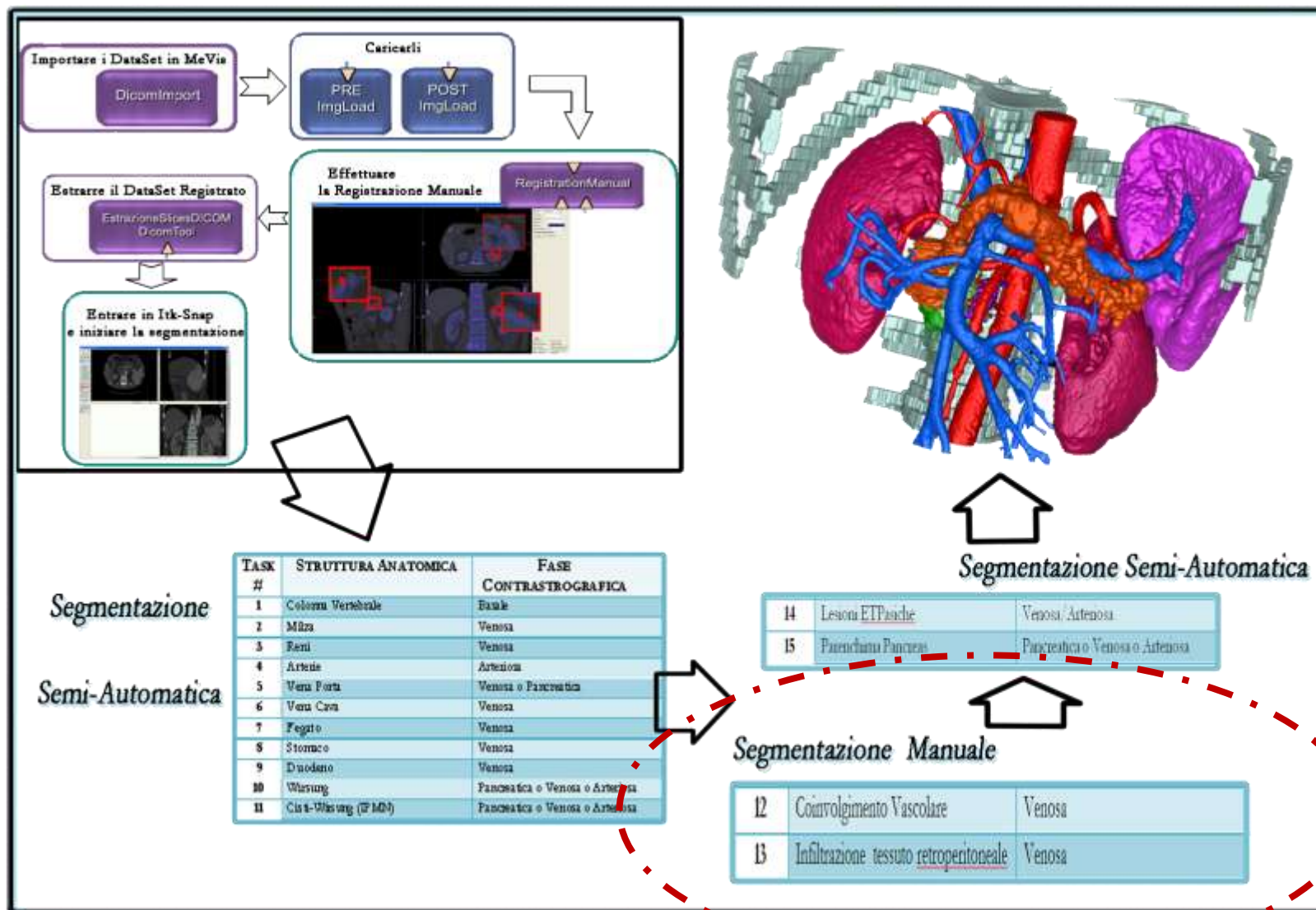




MevisLab – Manual Registration



Pancreas Segmentation Pipeline



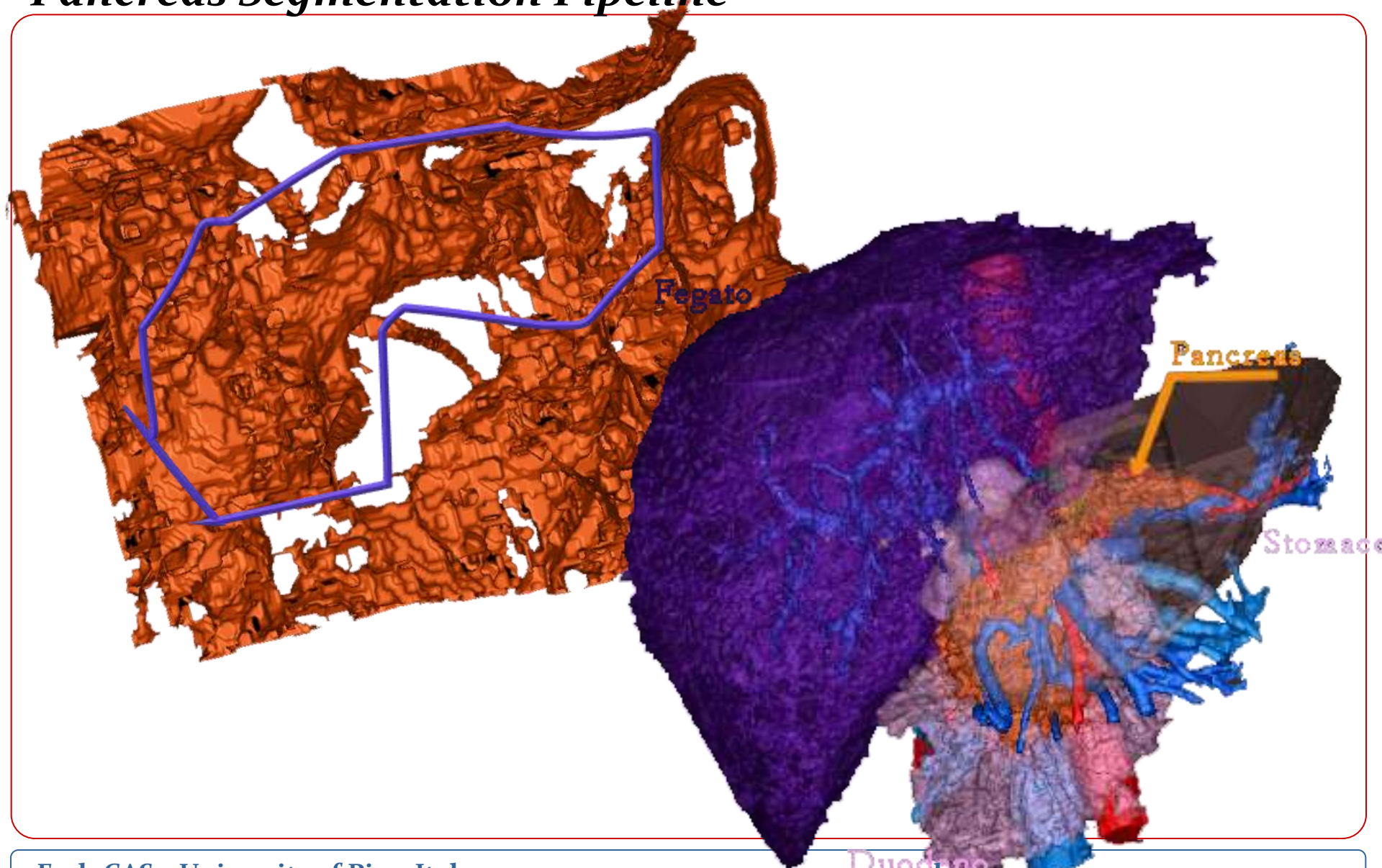


Pancreas Segmentation Pipeline

TASK #	ANATOMICAL STRUCTURE	CONTRASTOGRAPHIC Phase
1	Bones	Basal
2	Spleen	Venous
3	Kidneys	Venous
4	Arteries	Arterial
5	Portal System	Venous /Pancreatic
6	Cava Vein	Venous
7	Liver	Venous
8	Stomach	Venous
9	Duoden	Venous
10	Wirsung	Pancreatic / Venous / Arterial
11	Cyst-Wirsung (IPMN)	Pancreatic / Venous / Arterial
12	Vascular Involvement	Venous
13	Retroperitoneal tissue infiltration	Venous
14	ETPasic lesions	Venous /Arterial
15	Pancreas Parenchima	Pancreatic / Venous / Arterial



Pancreas Segmentation Pipeline





PSP: DUCTAL ADENOCARCINOMA

