厦门大学附属中山医院
ZHONGSHAN HOSPITAL XIAMEN UNIVERSITY

肝脏三维成像系统与精准肝脏切除术

Three-dimensional liver imaging system and precise hepatectomy

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自强不息 心于至善

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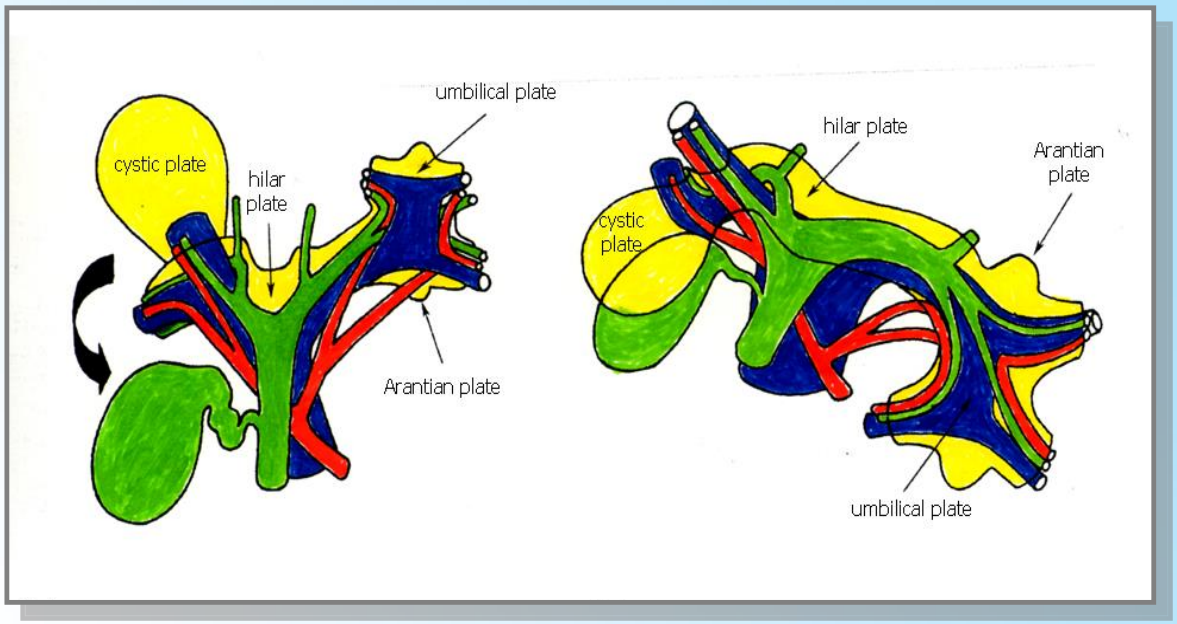
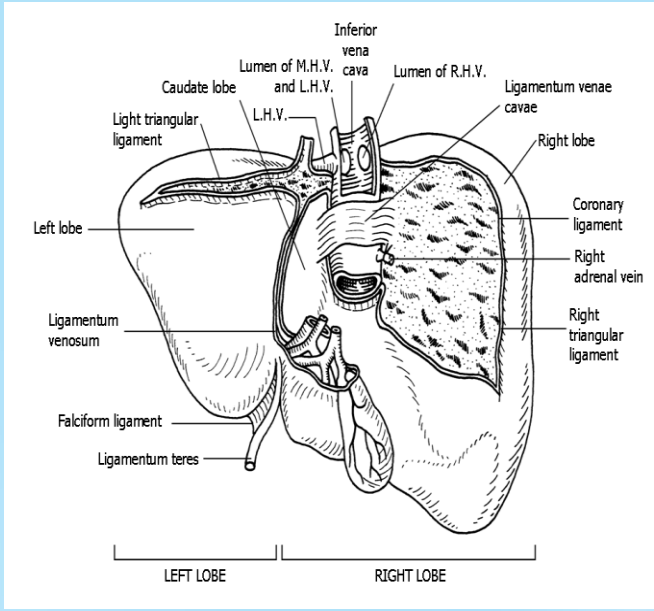
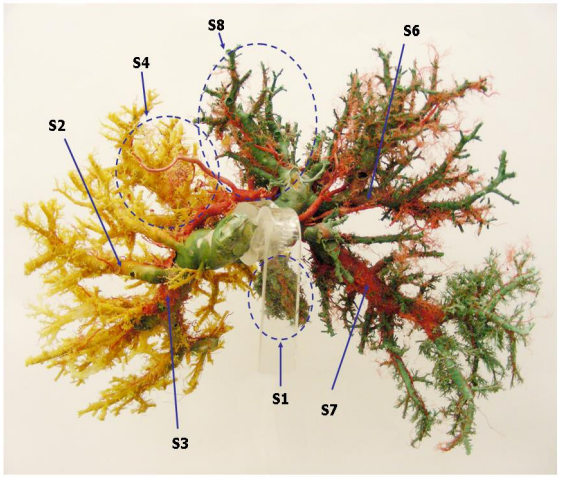
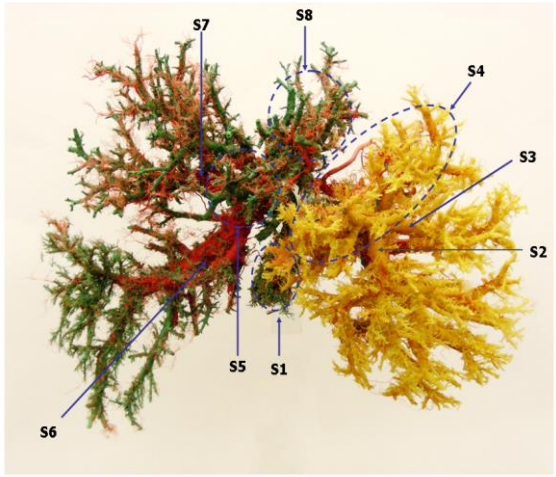
1. Concept of the precise hepatectomy

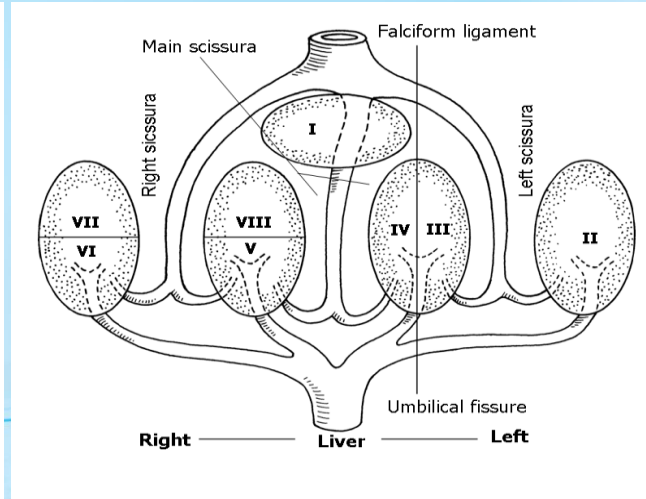
Complexity of the liver





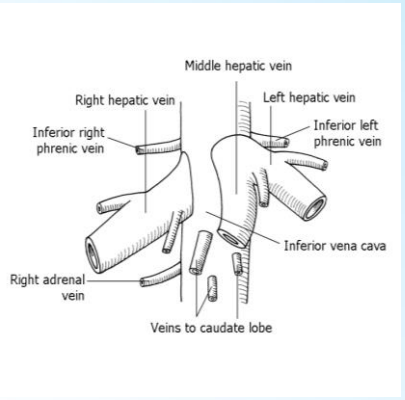


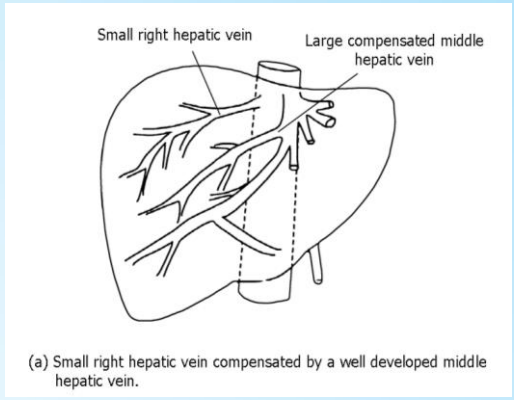




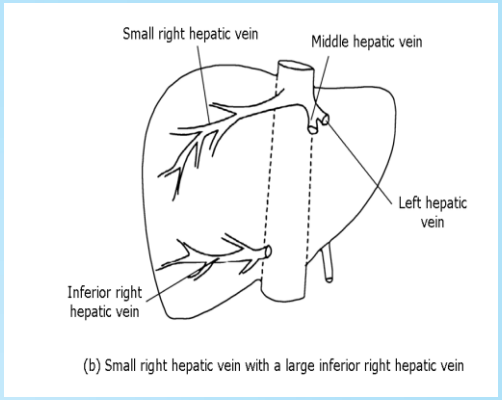
Vessels Variant

Hepatic vein

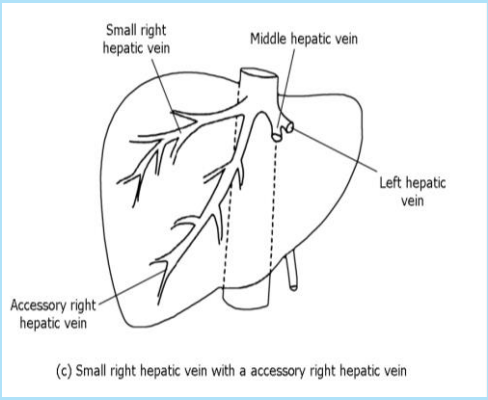




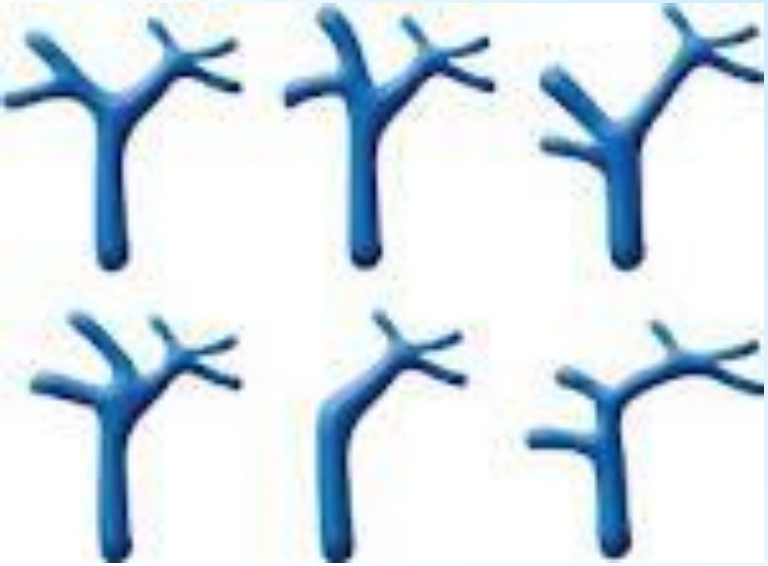
(a) Small right hepatic vein compensated by a well developed middle hepatic vein.

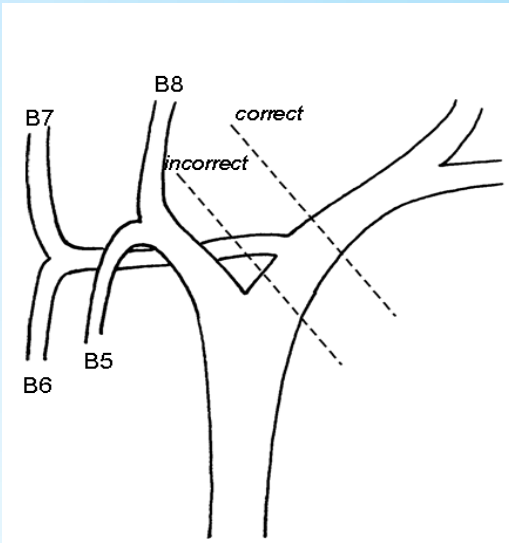


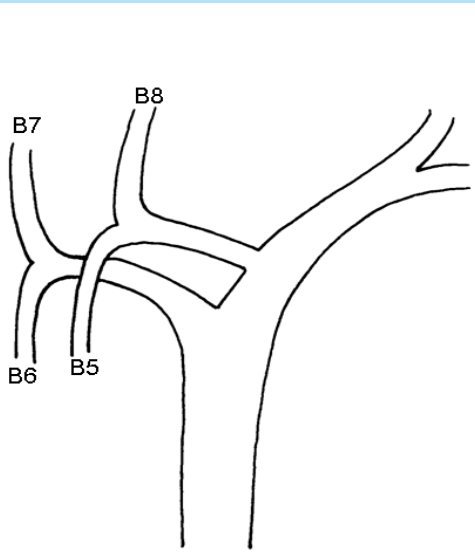
(b) Small right hepatic vein with a large inferior right hepatic vein



(c) Small right hepatic vein with a accessory right hepatic vein





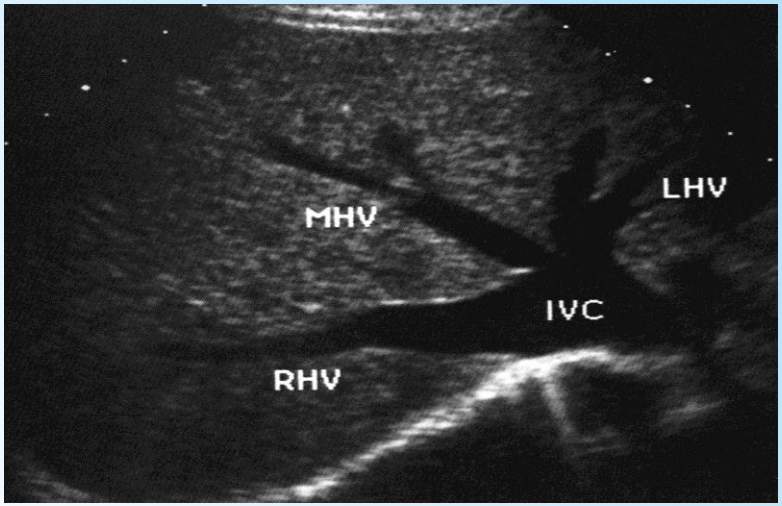


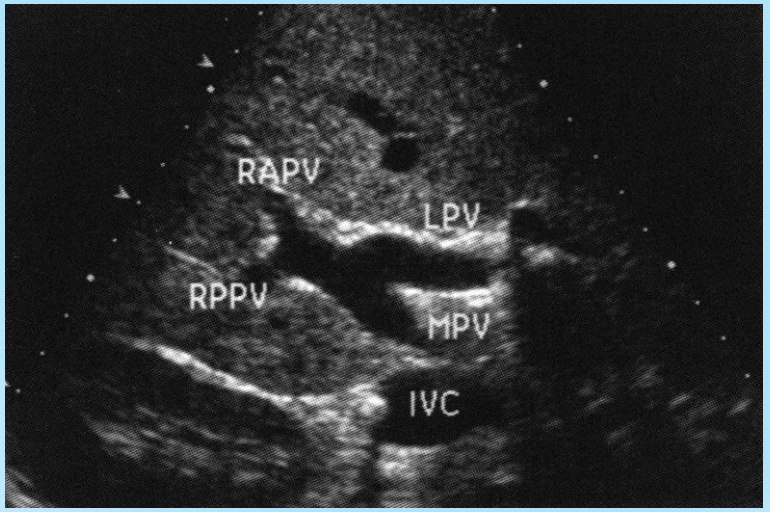
Portal vein

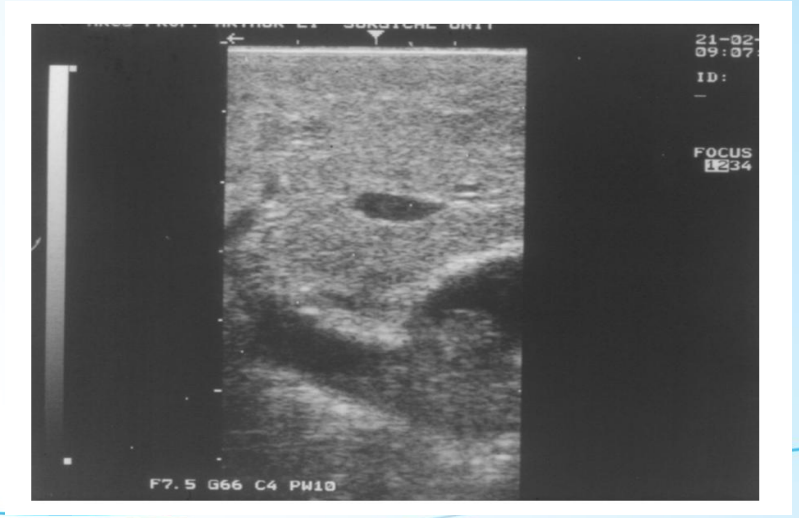
Bile Duct

Modern Image System

B-U

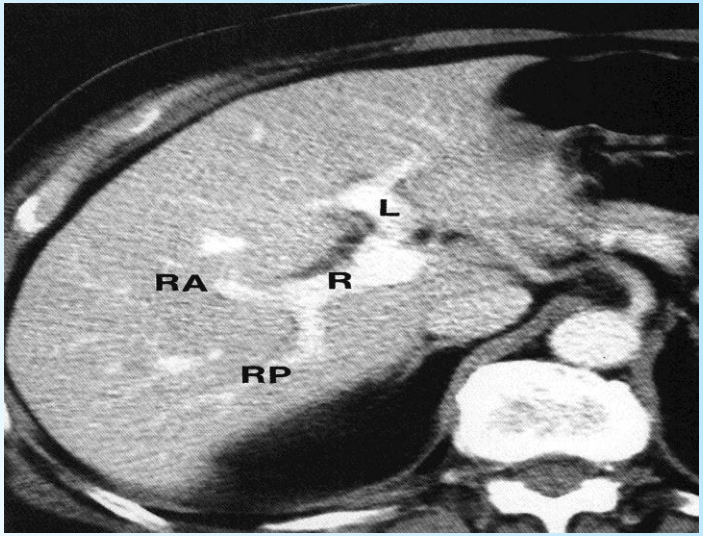


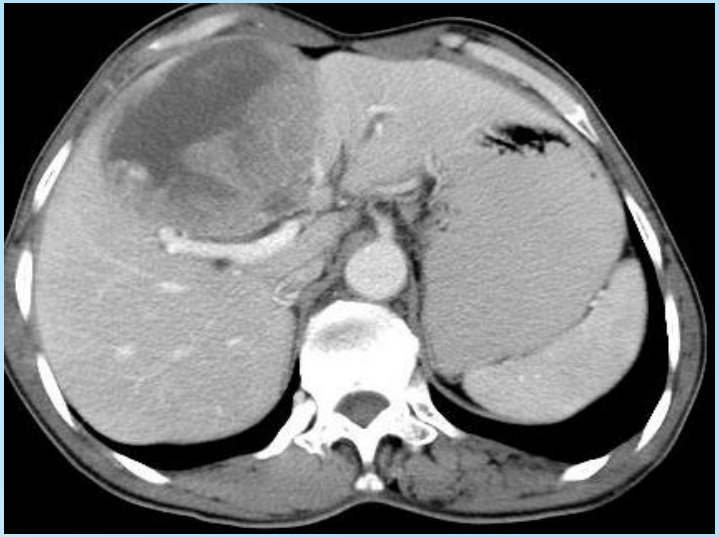


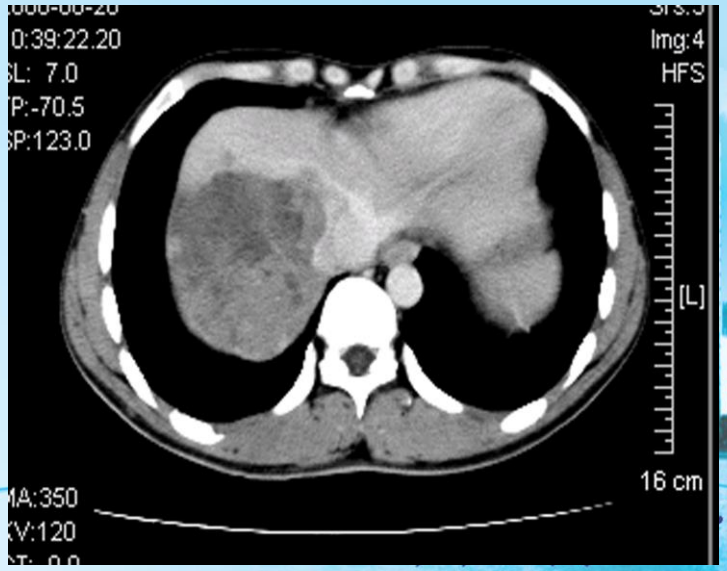


Modern Image System

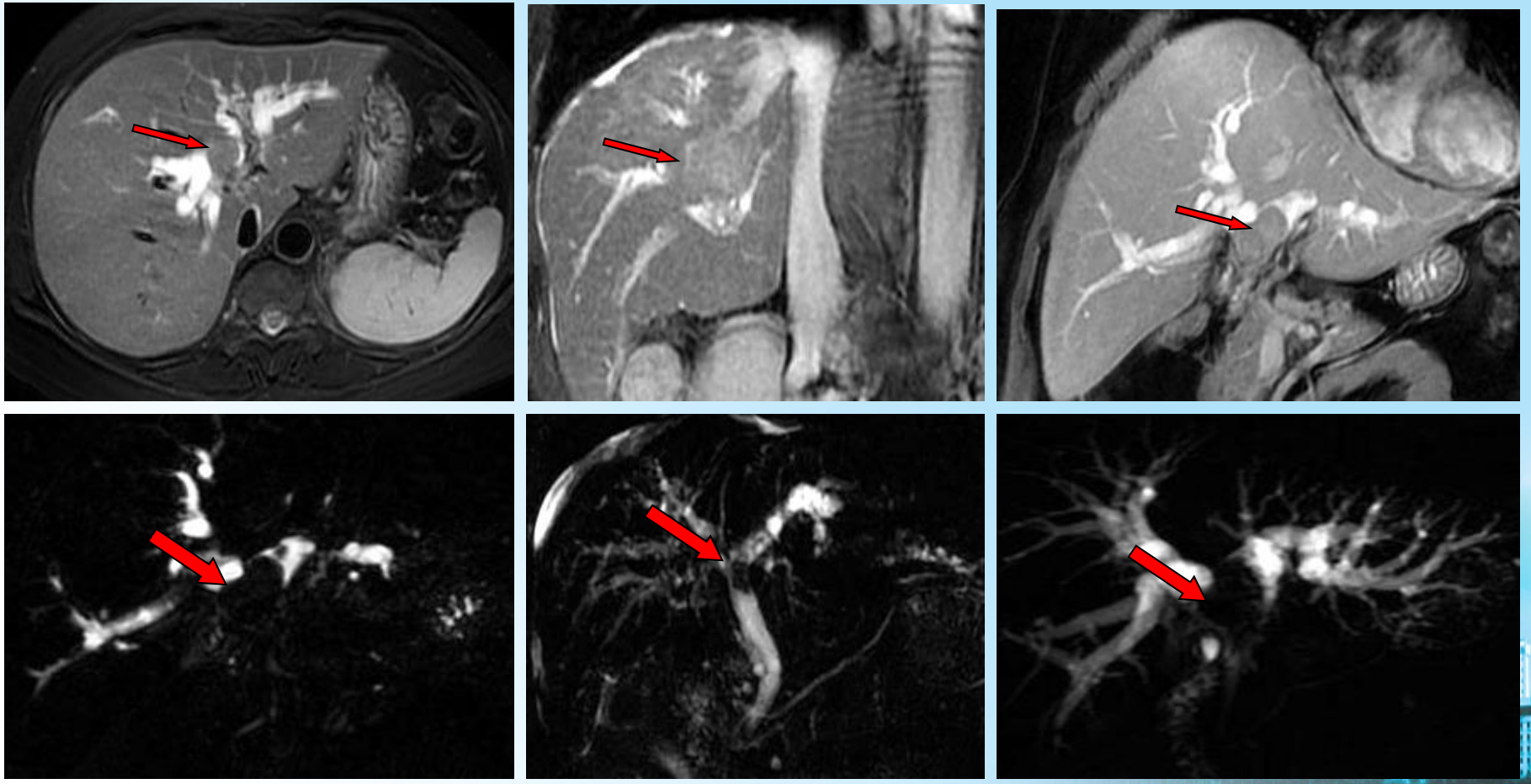
CT







Modern Image System

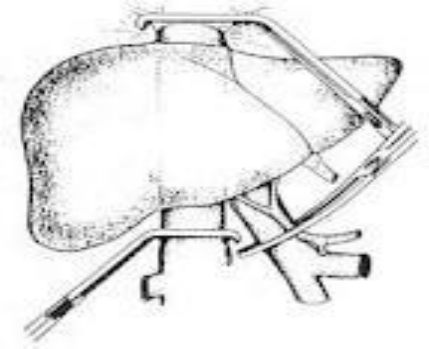


MRI and MRCP

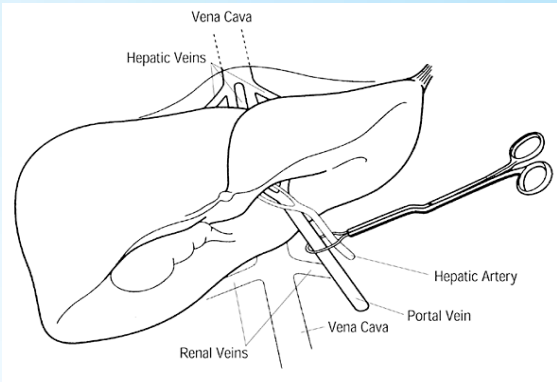
Methods for Hepatectomy

Vascular Exclusion Methods

Total Exclusion



Pringle's Maneuver



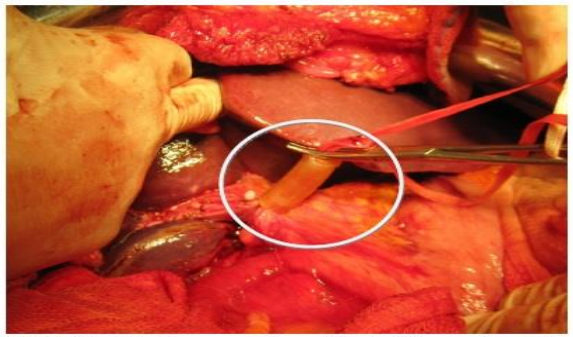
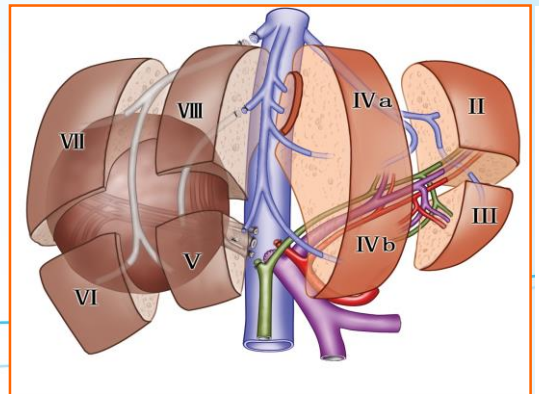
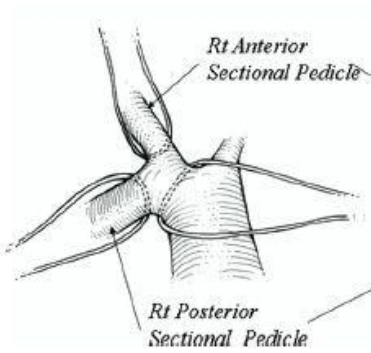
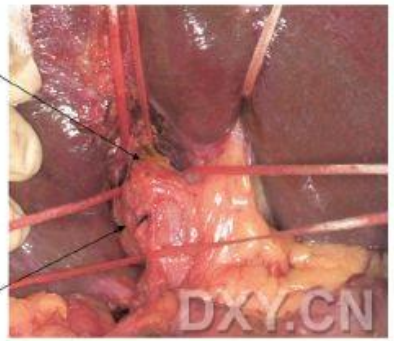


FIGURE 1 - Pringle maneuver (see white circle) by hepatic pedicle clamping for liver partial vascular exclusion (LPVE).

Distract Exclusion

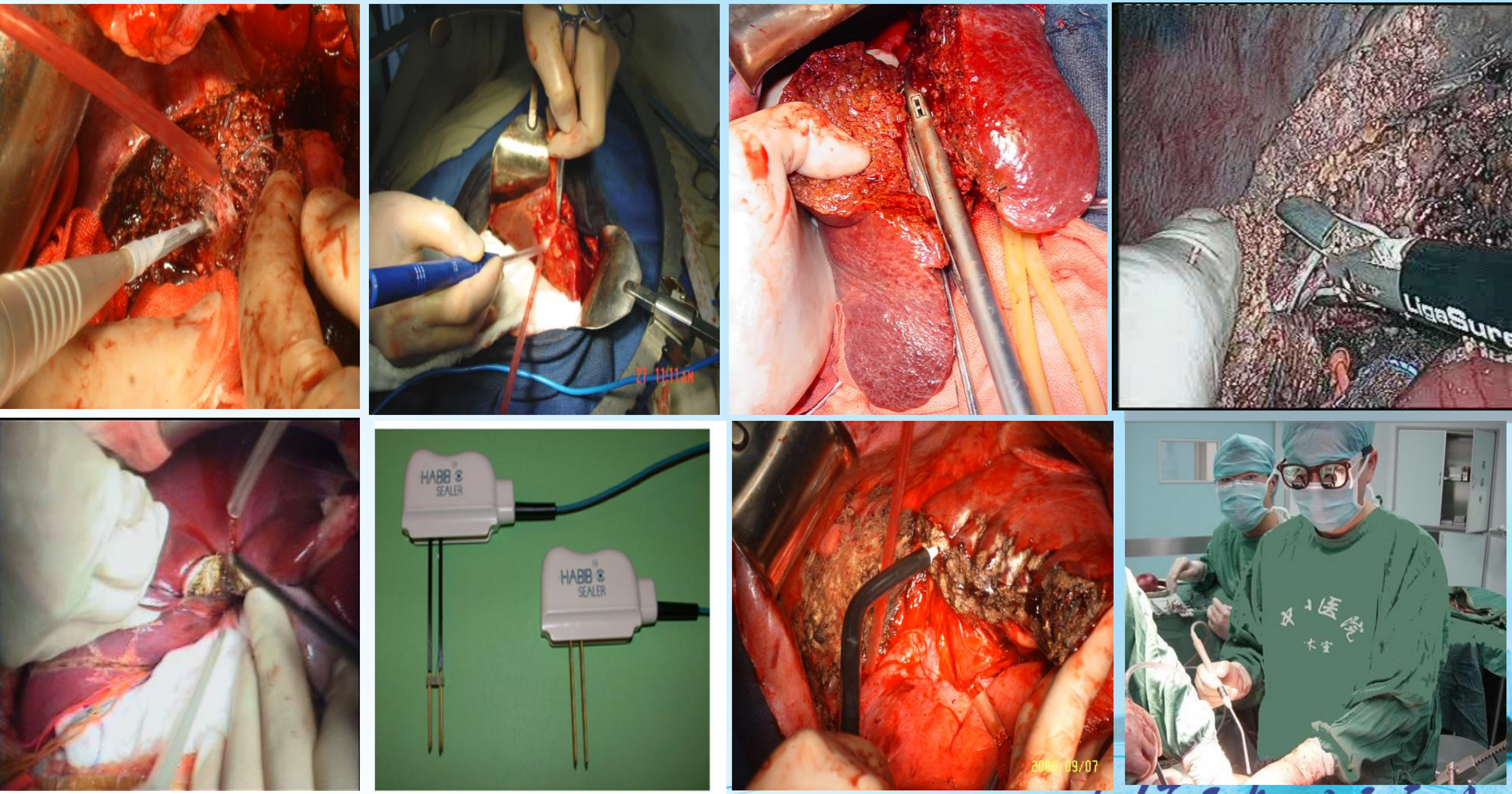






Methods for Hepatectomy

Instruments for liver resection



自强不息 止于至善

精准肝脏外科手术（Conception)

通过对肝脏手术：

- 精确术前评估
- 精密手术规划
- 精工手术操作
- 精良术后处理

AIM：

- 最小创伤侵袭（minimal invasiveness）
- 最大肝脏保护（maximal liver-saving）
- 最大效费比率（maximal effect/cost ratio)
- 最佳康复效果（maximal outcome）

Application: 1. Living donor liver transplantation
2. Liver tumor resection

2. 3D liver image system and living donor liver Trx

The technique of 3D liver image

Case report (video)

厦门大学附属中山医院
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The technique of 3D liver image

3D Image System Based on CT-Scan

CT Data Parameters:

- Slice thickness 2.5 mm, reconstruction interval1.25 mm
- Contrast: 180 ml non-ionic contrast agent, injection rate 6 ml/s
- Contiguous slices covering the whole organ
- No breathing artifacts or movement of the patient
- All phases are acquired at a similar breathing position
- Minimal or no beam hardening artifacts or artifacts due to foreign bodies such as stents or drains
- Resolution in plane (x and y) <= 1.0 mm

Arterial Phase

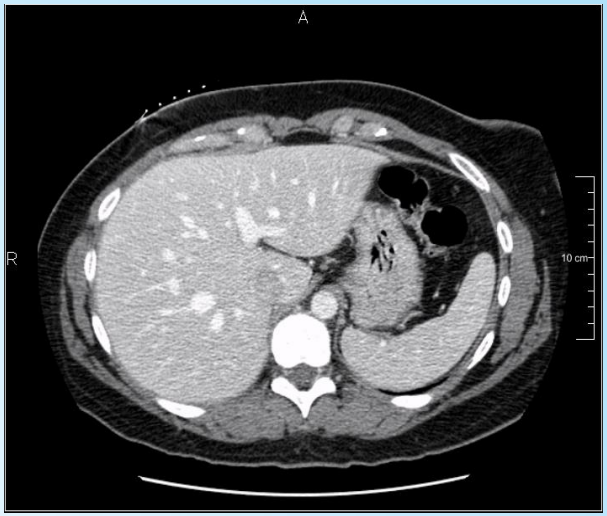
- Slice Thickness <= 1.5 mm
- Reconstruction Interval <=1.5 mm
- Tolerable image noise, i.e. standard deviation of density of liver parenchyma in a region of interest not including the tumor less than or equal to 20 HU
- Mean density in a main branch of the hepatic arteries at least 30 HU higher than mean density of liver parenchyma as measured above
- Portal vein only slightly contrasted.
- Bile ducts not contrasted simultaneously

Venous Phase（Portal and Hepatic Veins）

- Slice Thickness <= 2.0 mm
- Reconstruction Interval <=2.0 mm
- Tolerable image noise, i.e. standard deviation of density of liver parenchyma in a region of interest not including the tumor than less or equal to 20 HU
- Mean density in the main portal vein or a major hepatic vein at least 30 HU higher than mean density of liver parenchyma as measured above
- Hepatic arteries or bile ducts not contrasted simultaneously

Different CT Phase

Arterial Phase



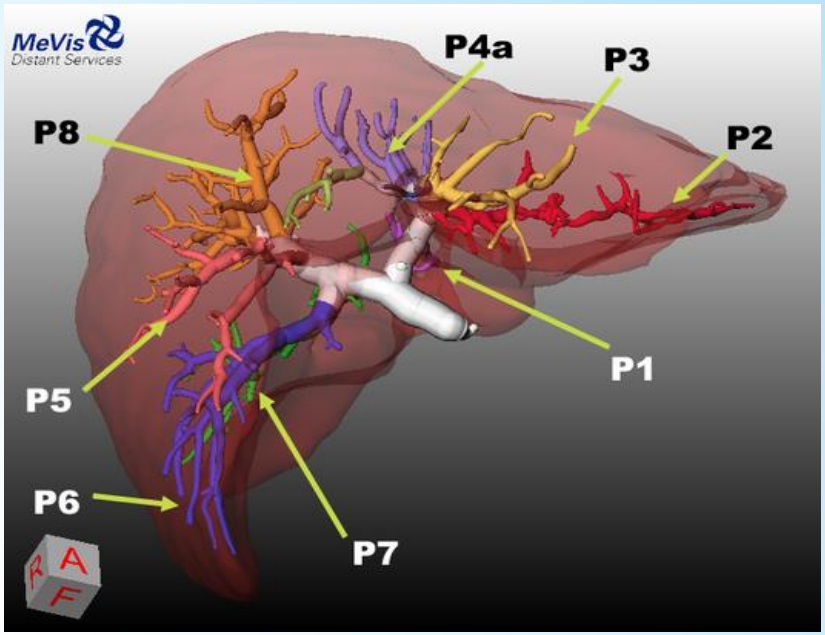
Venous Phase

Biliary Phase

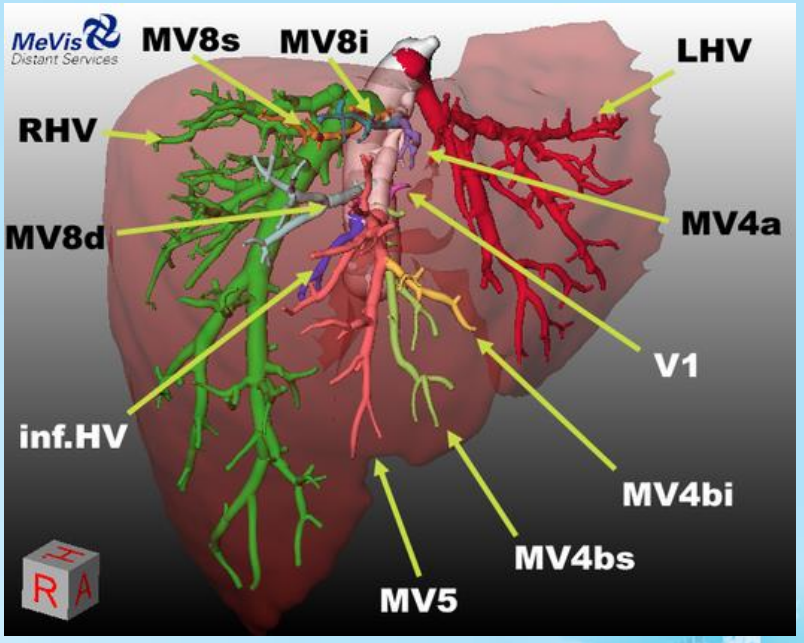
Image Analysis for Living Donor Liver Transplantation