Any model (even if very beautiful), that lacks in showing precise information about the level of vessel or adipe tissue involvement in the lesion, fails to spot the most important information in order to allow an efficient surgical planning

We arranged a new pipeline that include some compulsory manual steps reliant on radiologist's experience to refine segmentation around lesion borders.

We defined also a "color code" to quantify in a probabilistic way the involvements of other structures (vessels or whatever) in the lesion in order to obtain a complete 3D model for an efficient planning of surgery even in borderline cases.



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Color code:



0-3 level of vessel involvement

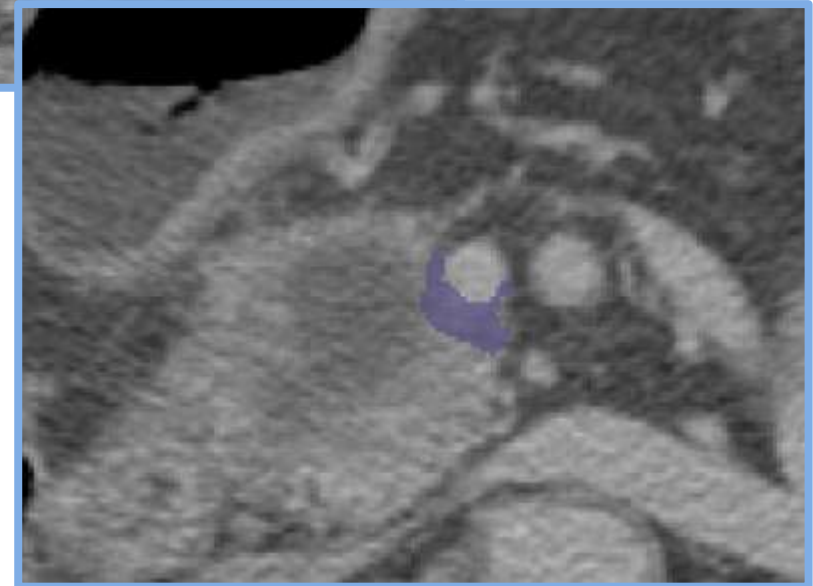
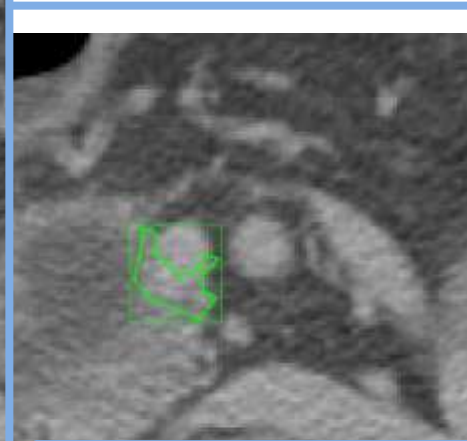
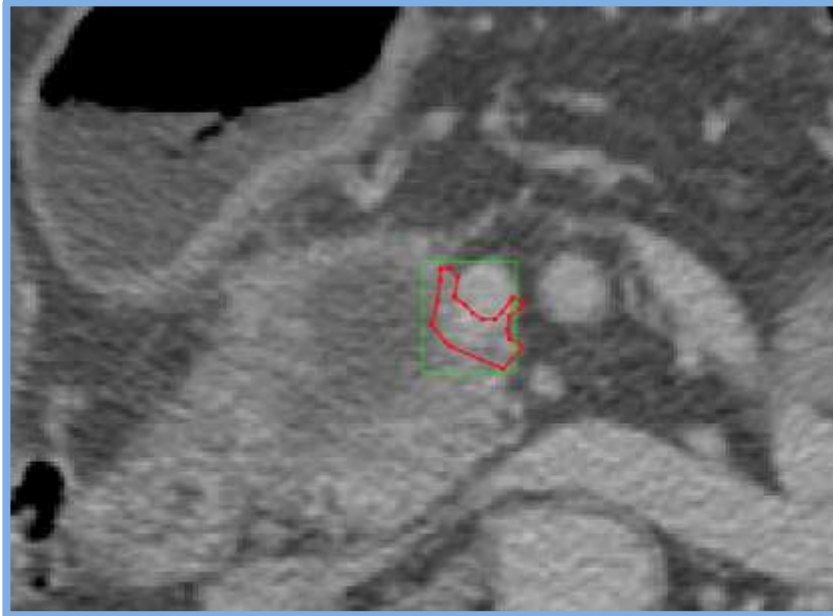


0-1 level of adipe involment)