- Vascular Analysis
- Vascular Territories
- Resection Planning
- Risk Analysis

Vascular Analysis

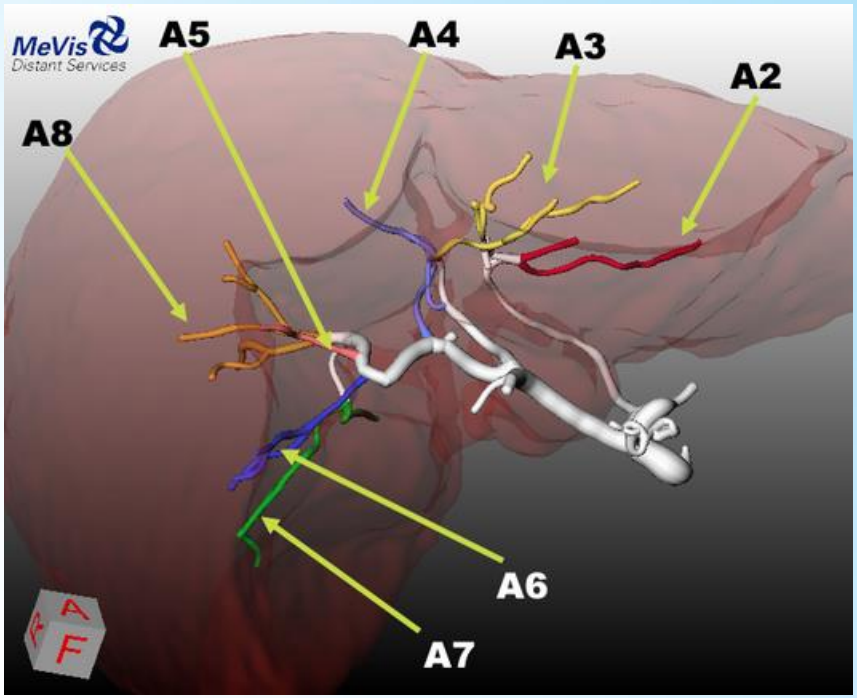


Analysis of the portal vein. The main branches are coded by different colors and are labeled similar to Couinaud's scheme

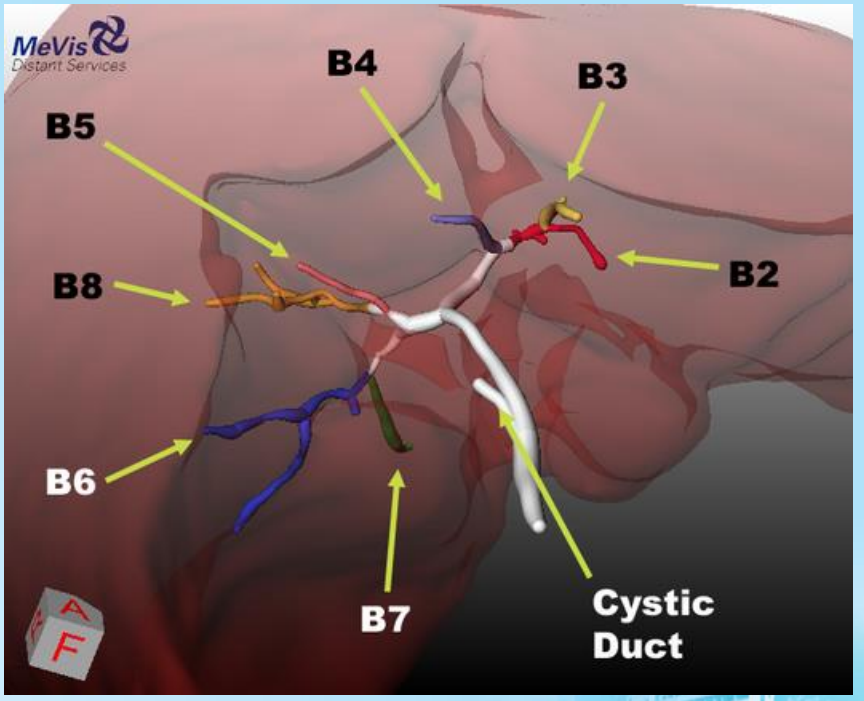


Analysis of the hepatic veins. The right hepatic vein, left hepatic vein and inferior hepatic veins are coded as one vascular branch. The middle hepatic venous branches are further divided since this is essential for the risk analysis.

Vascular Analysis

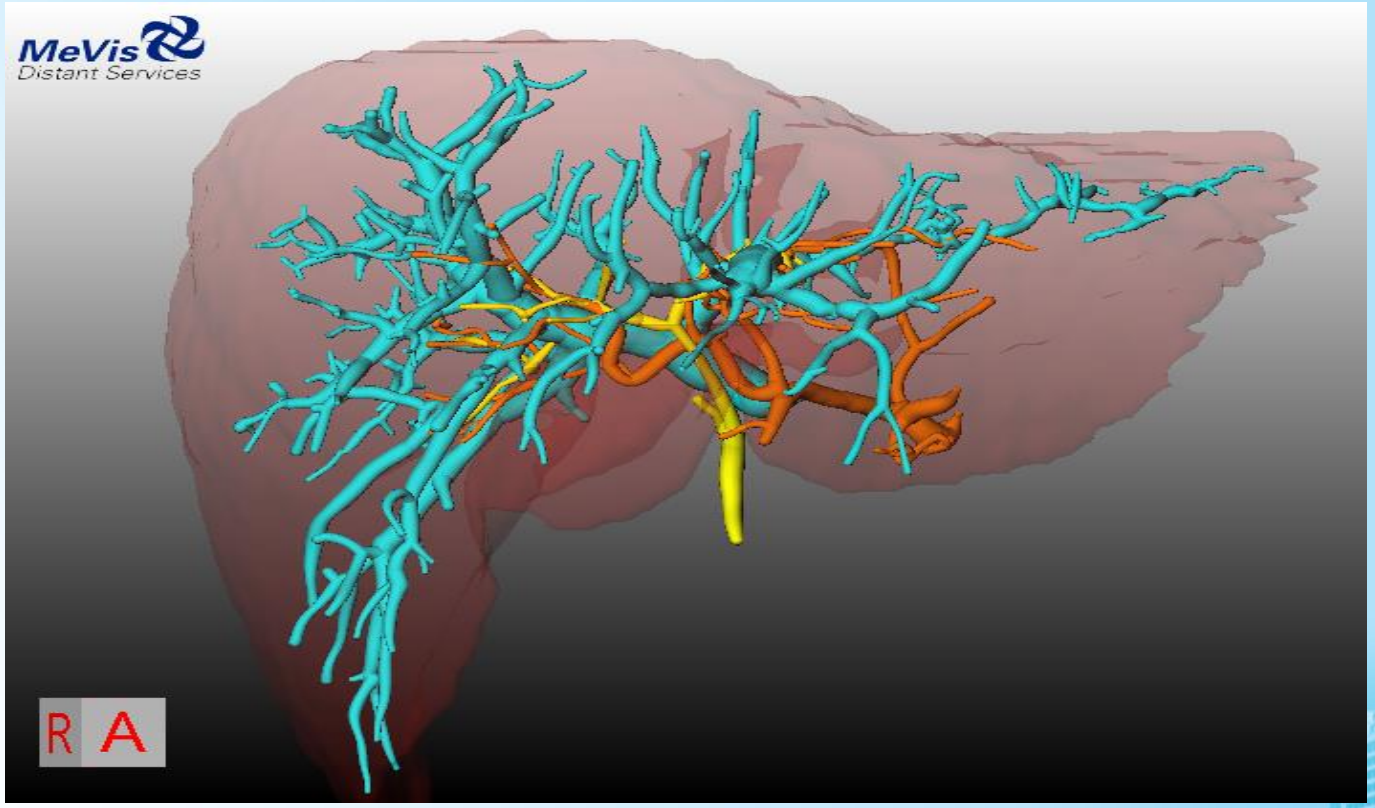


Patient individual hierarchical analysis of the hepatic arteries. The main branches are coded by different colors to allow for easy identification.



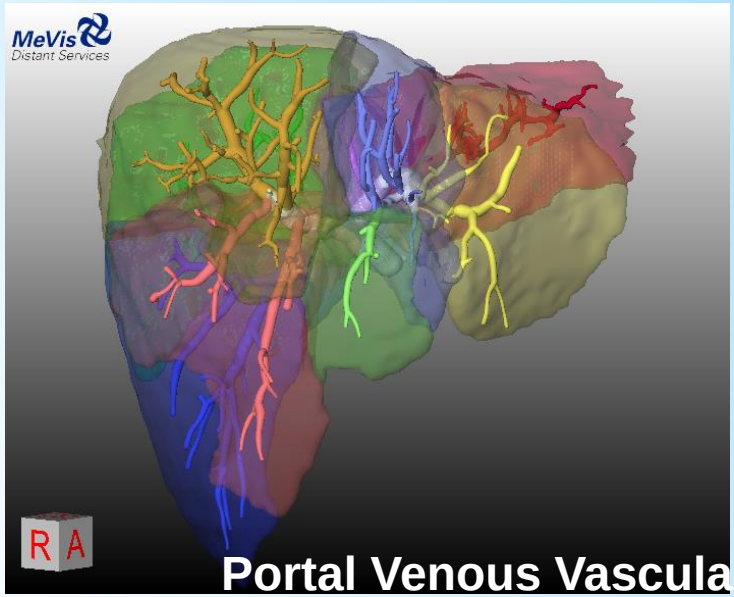
Patient individual hierarchical analysis of the bile ducts. The major bile ducts can easily be identified. The branching pattern of the bile ducts is normal.

Vascular Analysis



The portal vein, hepatic arteries and bile ducts are displayed together. All of these vascular systems were extracted from different phases of the CT. The results were registered to compensate for different positioning of the potential donor or different breathing positions.

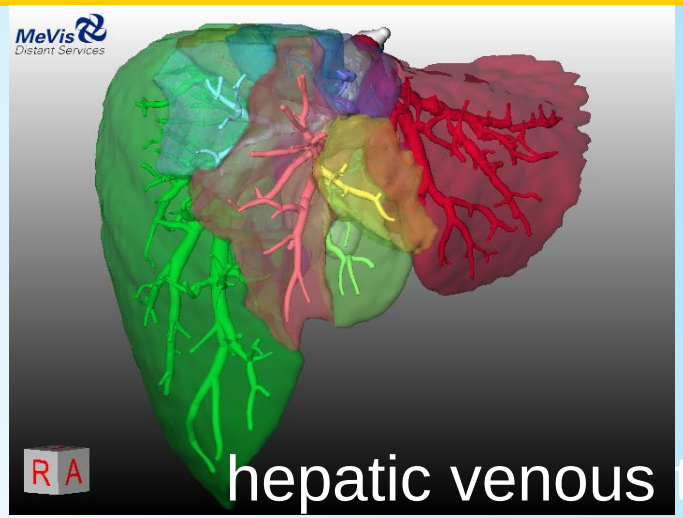
Vascular territories



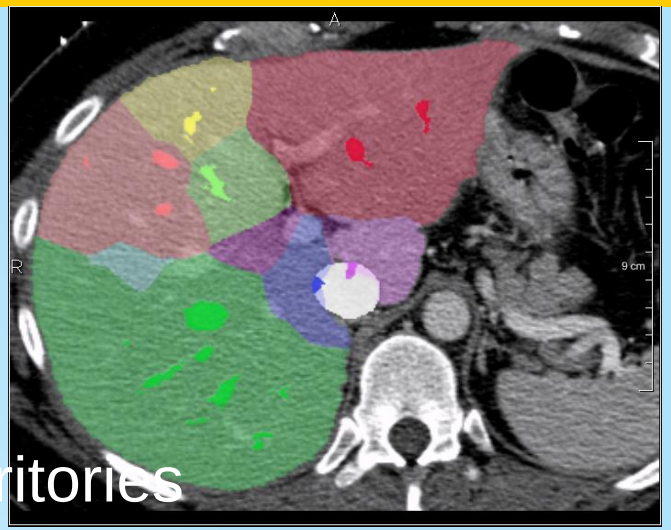
Portal Venous Vascular Territories

Vascular Territory	Volume (in ml)	(relative) (% of total)
I	43	(2.5%)
II	156	(9.0%)
III	172	(9.9%)
IVa	172	(9.9%)
IVb	58	(3.4%)
V	207	(12.0%)
VI	217	(12.5%)
VII	259	(14.9%)
VIII	448	(25.9%)
Total	**1732**	**(100.0%)**

Vascular territories

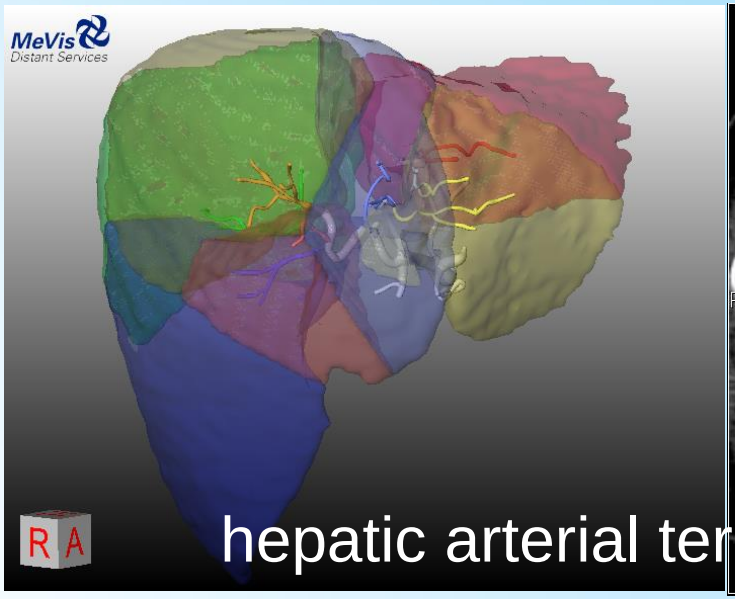


hepatic venous territories



Vascular Territory	Volume (in ml)	(relative) (% of total)
LHV	350	(20.2%)
MV4a	39	(2.3%)
MV4bi	41	(2.4%)
MV4bs	69	(4.0%)
MV5i	158	(9.1%)
MV5s	92	(5.3%)
MV8d	16	(0.9%)
MV8i	27	(1.5%)
MV8s	37	(2.1%)
RHV	824	(47.6%)
V1	34	(2.0%)
inf.HV	46	(2.6%)
Total	**1732**	**(100.0%)**

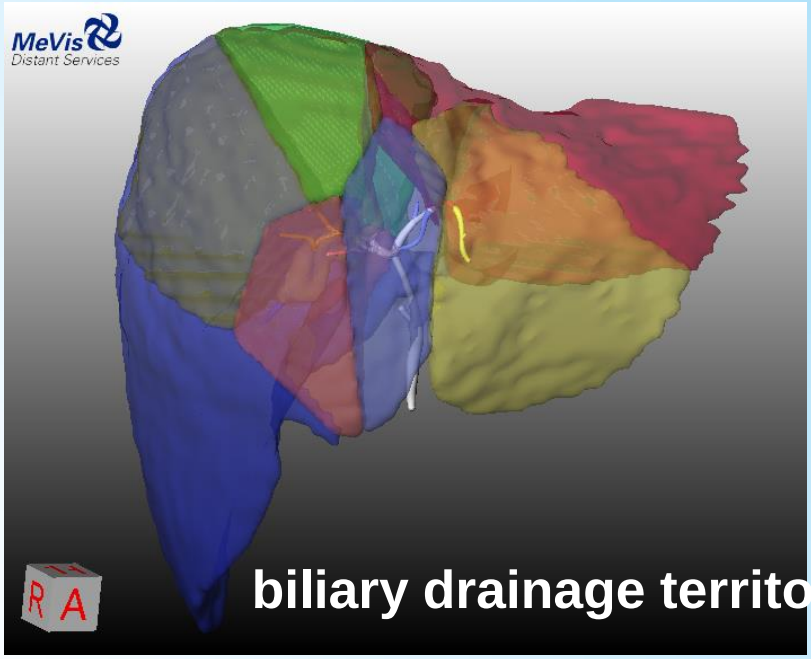
Vascular territories

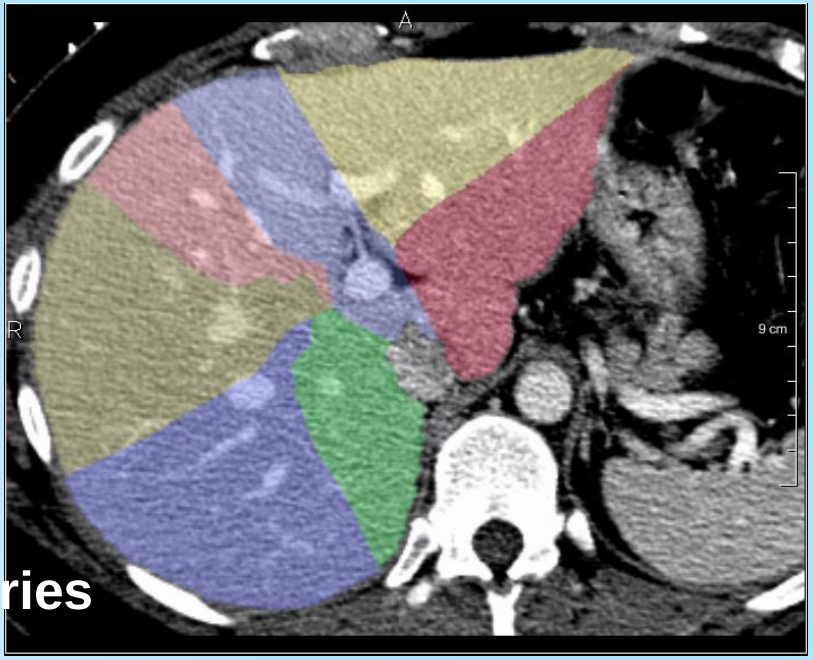


hepatic arterial territories

Vascular Territory	Volume (in ml)	(relative) (% of total)
A2	191	(11.1%)
A3	173	(10.0%)
A4	216	(12.5%)
A5	98	(5.7%)
A6	324	(18.7%)
A7	304	(17.6%)
A8	424	(24.5%)
Total	**1732**	**(100.0%)**