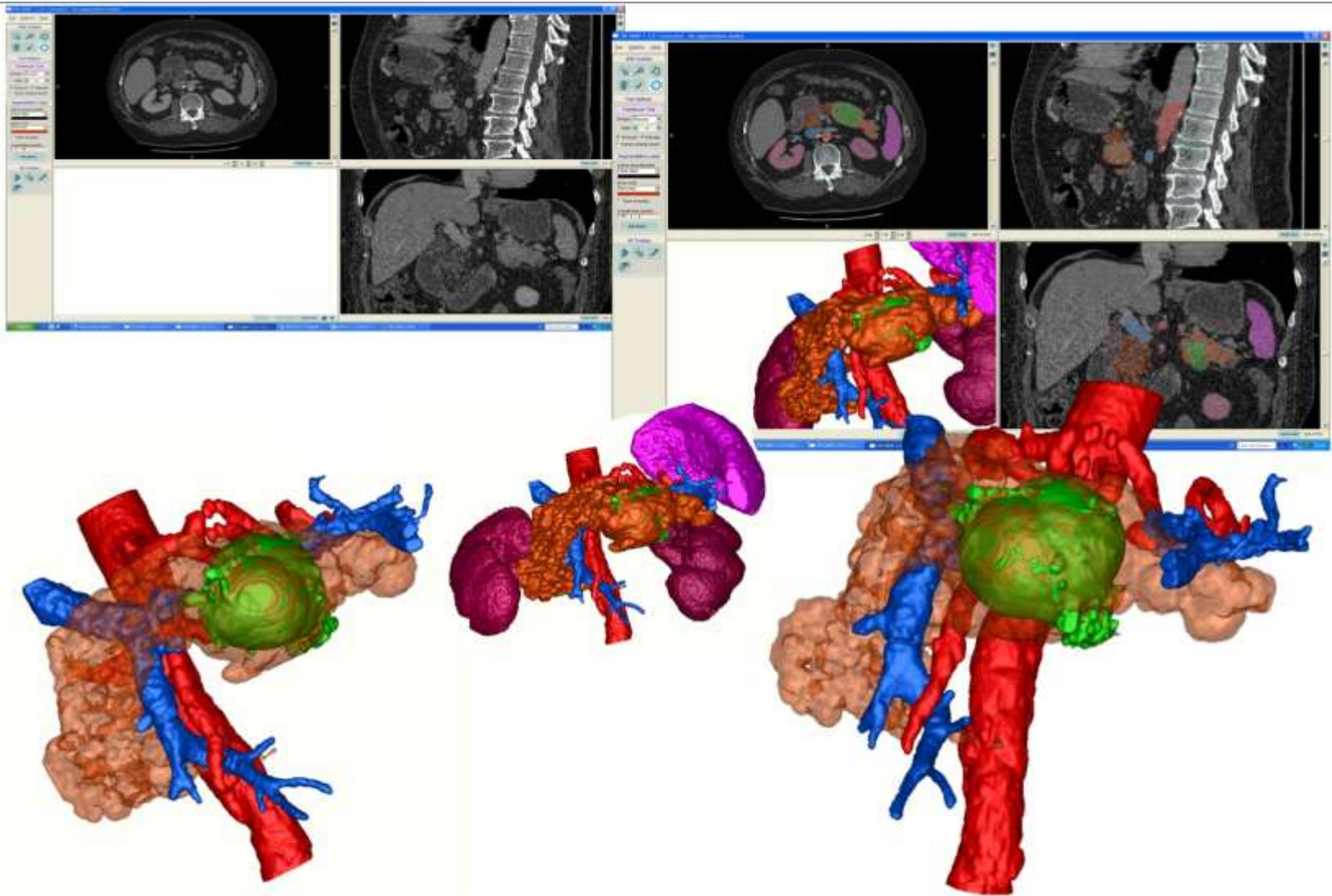
		Neoplasy
	G0	No tissue/vessels involvement (just the tumor is visible)
	G1	Neoplasy surround a vessel <50%
	G2	Neoplasy surround a vessel >50% but the lumen is free
	G3	Neoplasy surround a vessel >50% and there is a striction of the vessel lumen
	PLR	Possible Infiltration Retroportal Lamina/Retroperineal adipe
	CLR	Sure Infiltration Retroportal Lamina/Retroperineal adipe



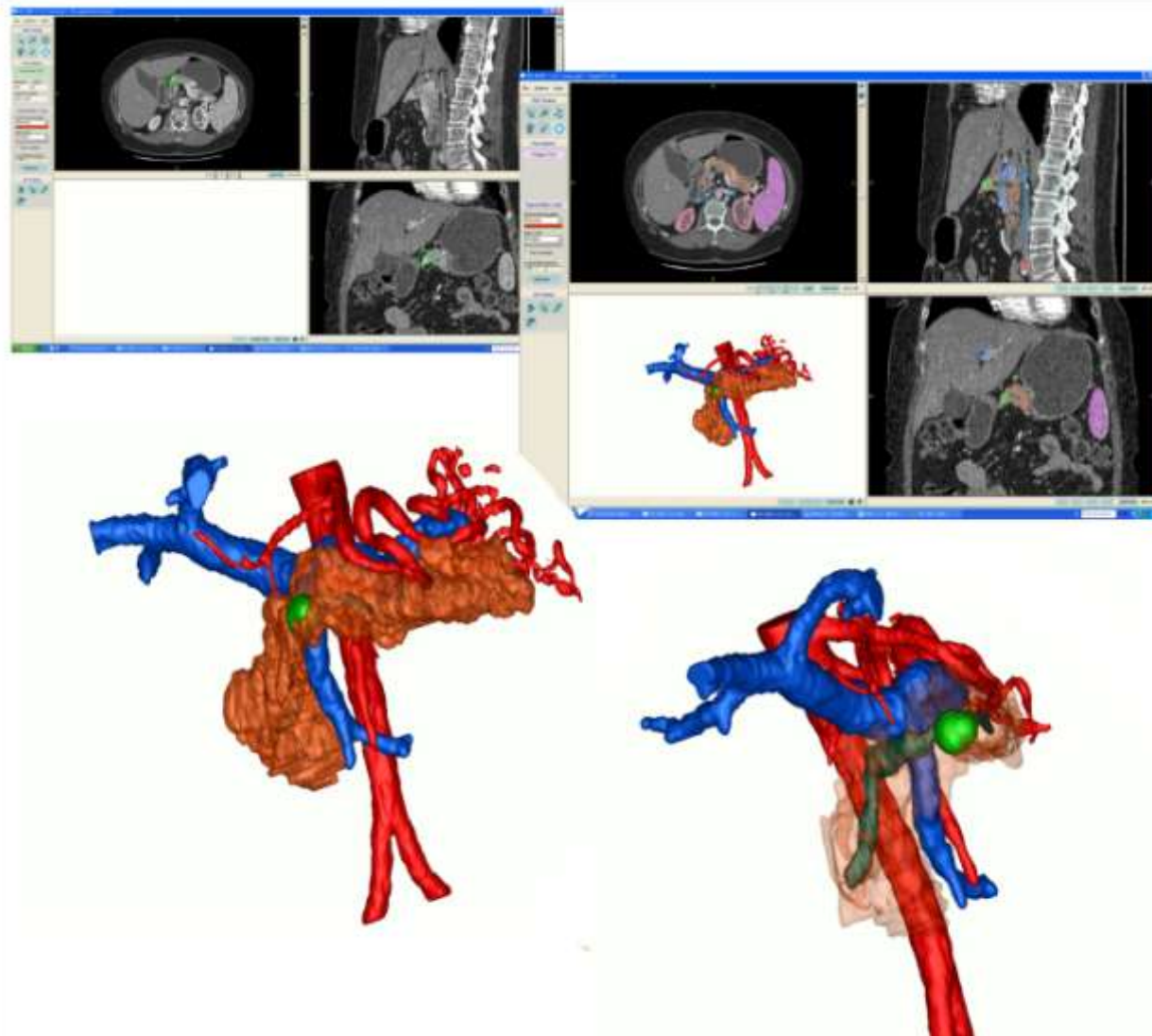
PSP: DUCTAL ADENOCARCINOMA



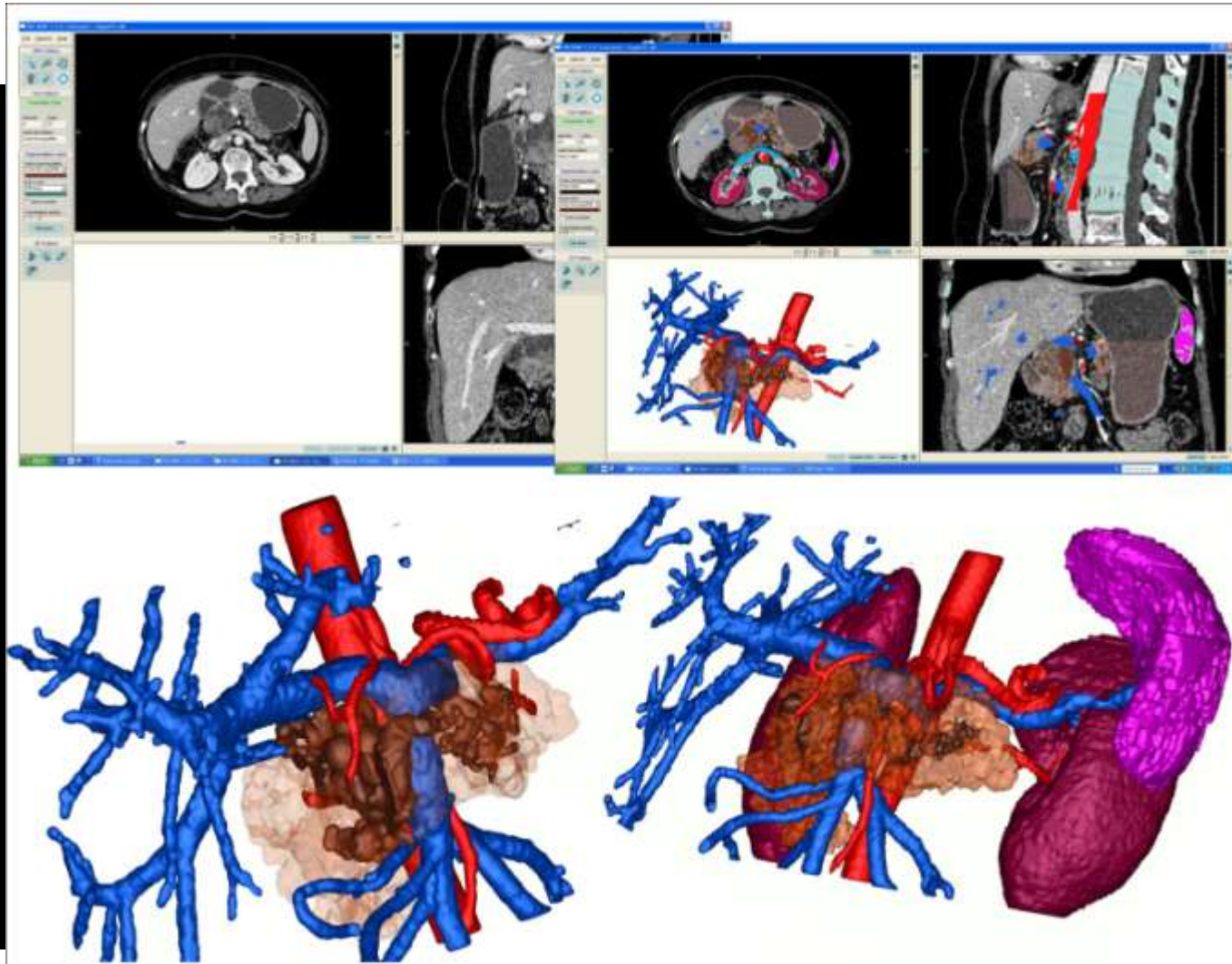