Vascular territories

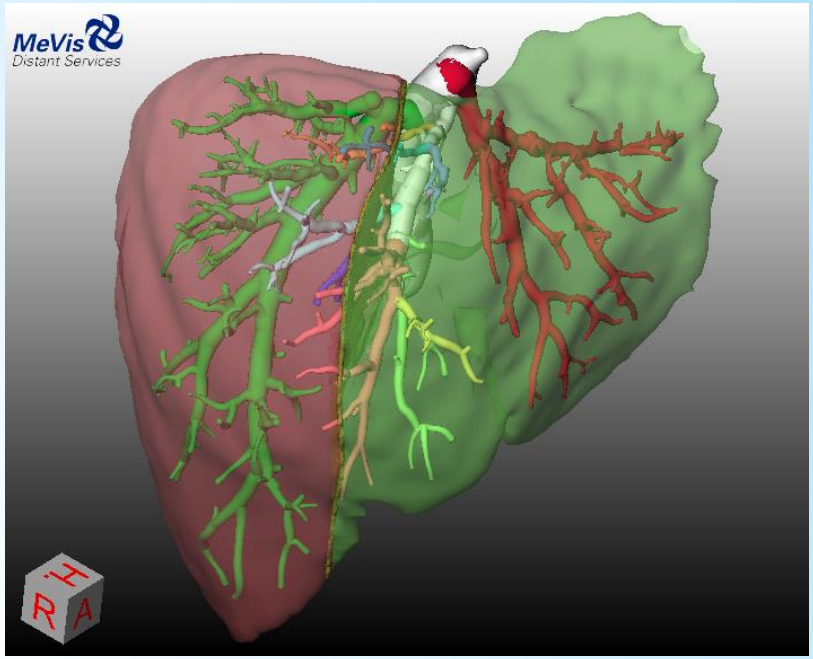




Volumetry of the Biliary Drainage Territories

Vascular Territory	Volume (in ml)	(relative) (% of total)
B2	240	(13.9%)
B3	175	(10.1%)
B4	127	(7.4%)
B5	85	(4.9%)
B6	600	(34.7%)
B7	161	(9.3%)
B8	343	(19.8%)
Total	**1732**	**(100.0%)**

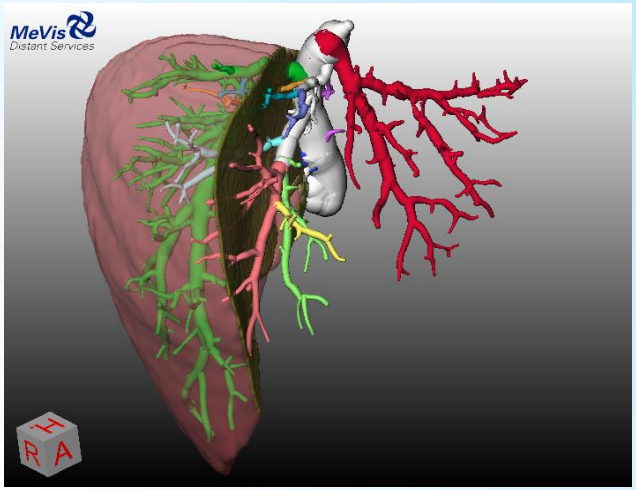
Resection Planning1



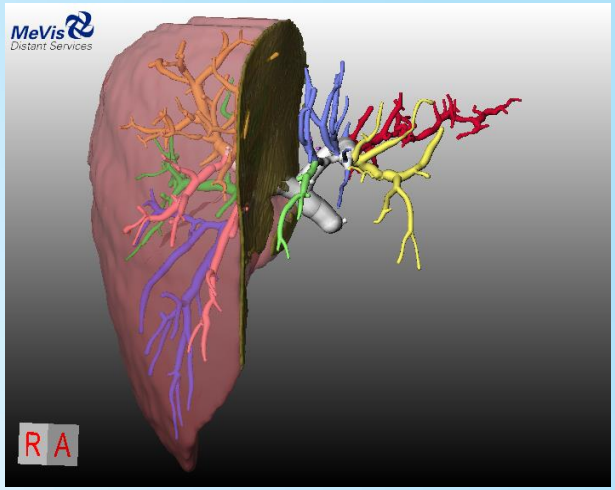
Resection Proposal 1: Leaving the Middle Hepatic Vein with the Donor

Vascular Territory	Volume (in ml)	(relative) (% of total)
Graft	1062	(61.4%)
Remnant	655	(37.8%)
Resection Plane	15	(0.9%)
Total	**1732**	**(100.0%)**

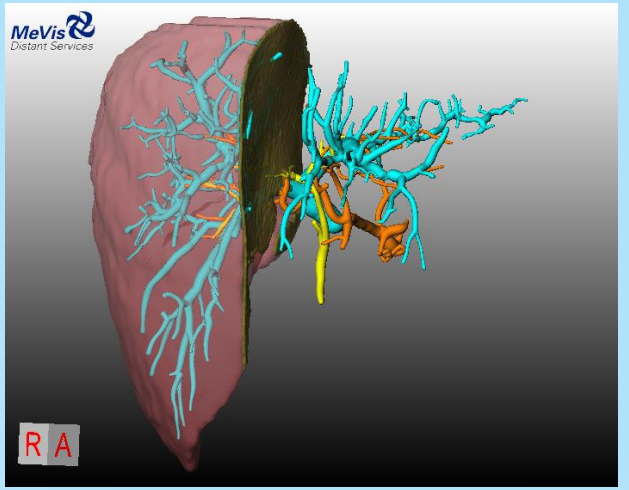
Resection Planning1



A typical resection proposal is shown with the resection surface to the right of the middle hepatic vein. The graft is displayed together with the hepatic veins.

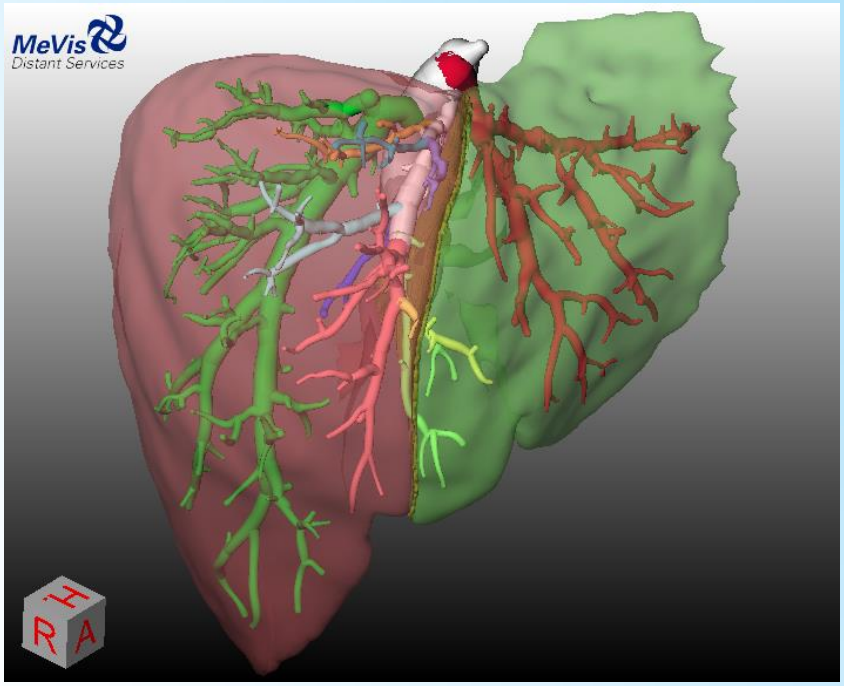


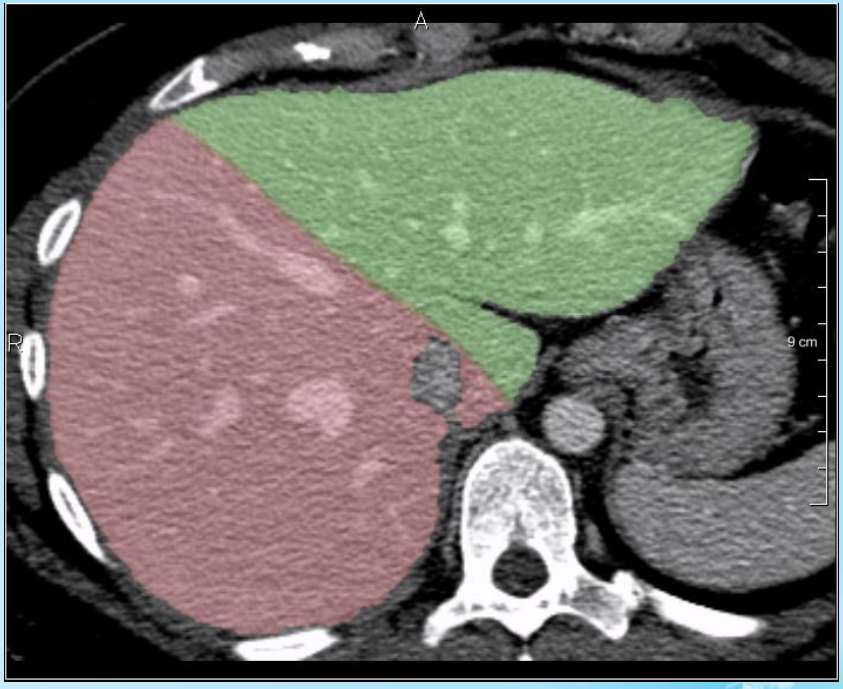
The same resection proposal is shown with the portal vein. No major branches except for the right portal vein will have to be transected according to this proposal.



The graft is shown together with the portal vein, the hepatic arteries, and the bile ducts.

Resection Planning 2





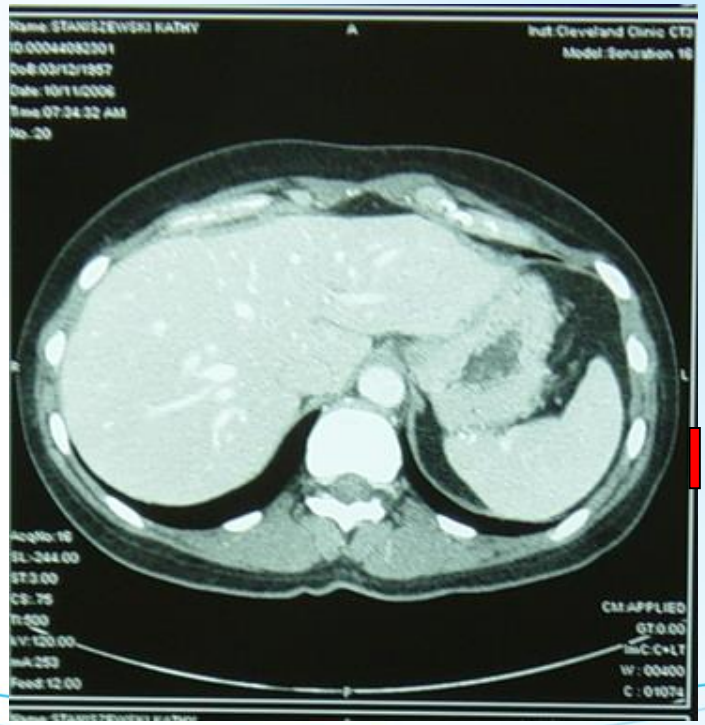
Resection Proposal 2: Including the Middle Hepatic Vein in the Graft

Vascular Territory	Volume (in ml)	(relative) (% of total)
Graft	1245	(71.9%)
Remnant	473	(27.3%)
Resection Plane	14	(0.8%)
Total	**1732**	**(100.0%)**

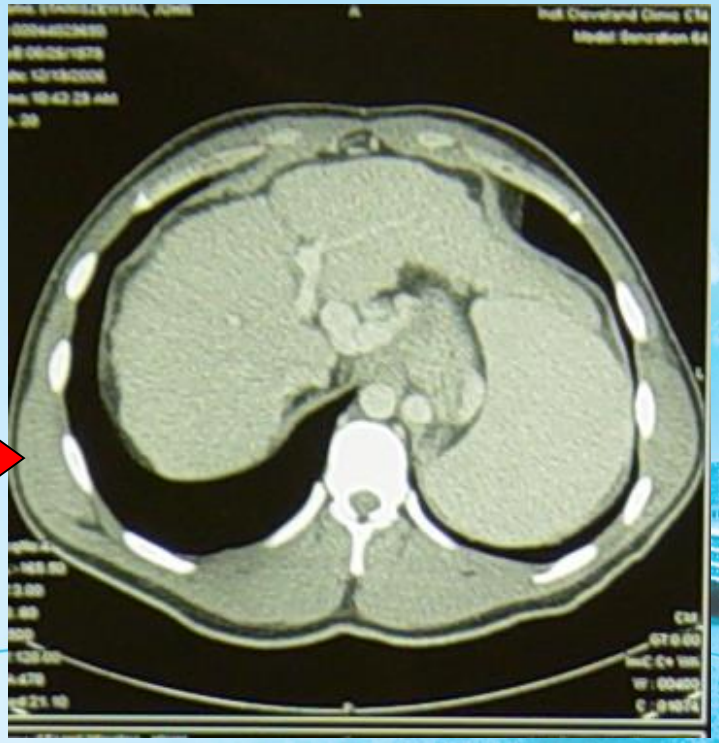
Case report (video)

living donor liver transplantation

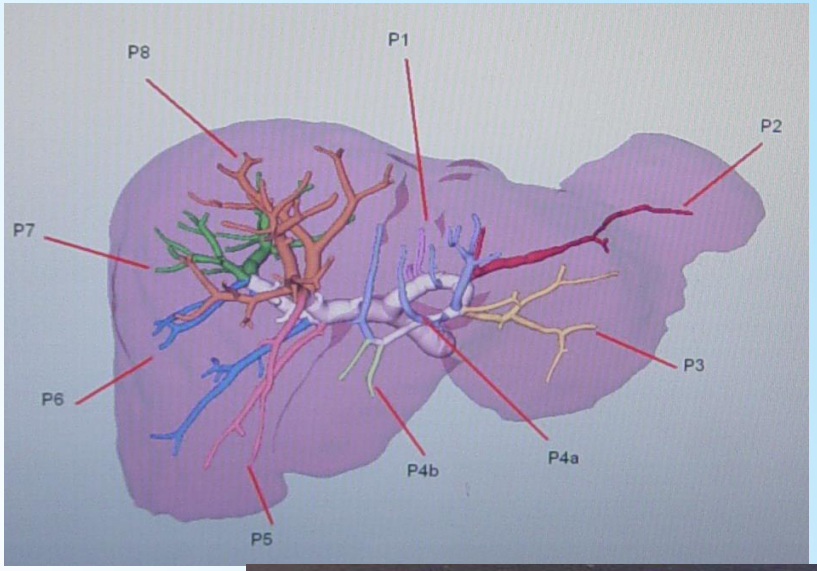
Donor

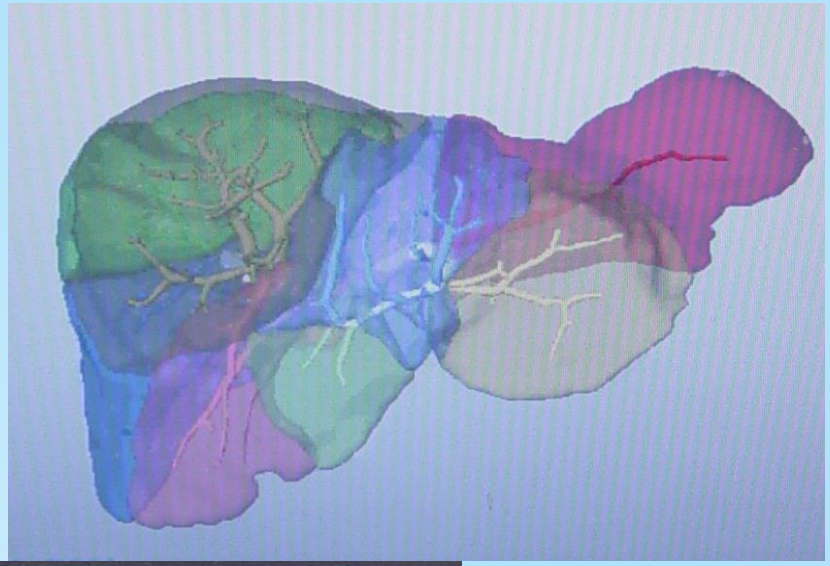


Recipent



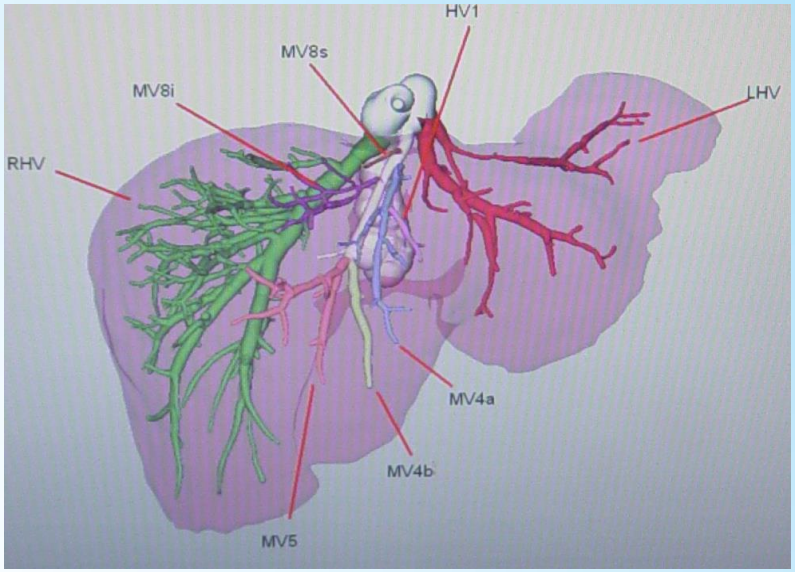
Portal vein system

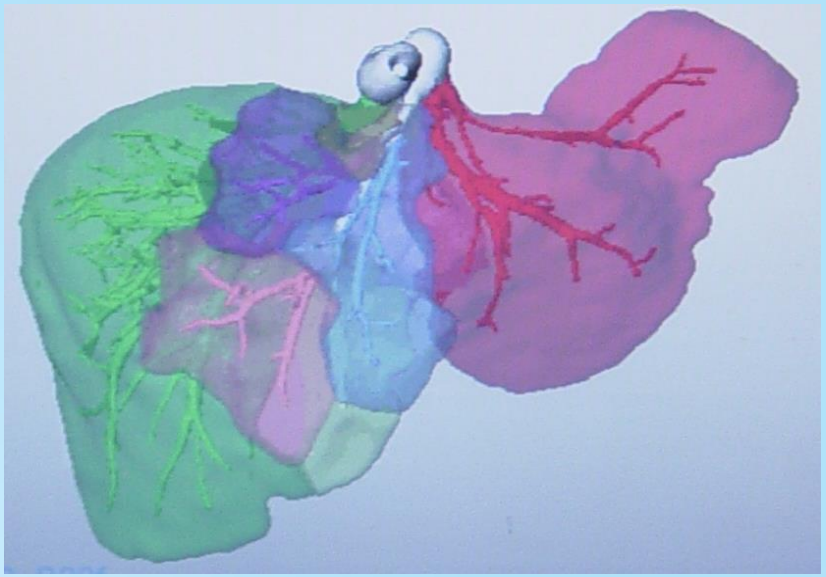




Territory	Volume (in ml)	(relative) (% of total)
P1	38	(3.4%)
P2	117	(10.5%)
P3	90	(8.1%)
P4a	112	(10.0%)
P4b	35	(3.2%)
P5	72	(6.4%)
P6	147	(13.2%)
P7	194	(17.4%)
P8	308	(27.7%)
Total	1112	(100.0%)