Results: Neuroendocrine Tumor

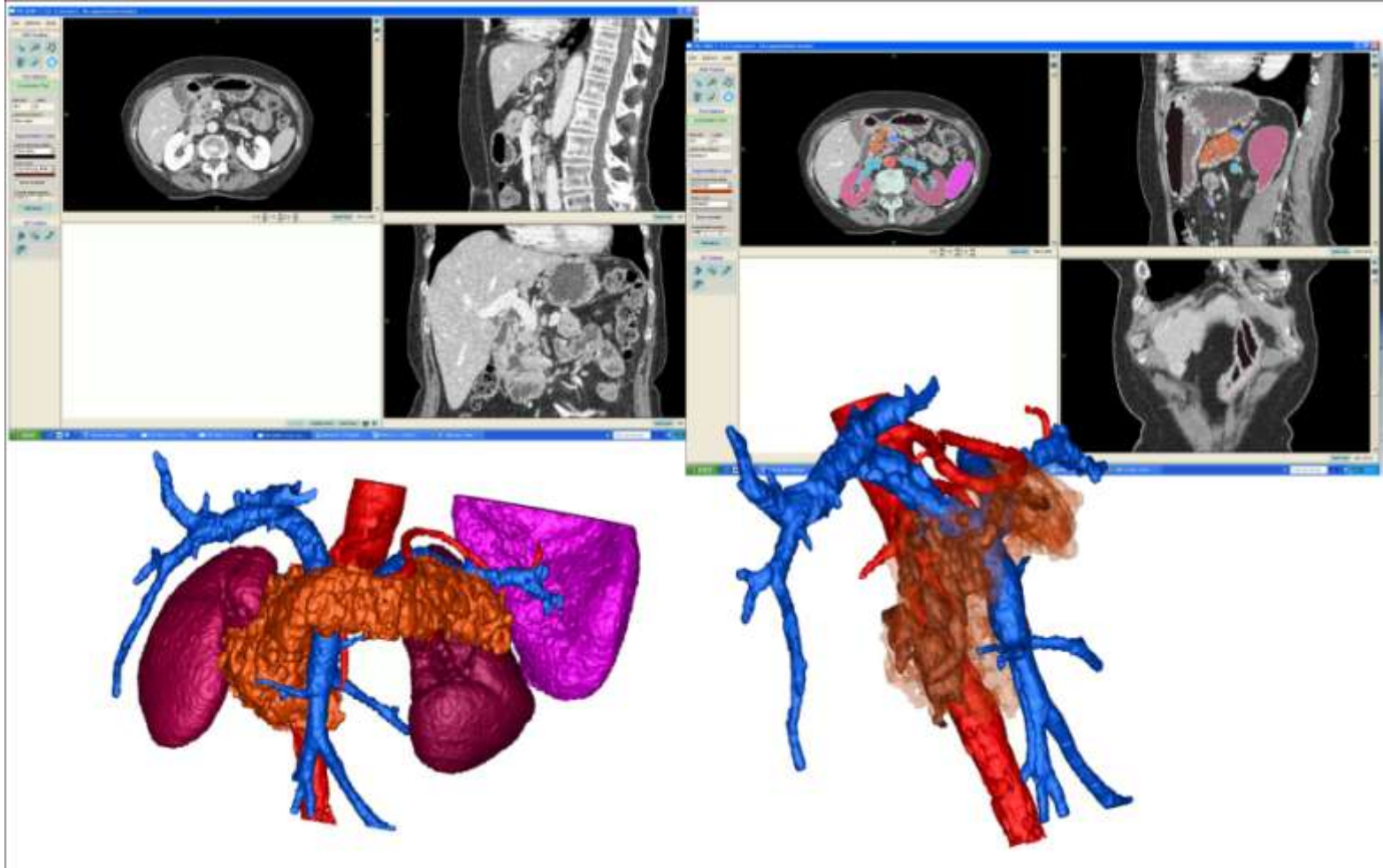


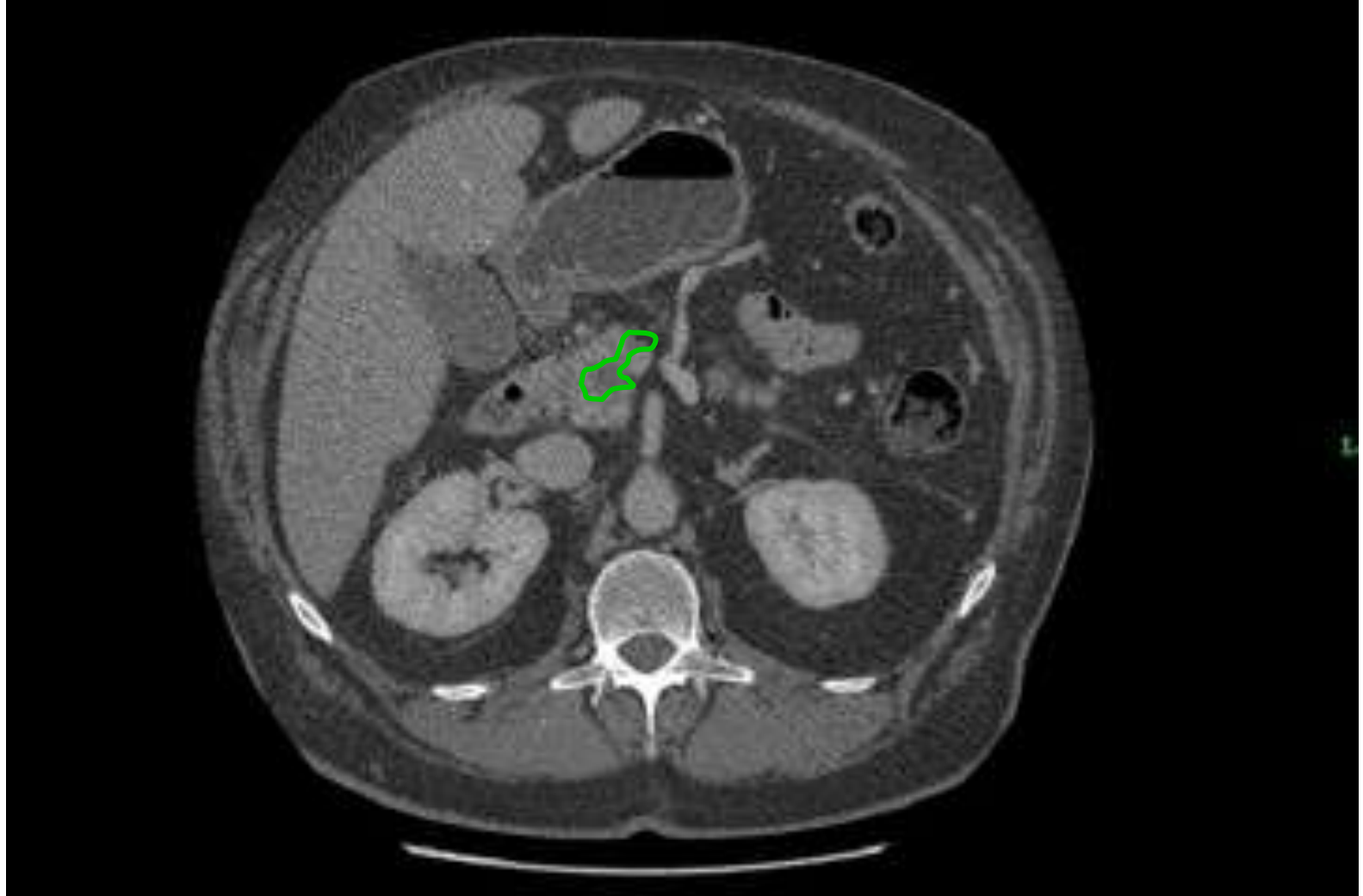