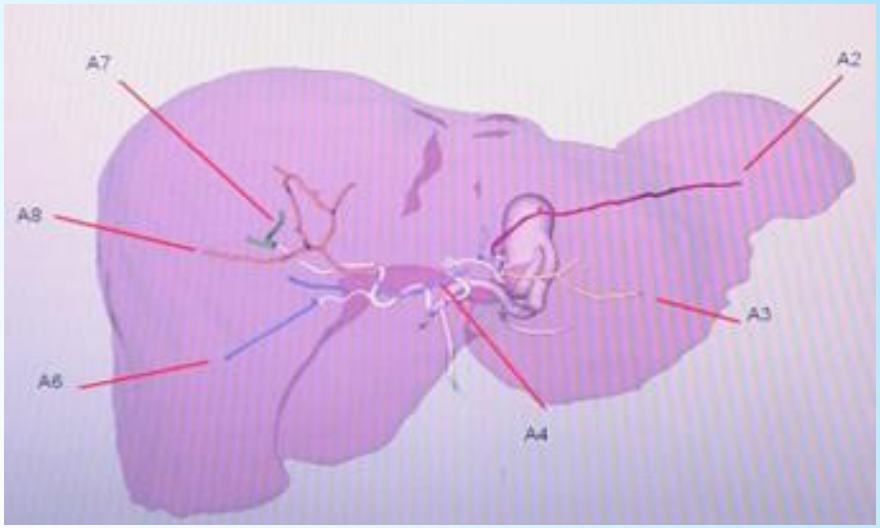
Hepatic vein system

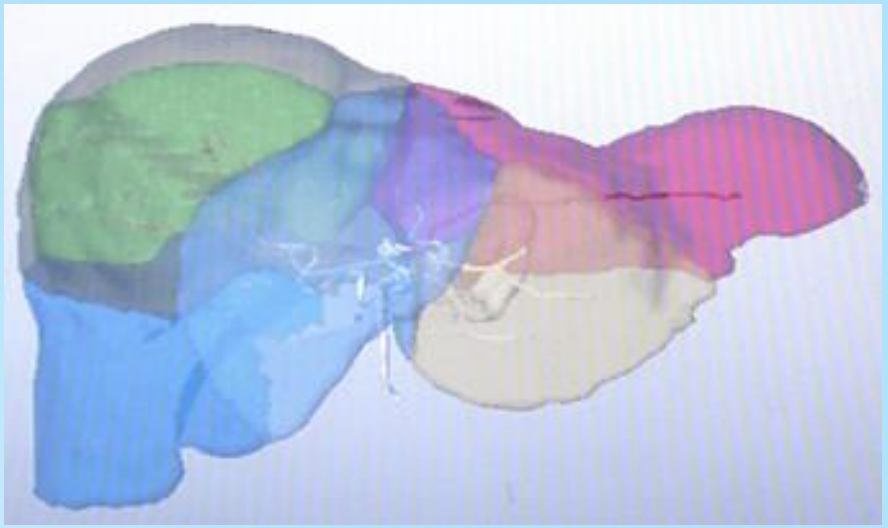




Territory	Volume (in ml)	(relative) (% of total)
HV1	29	(2.6%)
LHV	236	(21.3%)
MV4a	69	(6.2%)
MV4b	30	(2.7%)
MV5	74	(6.6%)
MV8i	56	(5.0%)
MV8s	8	(0.7%)
RHV	610	(54.9%)
Total	1112	(100.0%)

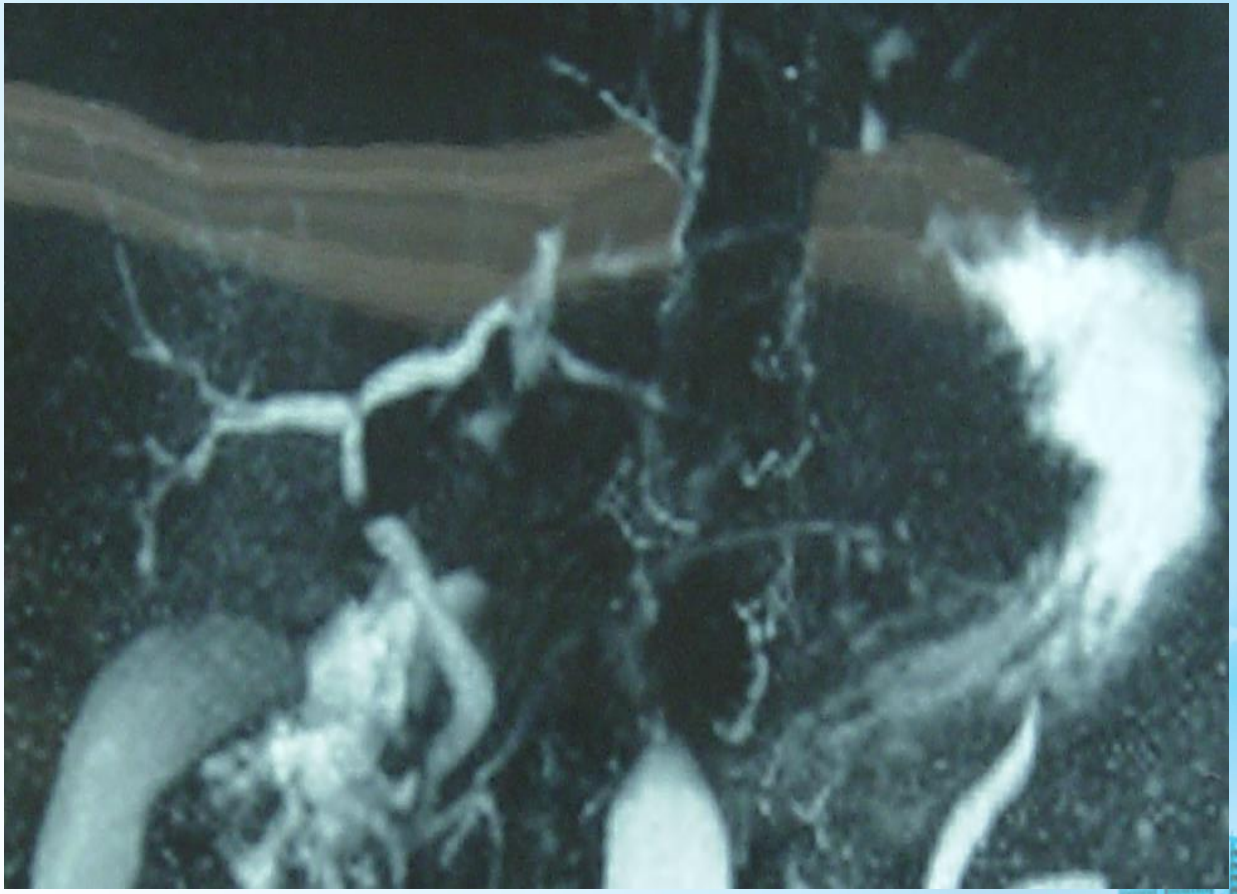
Bile duct image



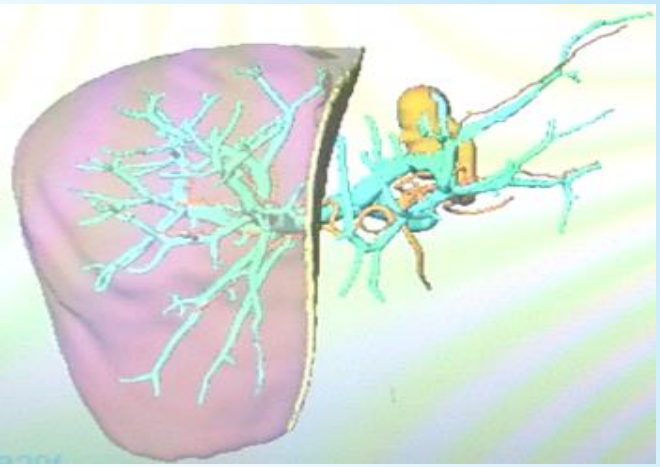


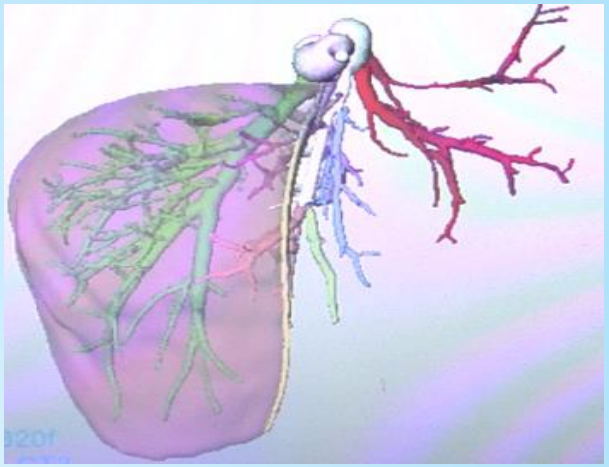
Territory	Volume (in ml)	(relative) (% of total)
A2	151	(13.6%)
A3	86	(7.7%)
A4	129	(11.6%)
A6	176	(15.9%)
A7	196	(17.6%)
A8	374	(33.6%)
Total	1112	(100.0%)

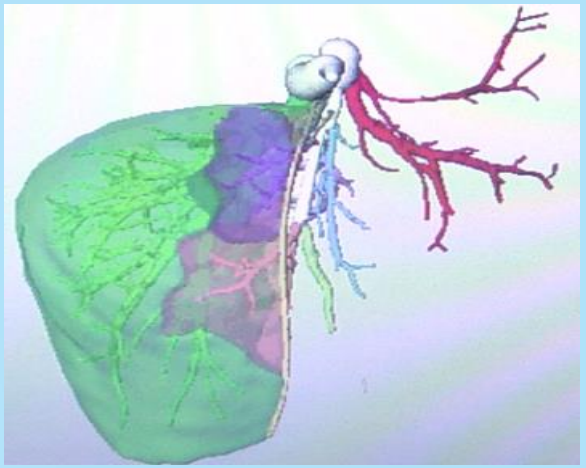
Bile duct image--- X ray



Cutting plan 1



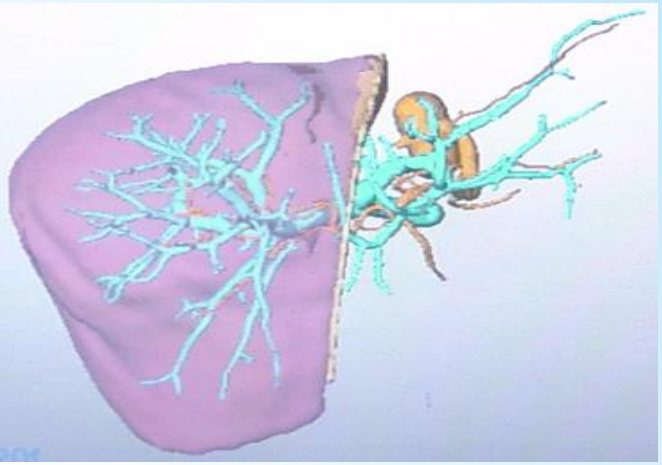


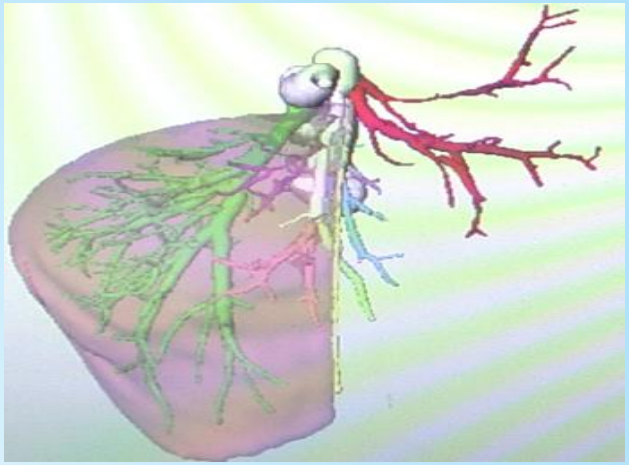


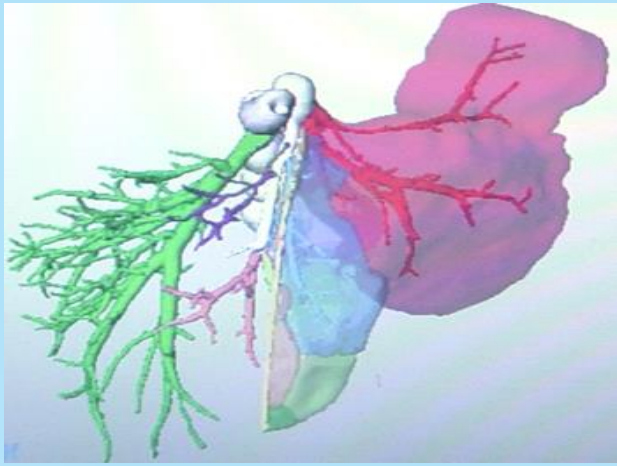
Territory	Volume (in ml)	(relative) (% of total)
HV1	1	(0.1%)
MV4b	1	(0.1%)
MV5	53	(7.5%)
MV8i	47	(6.6%)
MV8s	2	(0.3%)
RHV	607	(85.4%)
Total	711	(100.0%)

Volumes	Volume (in ml)	(relative) (% of total)
Graft	711	(63.9%)
Remnant	392	(35.2%)
Cutting Plane	10	(0.9%)
Total	1113	(100.0%)

Cutting plan 2







Territory	Volume (in ml)	(relative) (% of total)
HV1	23	(6.8%)
LHV	236	(70.2%)
MV4a	50	(14.9%)
MV4b	22	(6.5%)
MV5	4	(1.2%)
RHV	1	(0.3%)
Total	336	(100.0%)

Volumes	Volume (in ml)	(relative (% of total)
Graft	768	(69.1%)
Remnant	335	(30.1%)
Cutting Plane	9	(0.8%)
Total	1112	(100.0%)

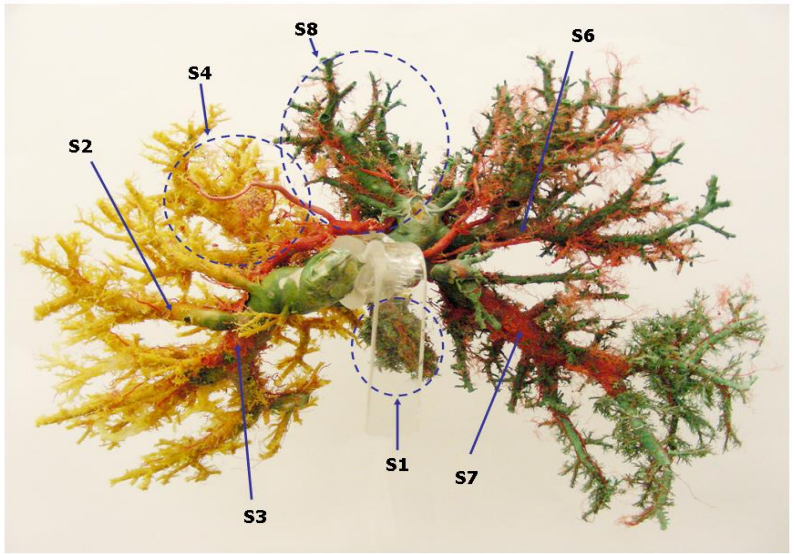

VIDEO

厦门大学附属中山医院
ZHONGSHAN HOSPITAL XIAMEN UNIVERSITY

3. 3D liver image system and liver tumor resection

The technique of 3D liver image

Case report (video)



XMQB-Liver 肝癌手术模拟系统

XMQB Liver 系统

中华人民共和国
PEOPLE'S REPUBLIC OF CHINA
医疗器械注册证
REGISTRATION CERTIFICATE FOR MEDICAL DEVICE

注册号：闽食药监械（准）字 2011 第 2700065 号

厦门强本科技有限公司：

你单位生产的肝癌手术模拟软件（型号规格：XMQB-Liver V2.0），经审查，符合医疗器械产品市场准入规定，准许注册。

自批准之日起有效期四年。

特此证明。

二〇一一年八月二十九日

注册专用章

附件：医疗器械注册登记表

No.1009386

证书号第726537号

发明专利证书

发明名称：基于CT增强扫描技术的肝脏分段体积测量方法

发明人：王博亮；黄晓阳；黄绍辉

专利号：ZL 2009 1 0112112.5

专利申请日：2009年07月02日

专利权人：厦门强本科技有限公司；厦门大学

授权公告日：2011年01月12日

本发明经过本局依照中华人民共和国专利法进行审查，决定授予专利权，颁发本证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。

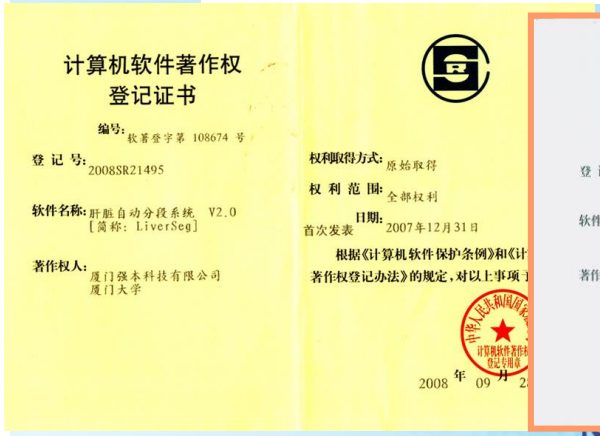
本专利的专利权期限为二十年，自申请日起算。专利权人应当依照专利法及其实施细则规定缴纳年费。本专利的年费应当在每年07月02日前缴纳。未按照规定缴纳年费的，专利权自应当缴纳年费期满之日起终止。

专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长 田力普

2011年01月12日

第1页（共1页）



计算机软件著作权登记证书

编号：软著登字第 108674 号

登记号：2008SR21495

软件名称：肝脏自动分段系统 V2.0 [简称：LiverSeg]

著作权人：厦门强本科技有限公司 厦门大学

权利取得方式：原始取得

权利范围：全部权利

首次发表日期：2007年12月31日

根据《计算机软件保护条例》和《计

著作权登记办法》的规定，对以上事项

2008 年 09 月

计算机软件著作权登记证书

编号：软著登字第 120050 号

登记号：2008SR32871

软件名称：数字化虚拟肝脏及治疗计划系统 V2.0 [简称：Liver]

著作权人：厦门大学 厦门强本科技有限公司

权利取得方式：原始取得

权利范围：全部权利

首次发表日期：2007年12月31日

根据《计算机软件保护条例》和《计算机软件著作权登记办法》的规定，对以上事项予以登记。

2008 年 12 月 08 日

The technique of 3D liver image

3D Image System Based on CT-Scan

CT Data Parameters:

- Slice thickness 2.5 mm, reconstruction interval1.25 mm
- Contrast: 180 ml non-ionic contrast agent, injection rate 6 ml/s
- Contiguous slices covering the whole organ
- Data in DICOM format
- No breathing artifacts or movement of the patient
- All phases are acquired at a similar breathing position
- Minimal or no beam hardening artifacts or artifacts due to foreign bodies such as stents or drains
- Resolution in plane (x and y) <= 1.0 mm