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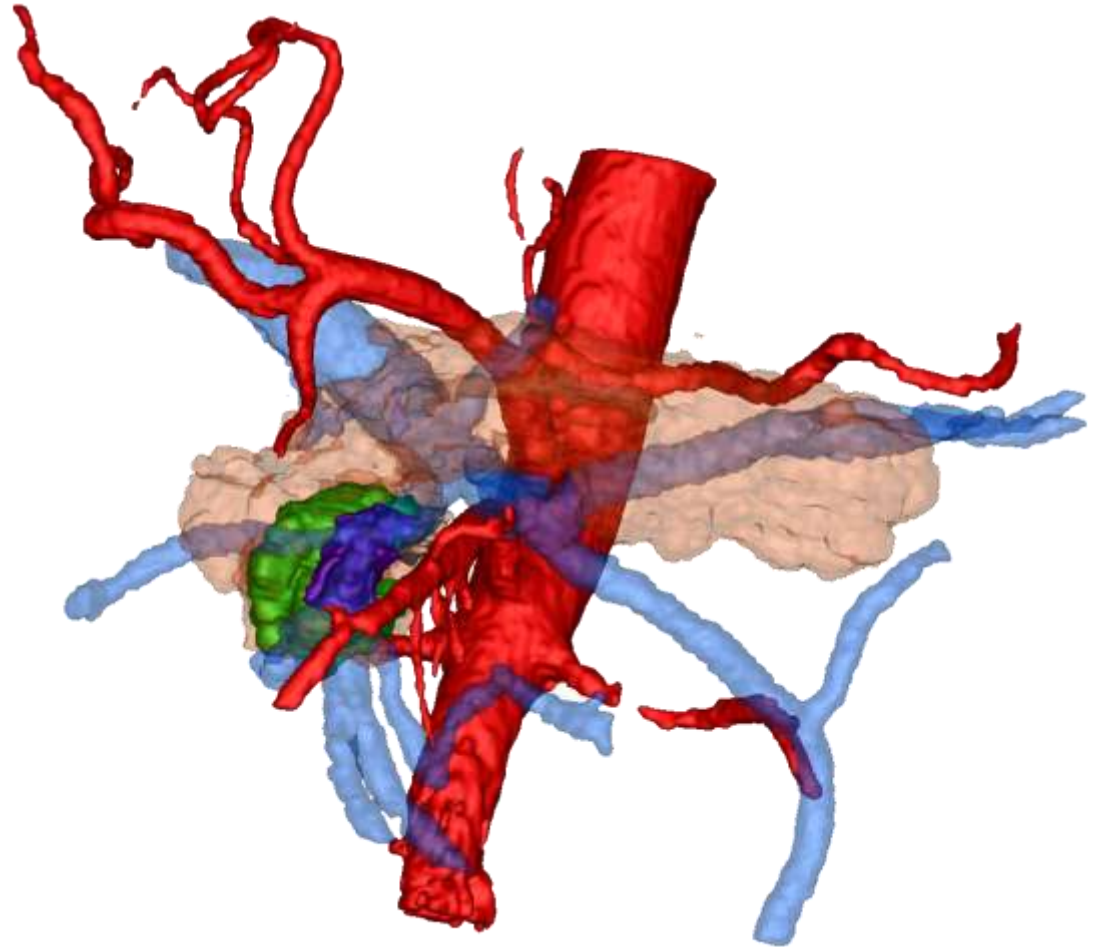
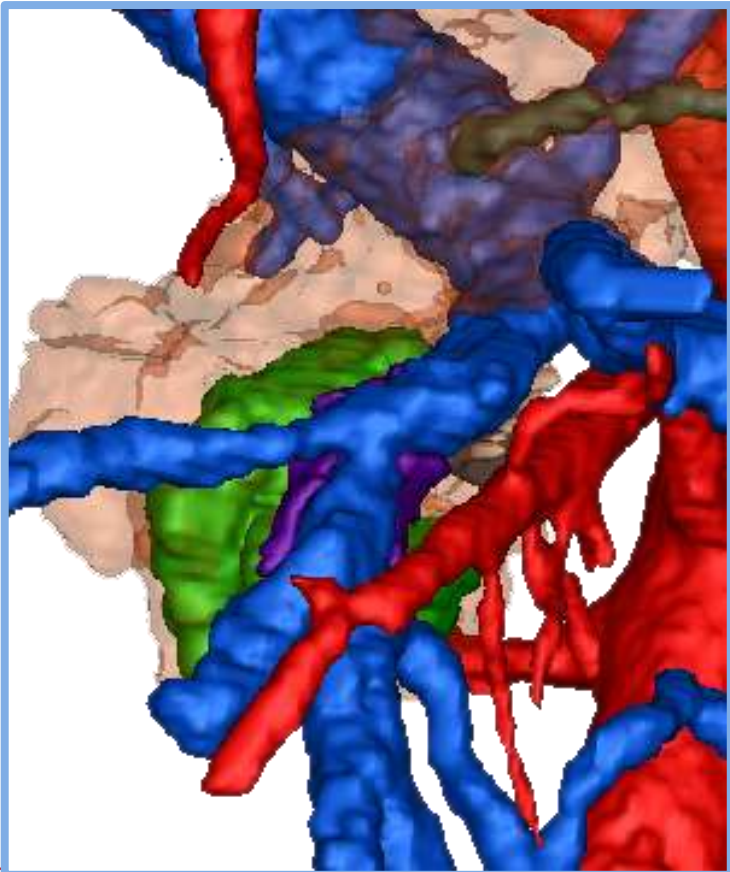