Imaging Parameters

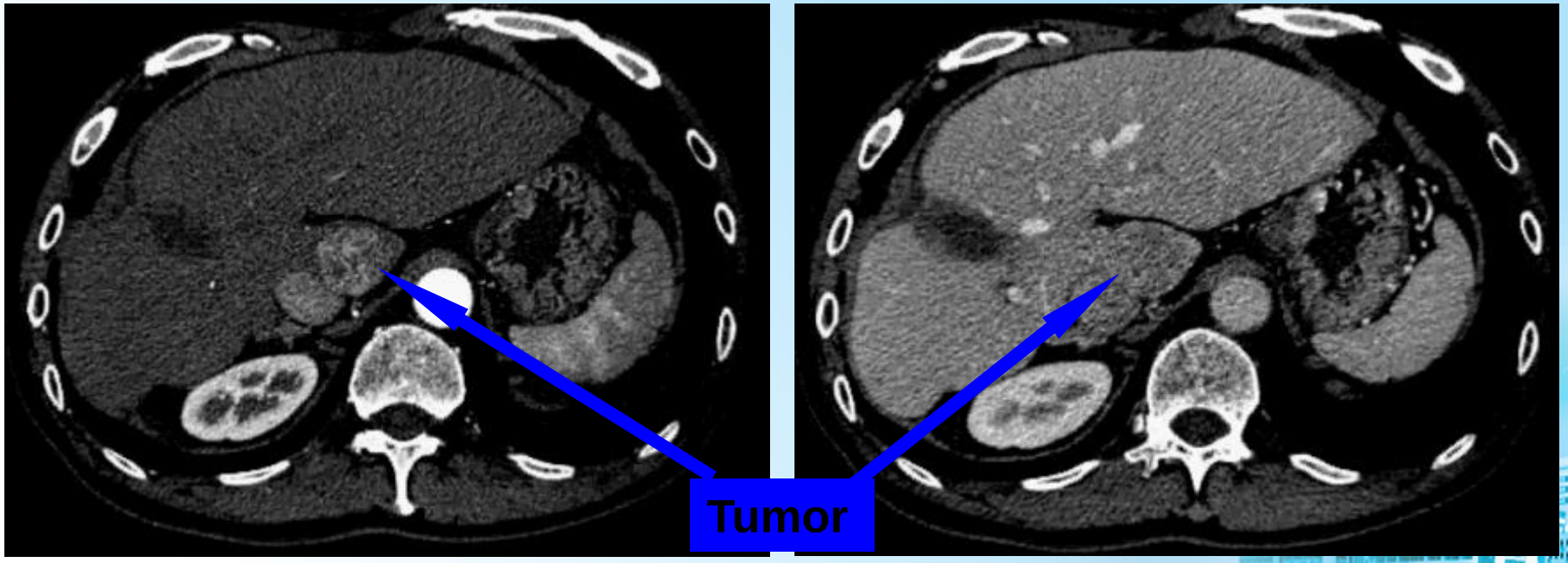
- Contiguous slices covering the whole organ
- Data in DICOM format
- Gantry-Tilt: No tilt
- No breathing artifacts or movement of the patient
- All phases are acquired at a similar breathing position
- Minimal or no beam hardening artifacts or artifacts due to foreign bodies such as stents or drains
- Resolution in plane (x and y) <= 1.0 mm

Imaging Parameters

1. Slice Thickness <= 2.0 mm
2. Reconstruction Interval <=2.0 mm
3. Mean density in the main portal vein or a major hepatic vein at least 30 HU higher than mean density of liver parenchyma
4. Portal vein only slightly contrasted
5. Hepatic arteries or bile ducts not contrasted simultaneously

1. Slice Thickness <= 1.5 mm
2. Reconstruction Interval <=1.5 mm
3. Mean density in a main branch of the hepatic arteries at least 30 HU higher than mean density of liver parenchyma
4. Portal vein only slightly contrasted
5. Bile ducts not contrasted simultaneously

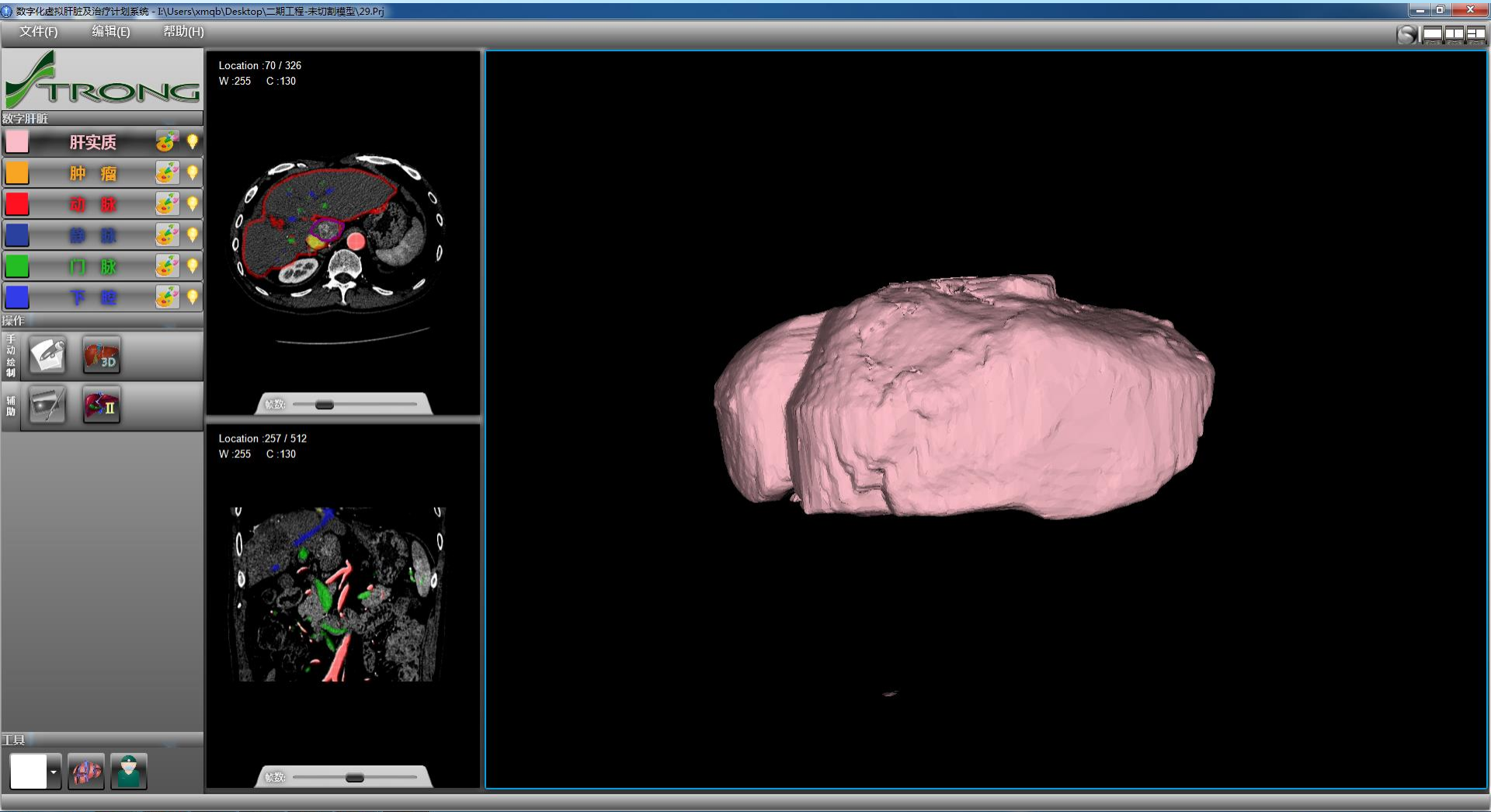
XMQB-Liver 3D Image System



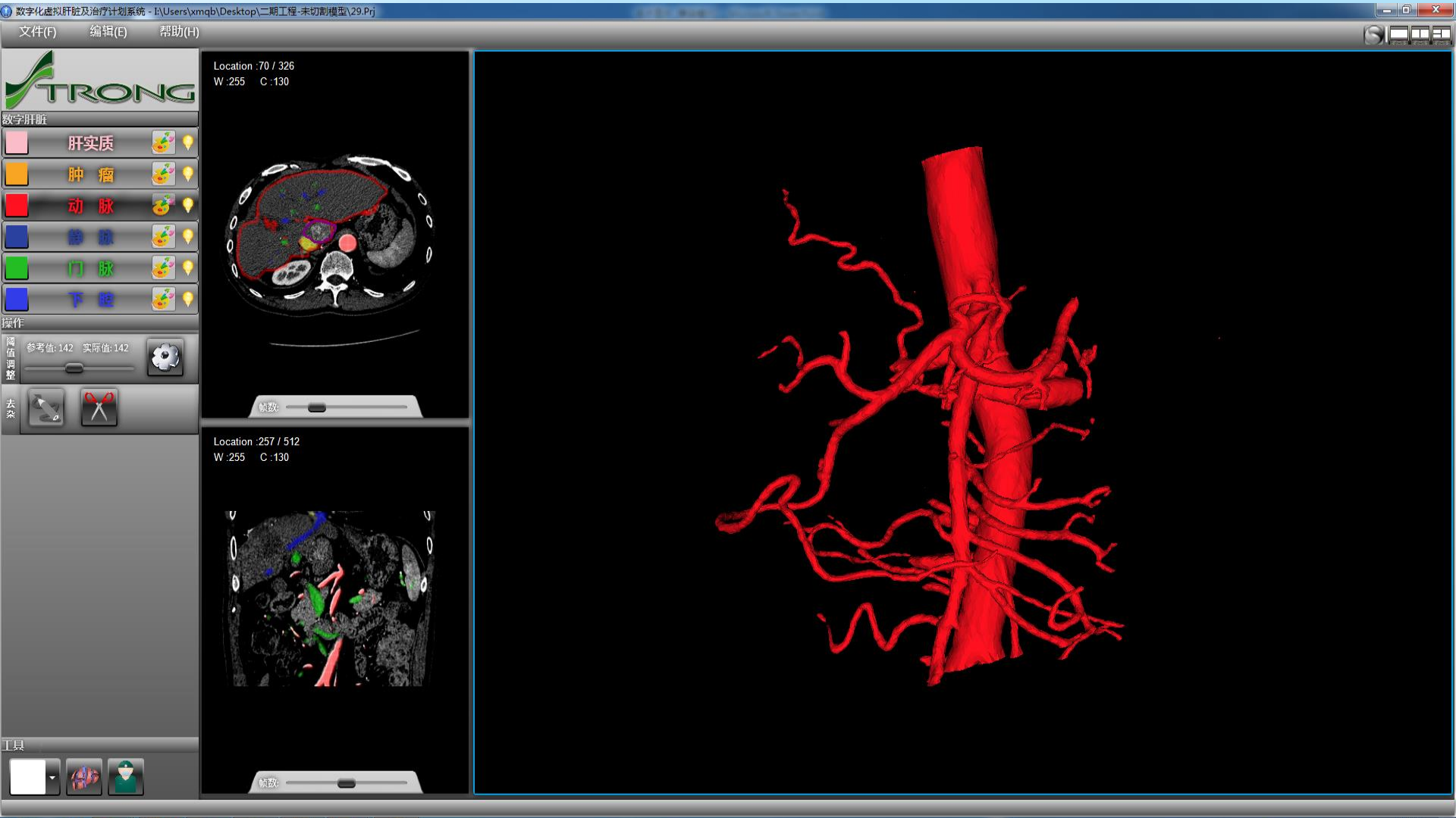
Arterial Phase

Venious Phase

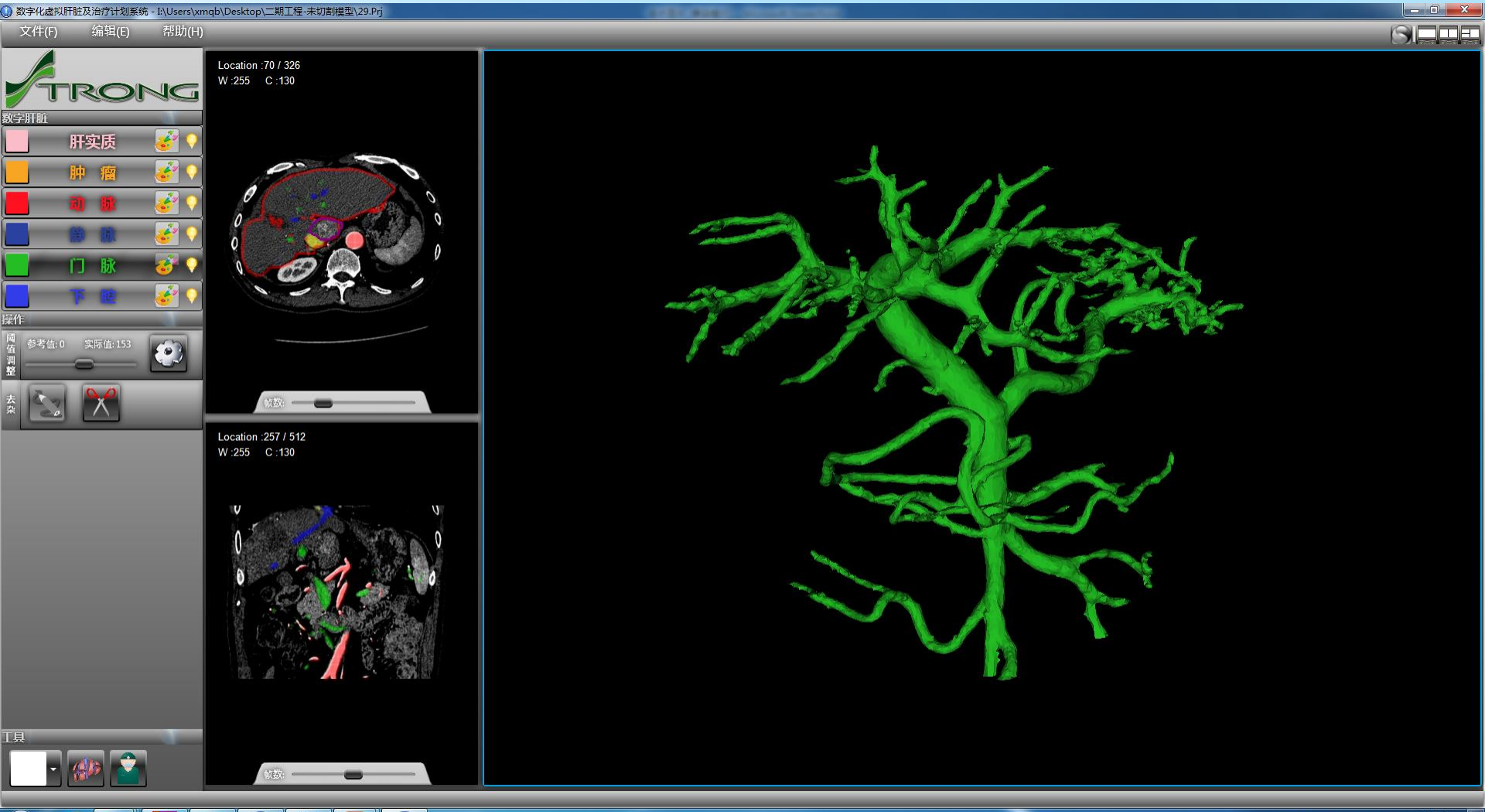
Step 1: Automatic Liver Dividing



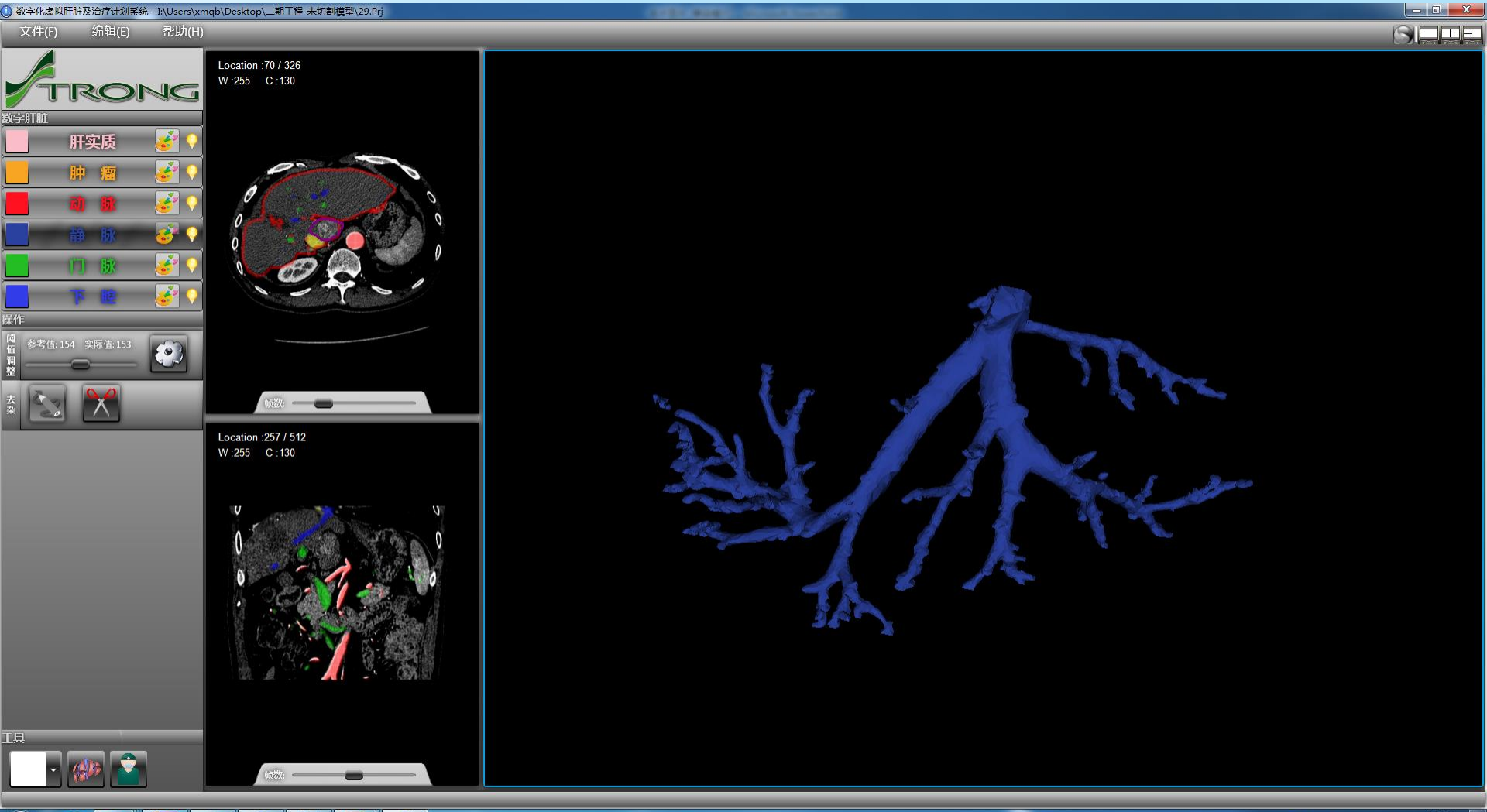
Step 2: Artery Harvest



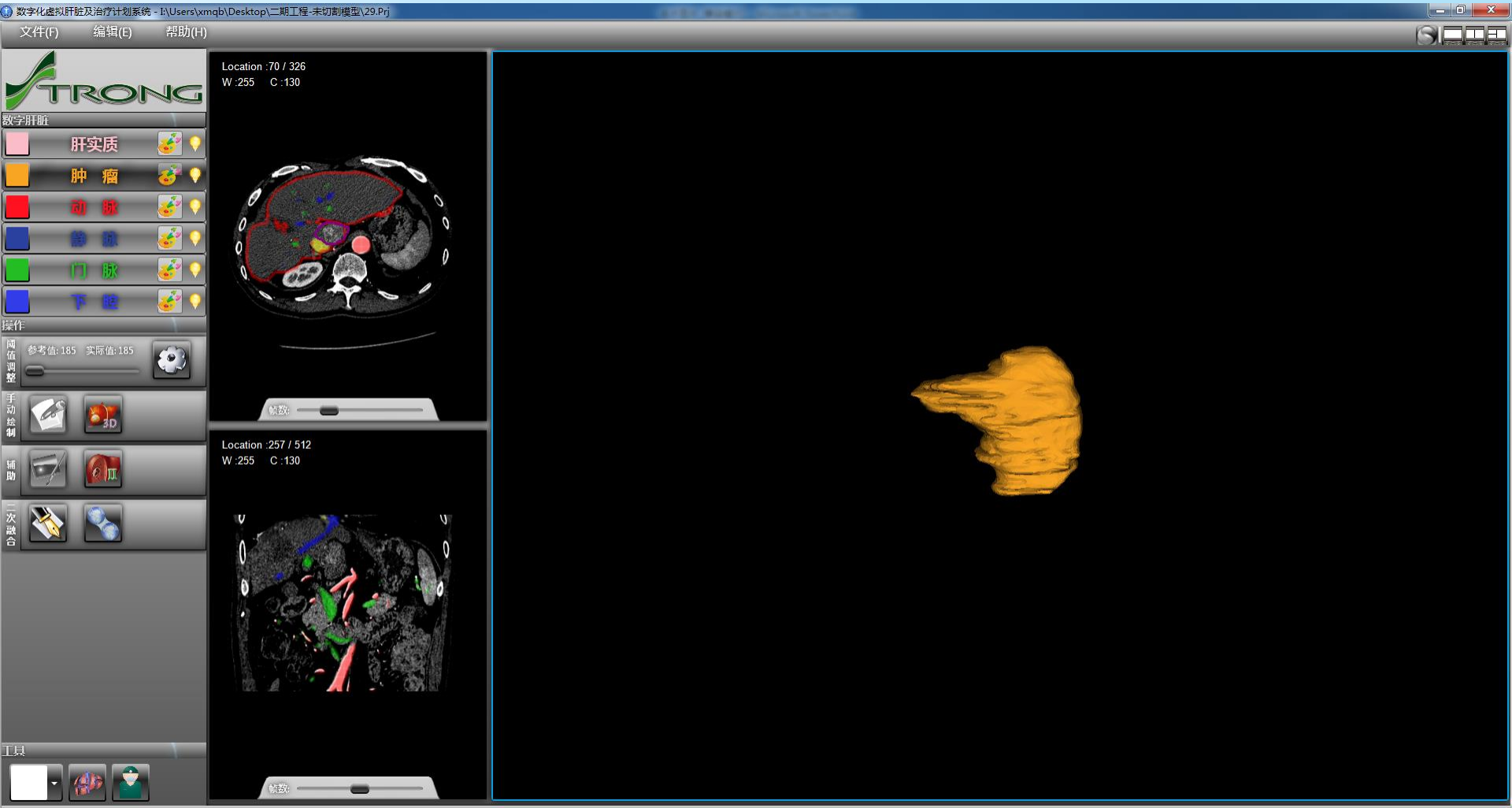
Step 3: Portal Vein Harvest



Step 4: Hepatic Vein Harvest



Step 5: Tumor Harvest

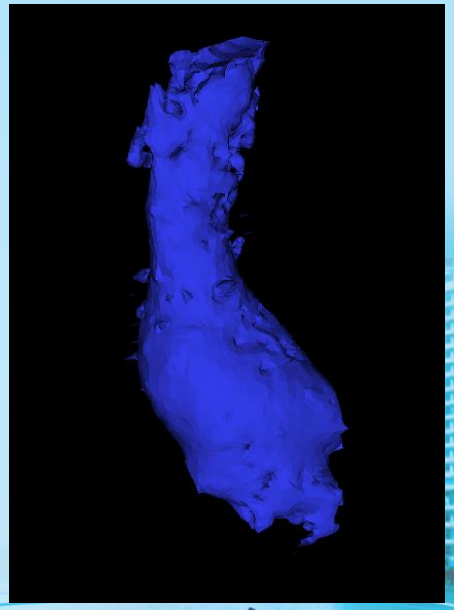


vessel and tumor

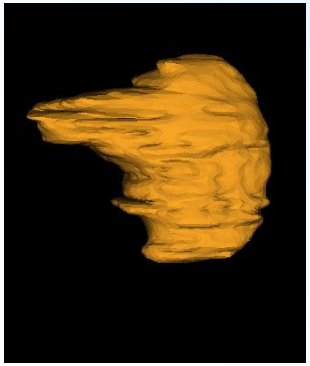
肝动脉

肝静脉

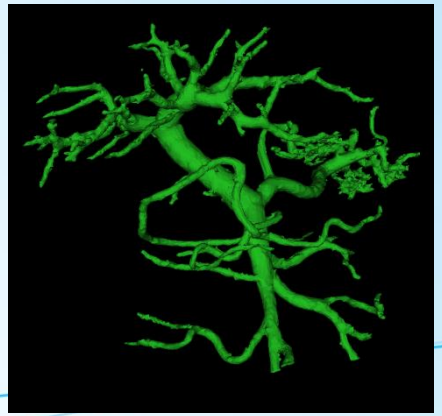
下腔静脉



肿瘤

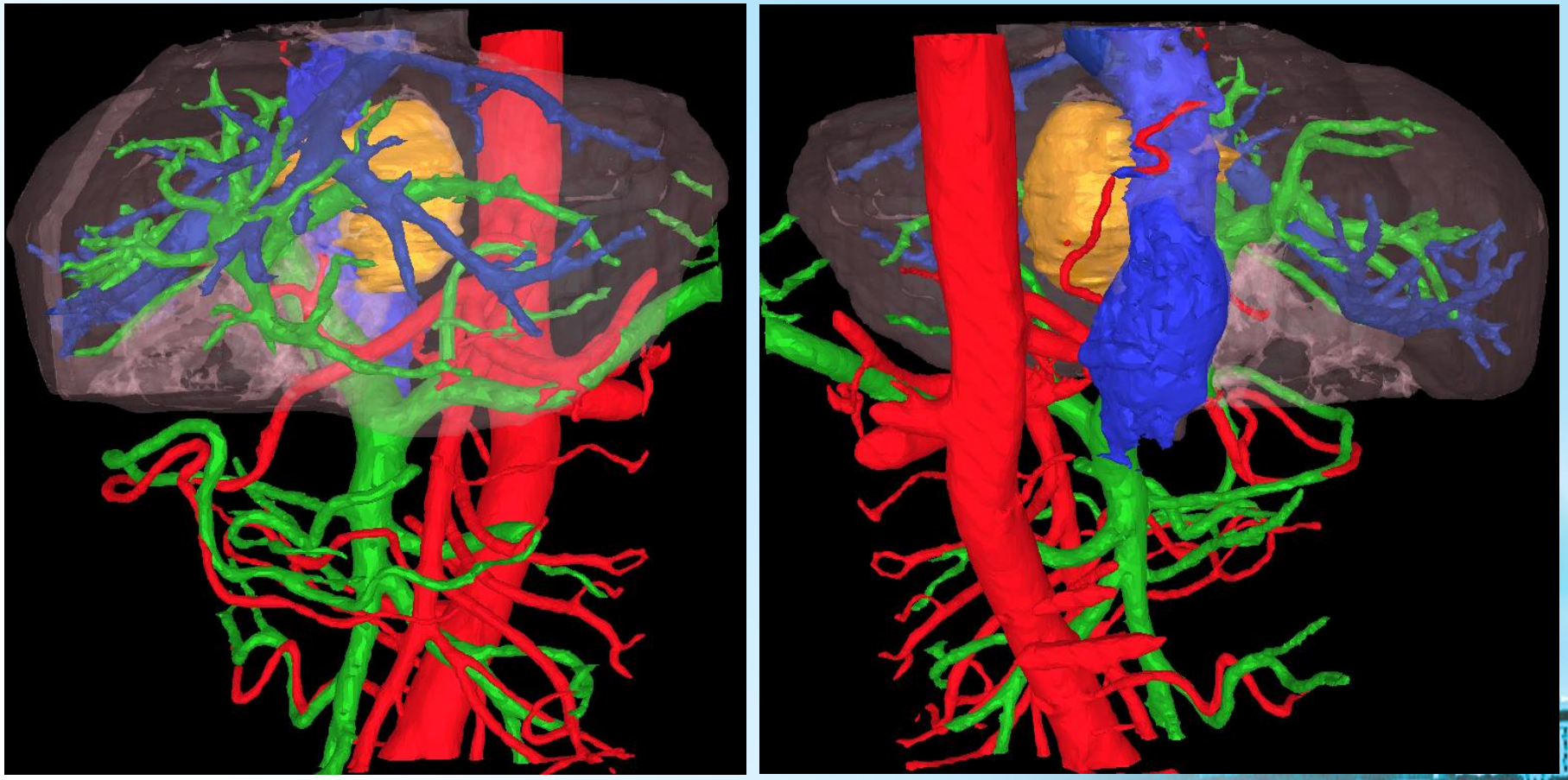


肝门脉

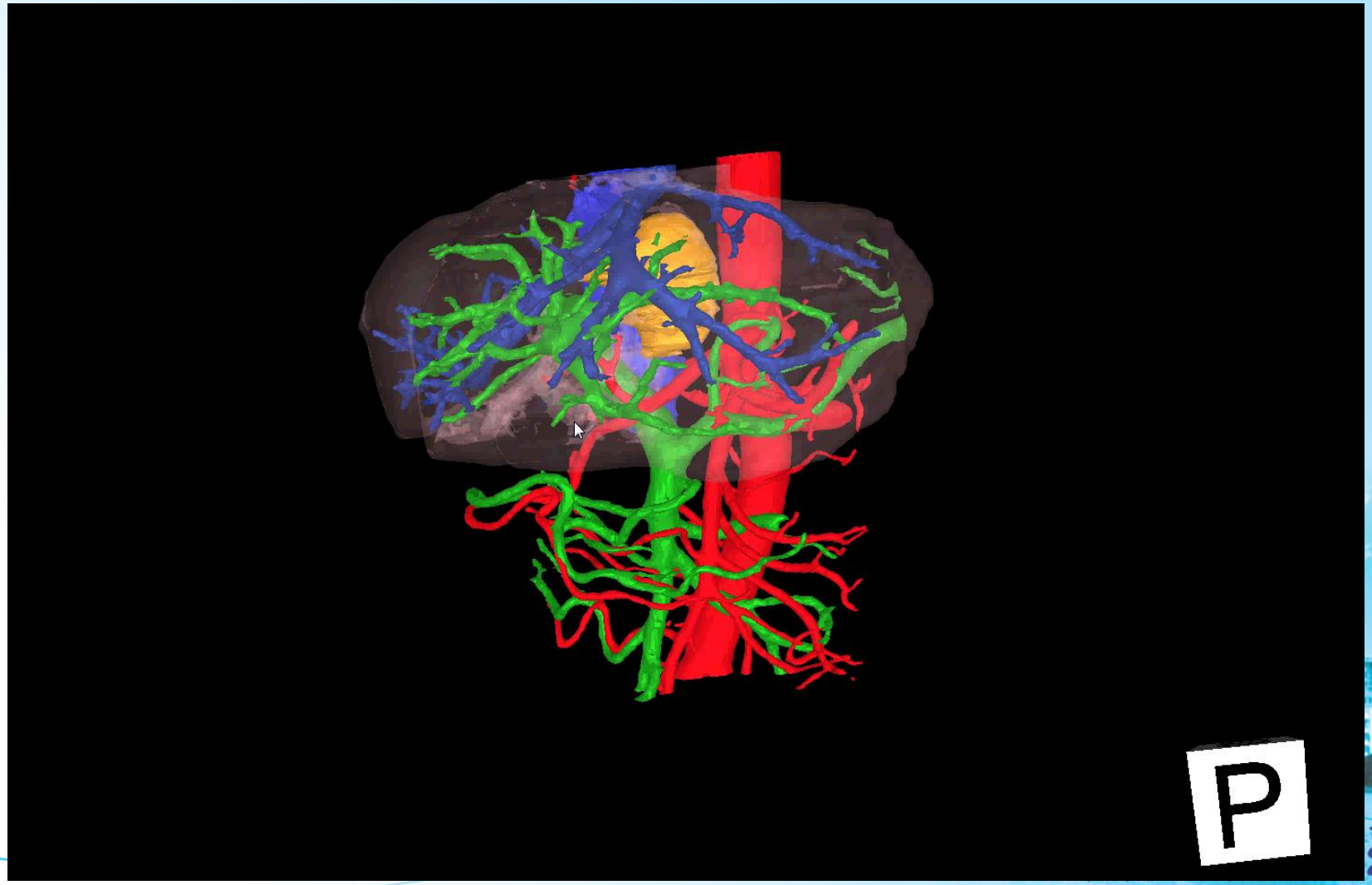


自强不息 厚德载物
STRONG

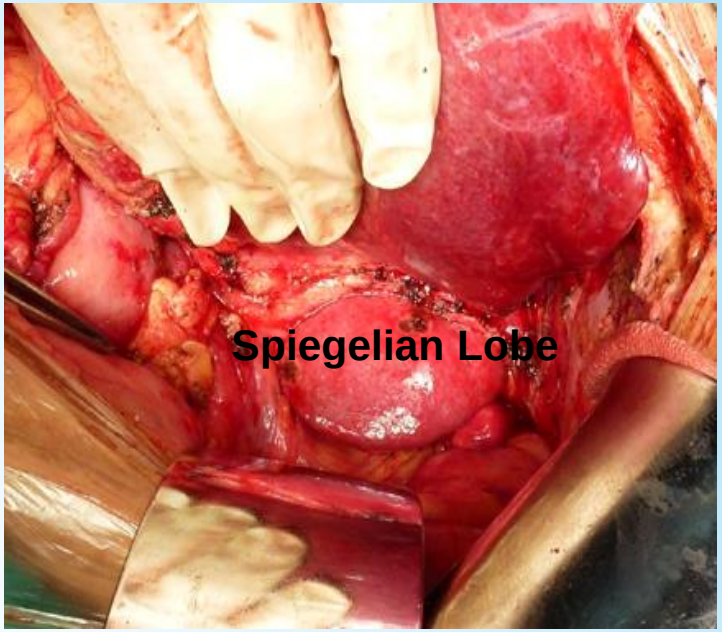
Mixed

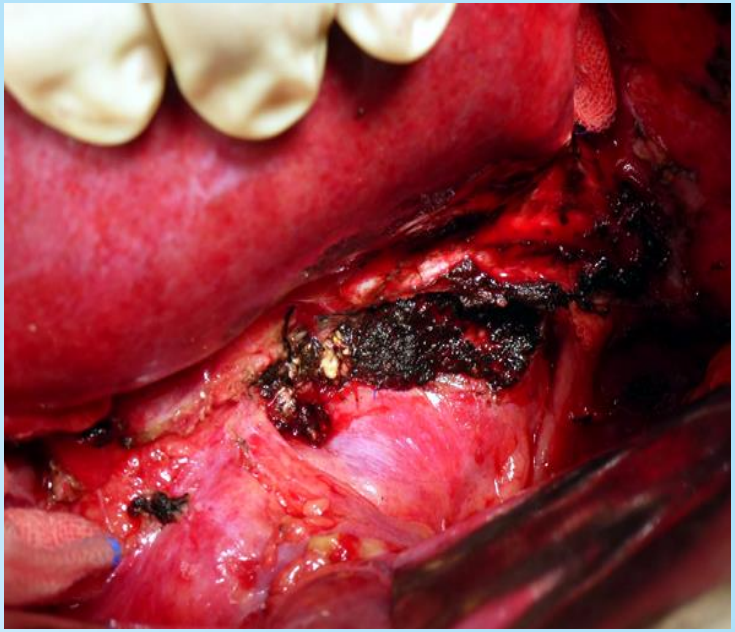