Results: Cystic Tumor - IPMN



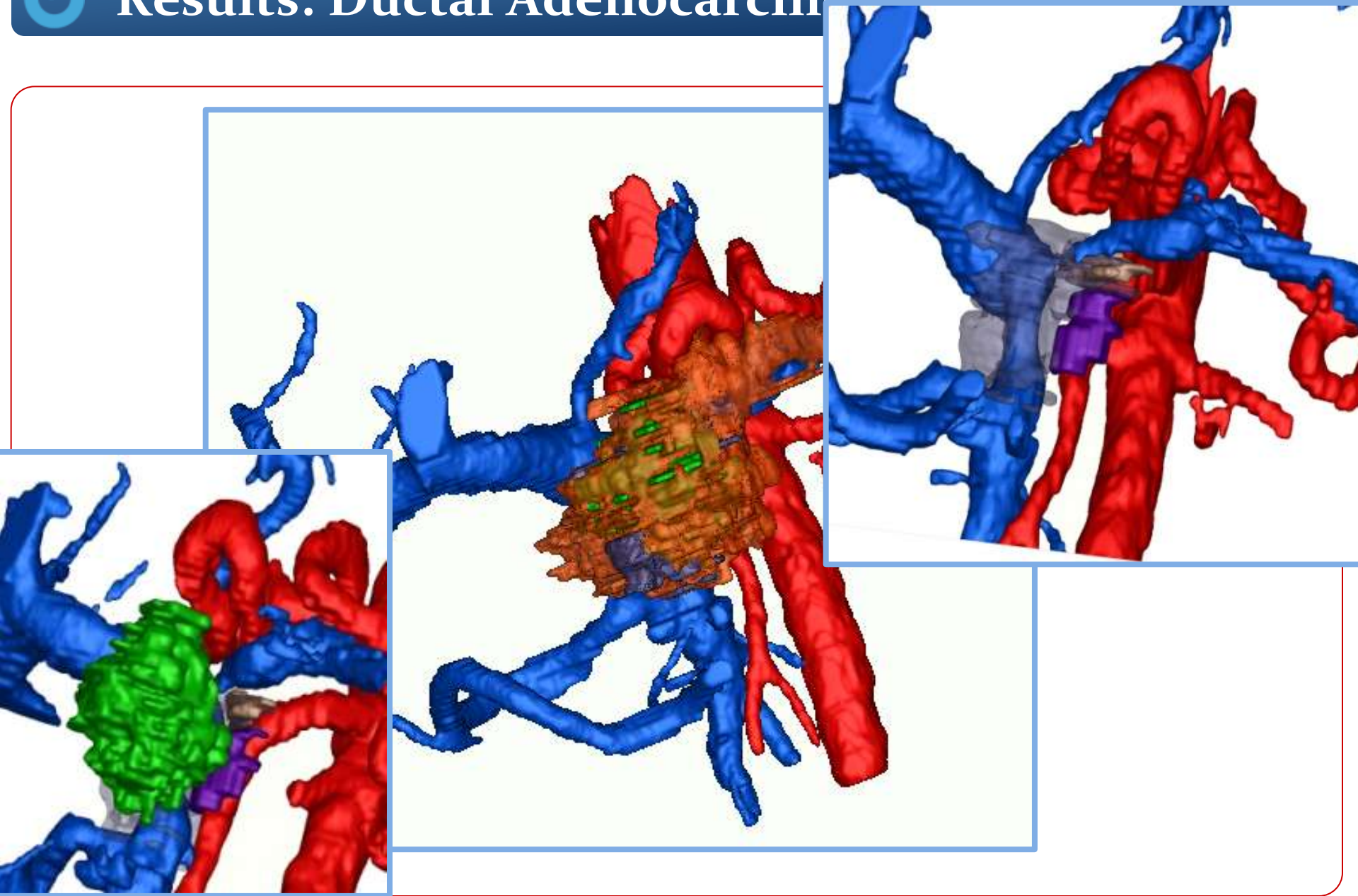








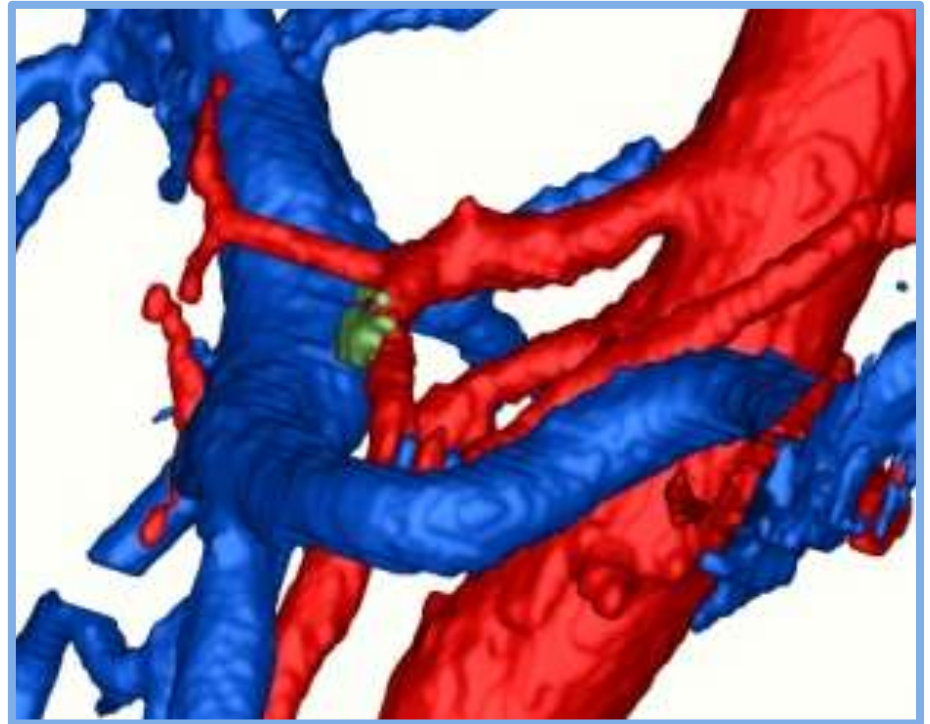
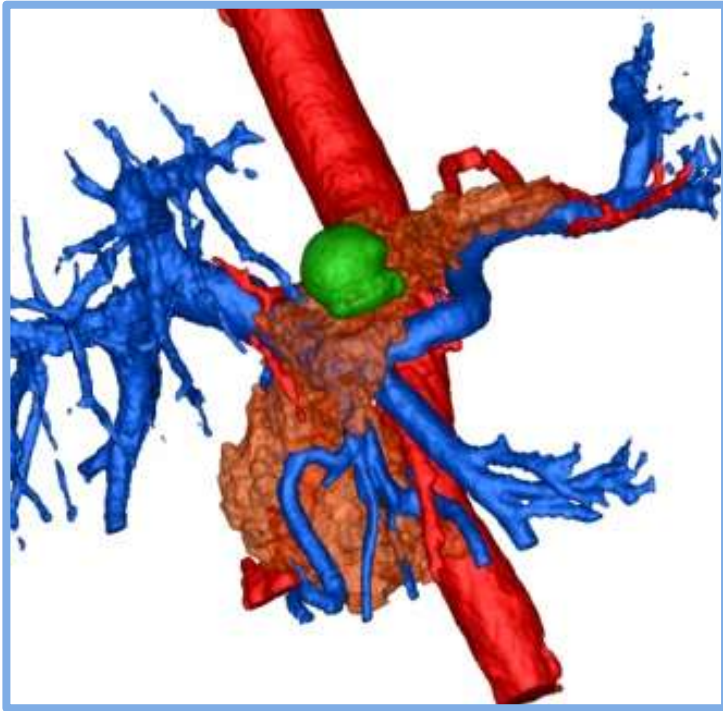
Results: Ductal Adenocarcinoma

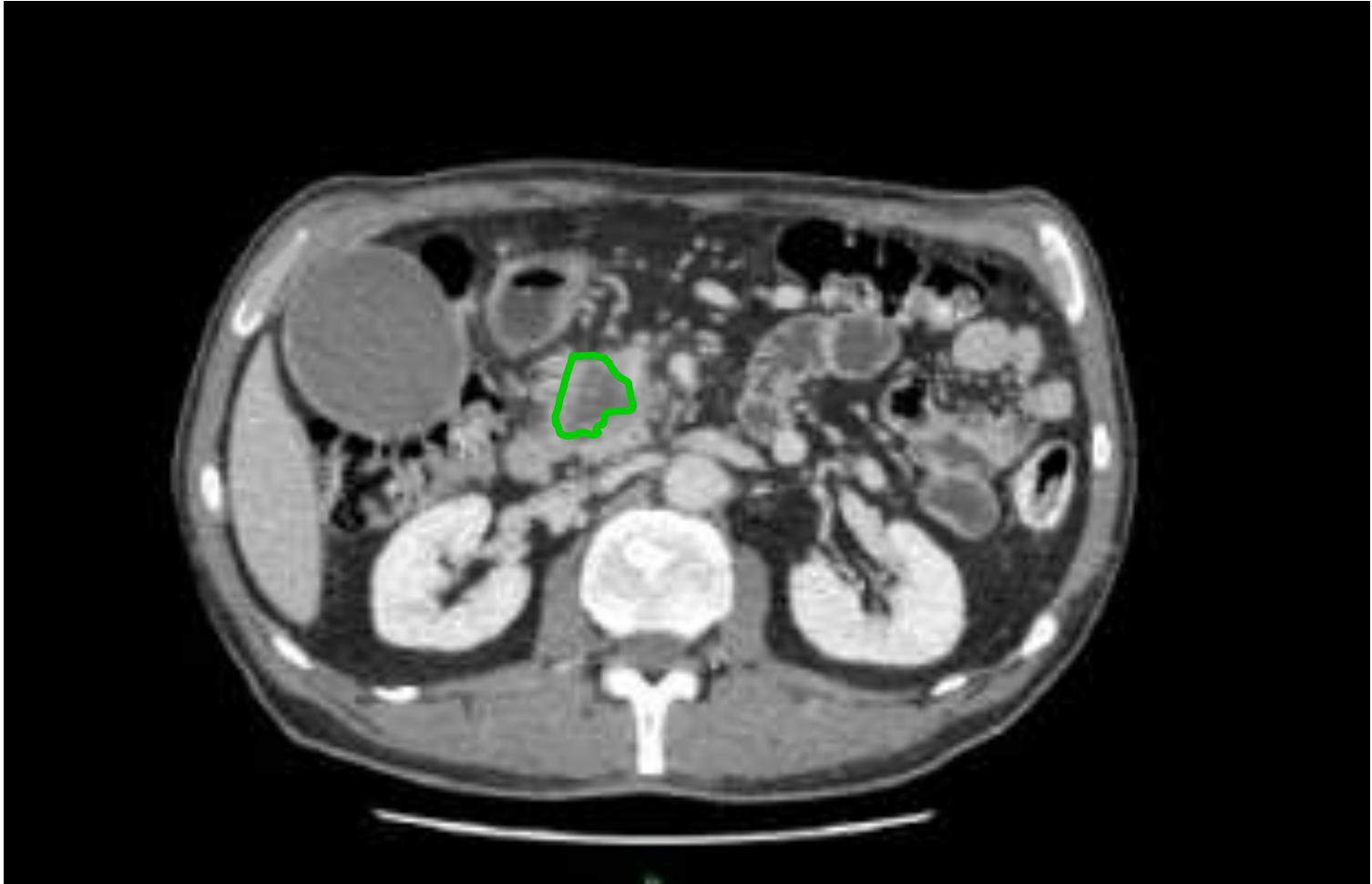


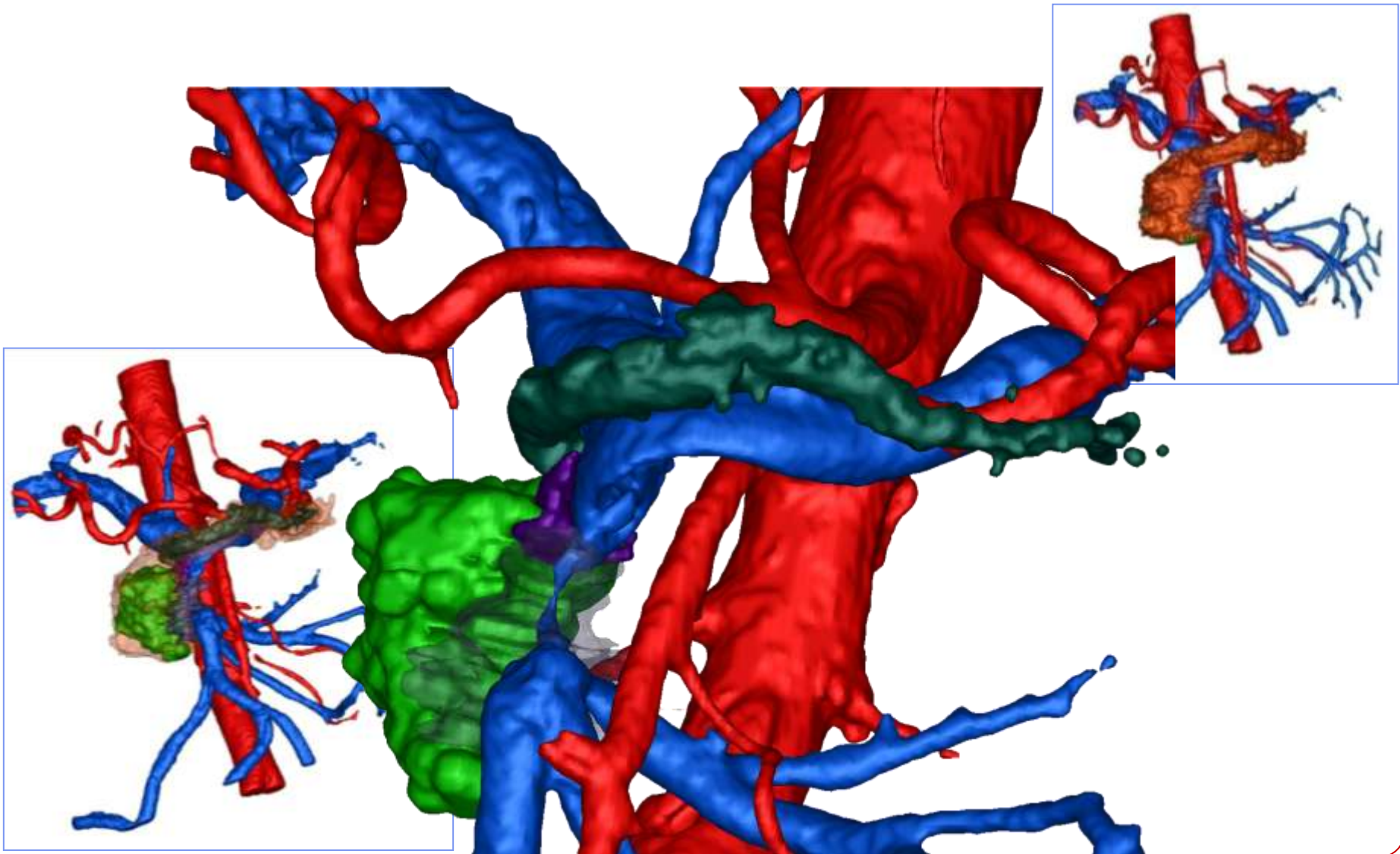
















- ✓ The using of patient specific 3D models to plan critical pancreas surgical interventions can actually be useful
- ✓ Planning the intervention using a segmented dataset could allow the surgeon to afford critical interventions with a major awareness of the specific patient anatomy and can in some cases guide him on a more efficient surgical approach
- ✓ On Pancreas surgical planning we tested the Endocas Segmentation Pipeline on about 15 CT Datasets and asked from feedbacks both at radiologist and surgeons to evaluate the effectiveness and usefulness of such an instrument for surgical planning.

It has anyway to be underlined that any further development has still to include some manual steps that could not be avoided depending too strongly on "radiologist's eye" in detecting lesion borders.





Grazie per l'Attenzione