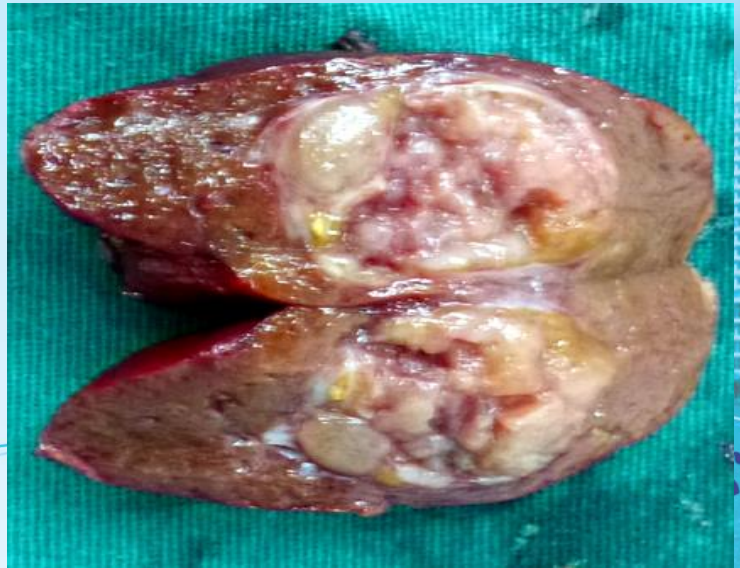
Mixed



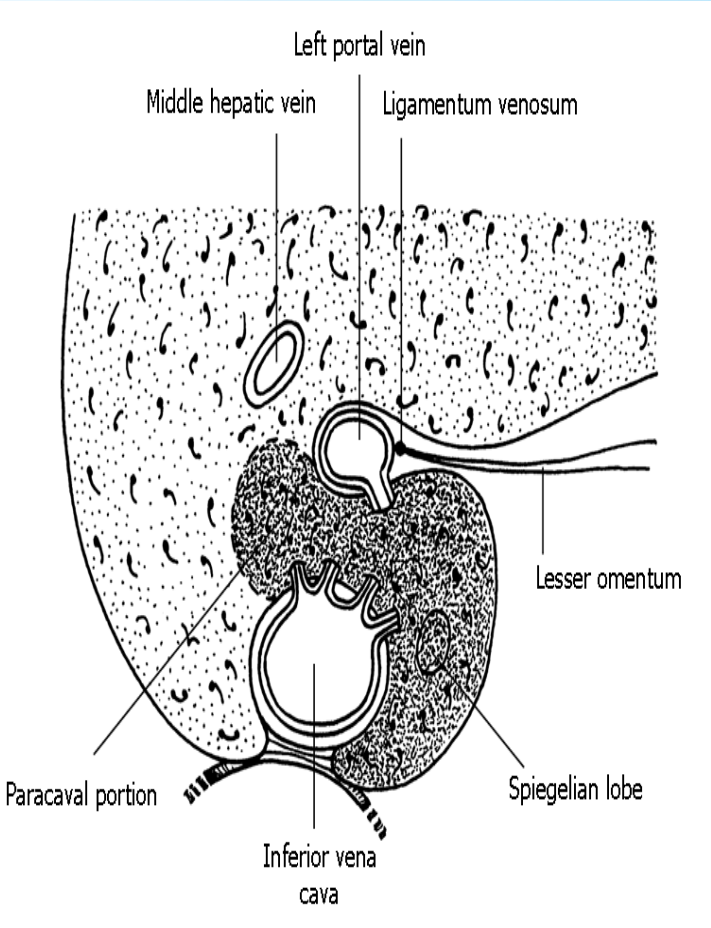
Operation Photo

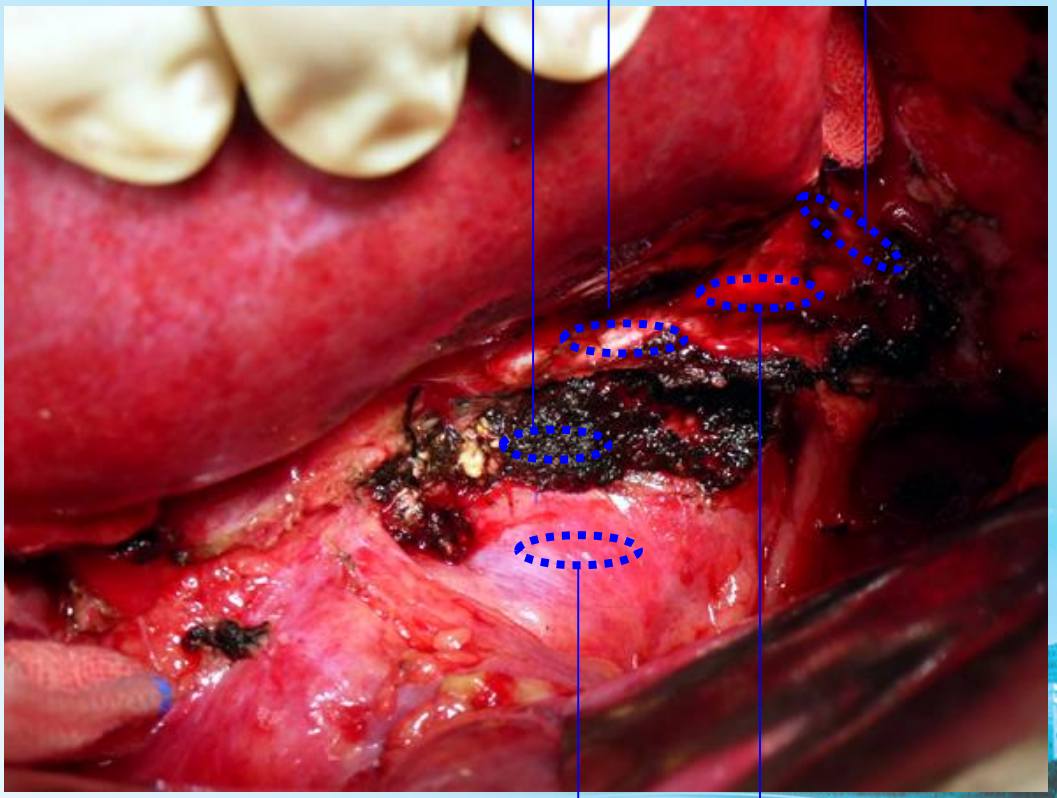




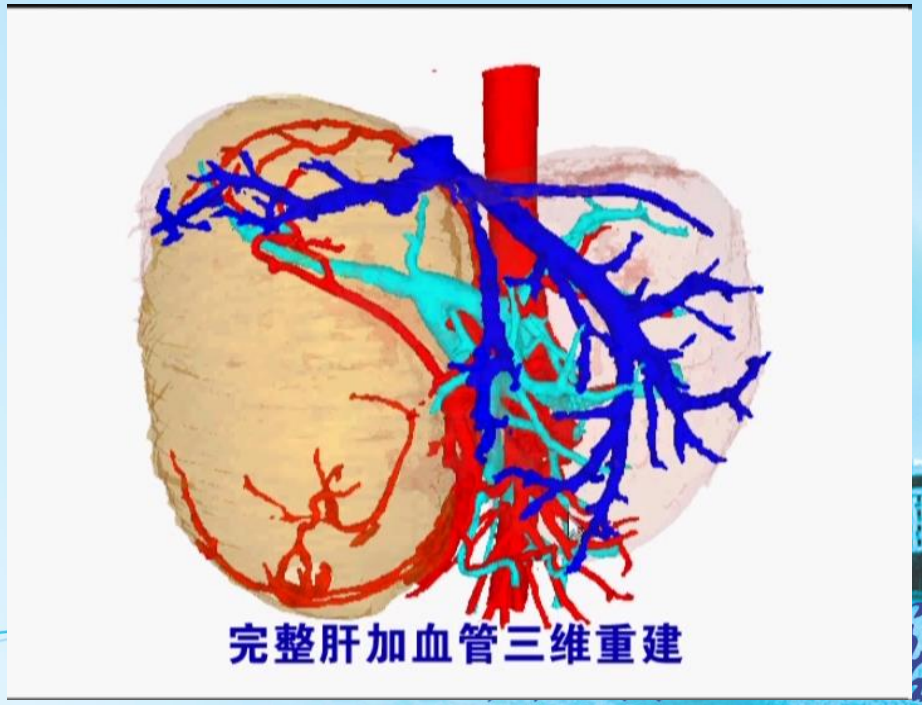


Operation Photo





Case report: Large HCC Resection (video)

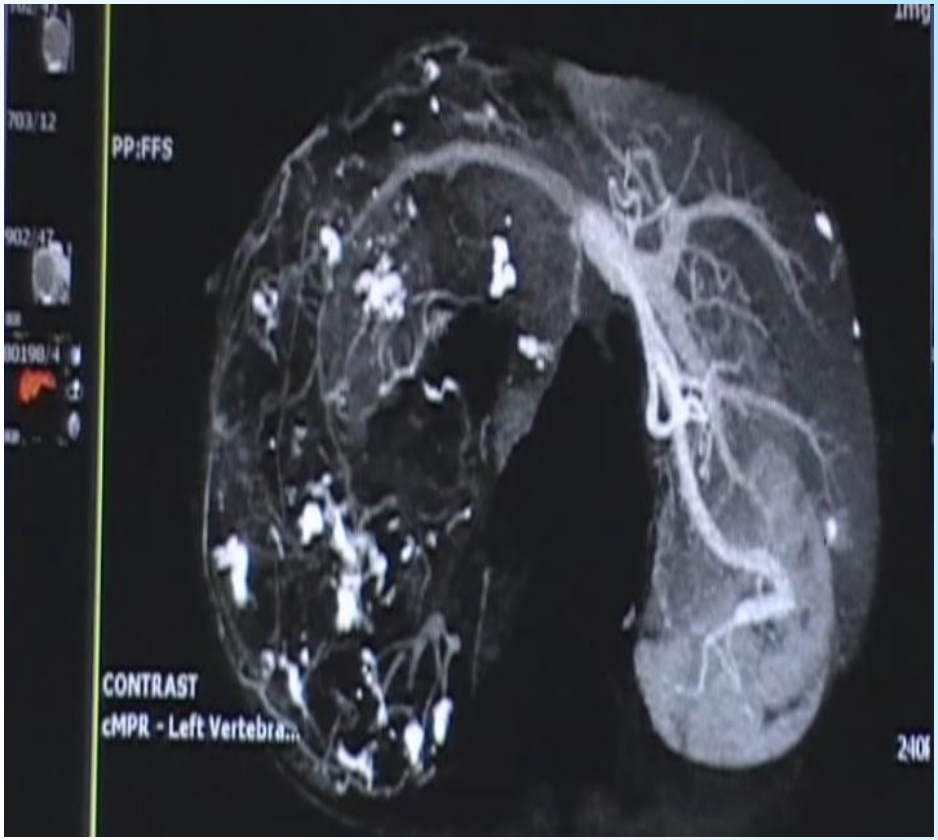


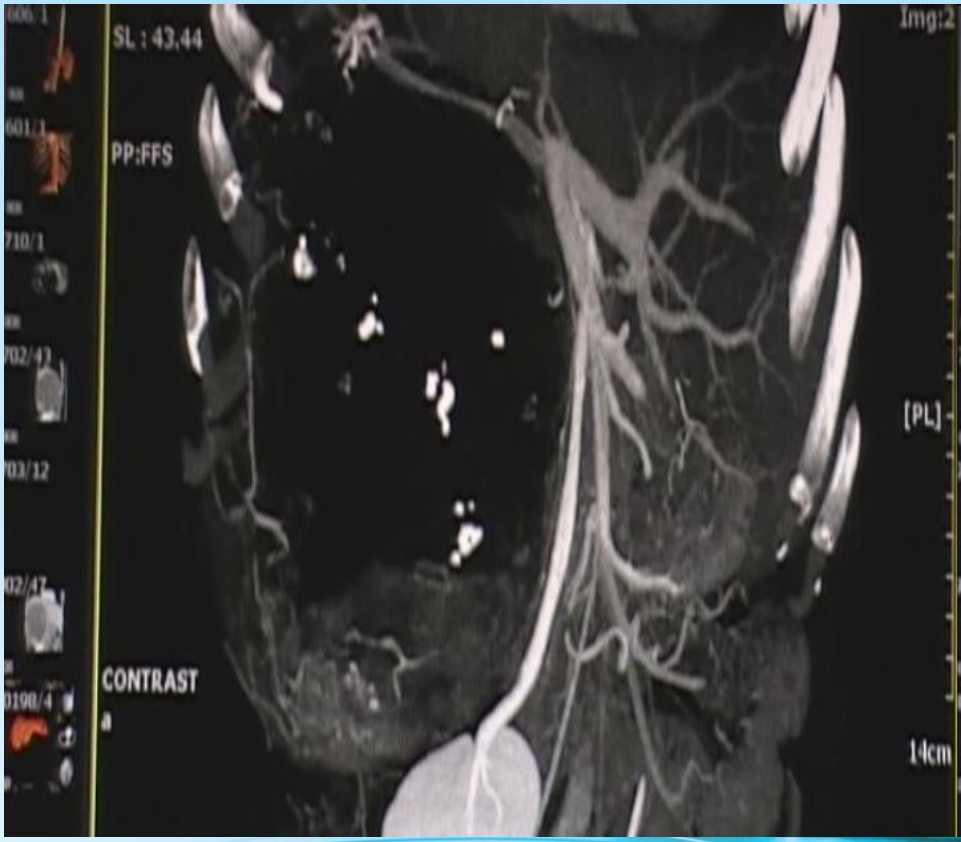
General Information

1. Male, 50yrs, No HBV history
2. HCG-15mins 7%; Child-Pugh:

   Grade A; MELD score:12
3. Normal Liver Function

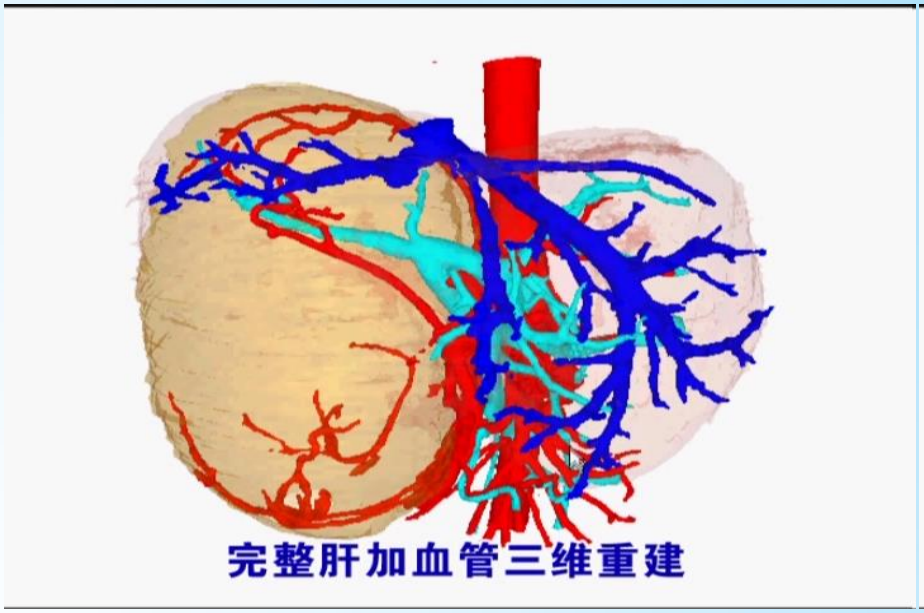
CT-A

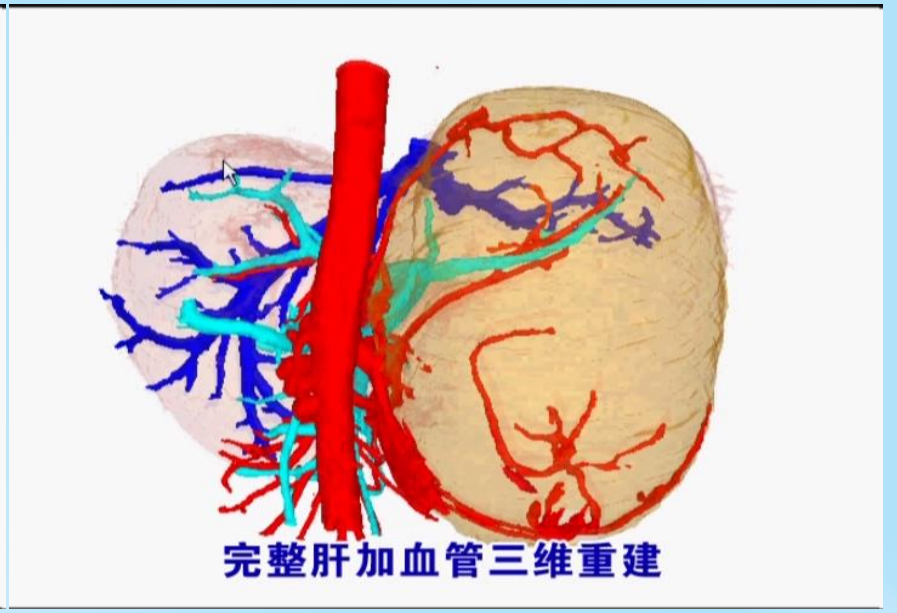


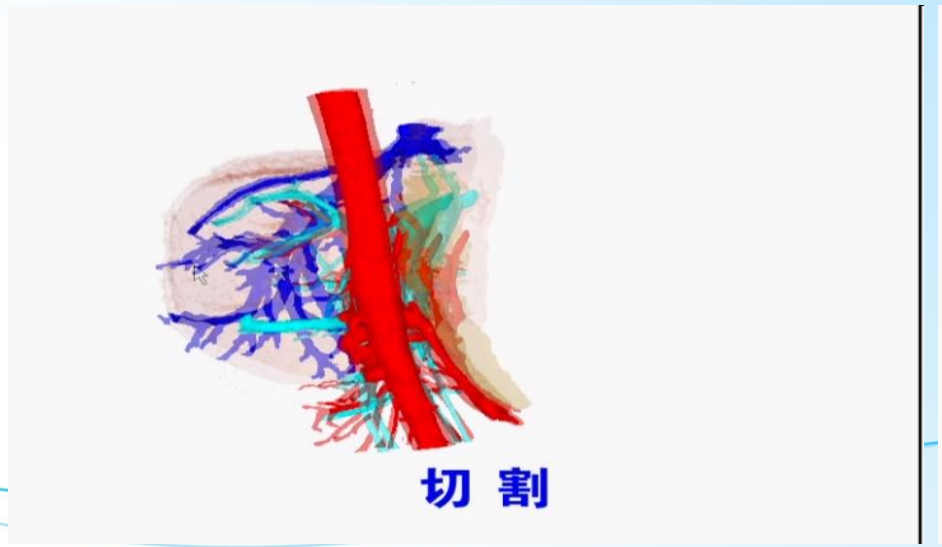


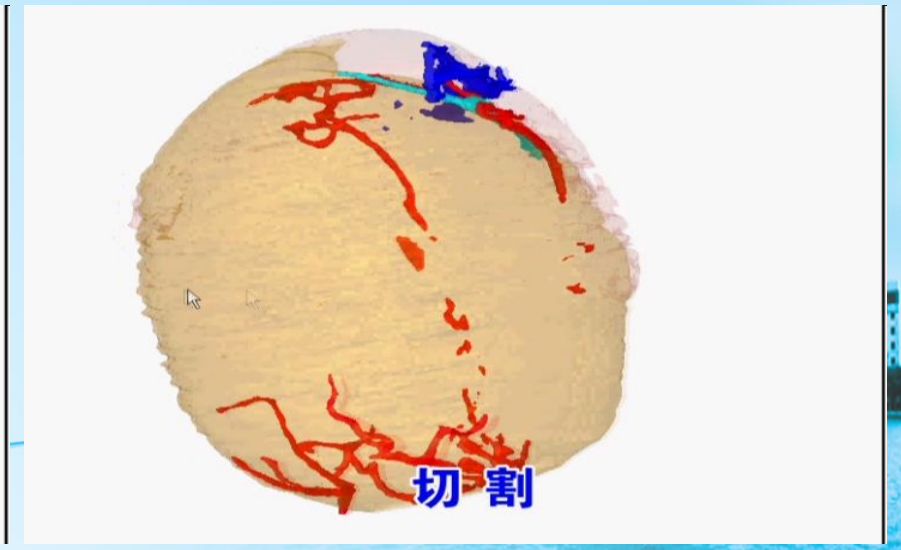
自强不息 心手至善

3D Image of the liver and tumor

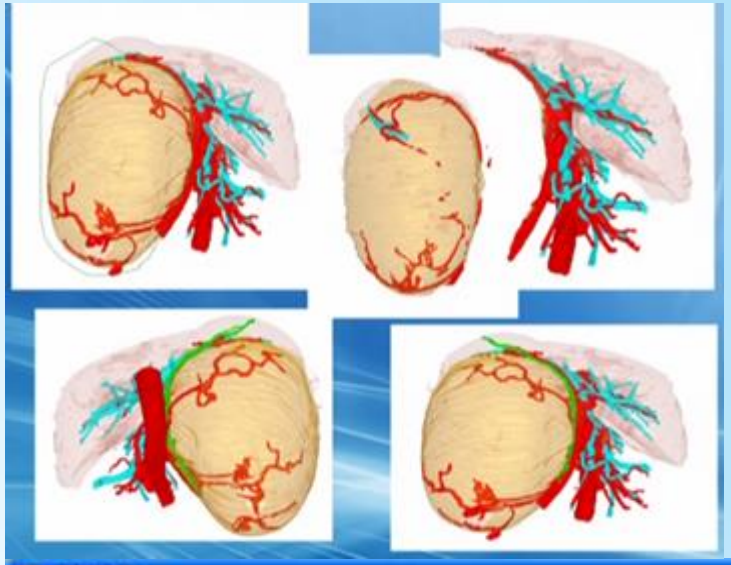








Resection and Risk Analysis



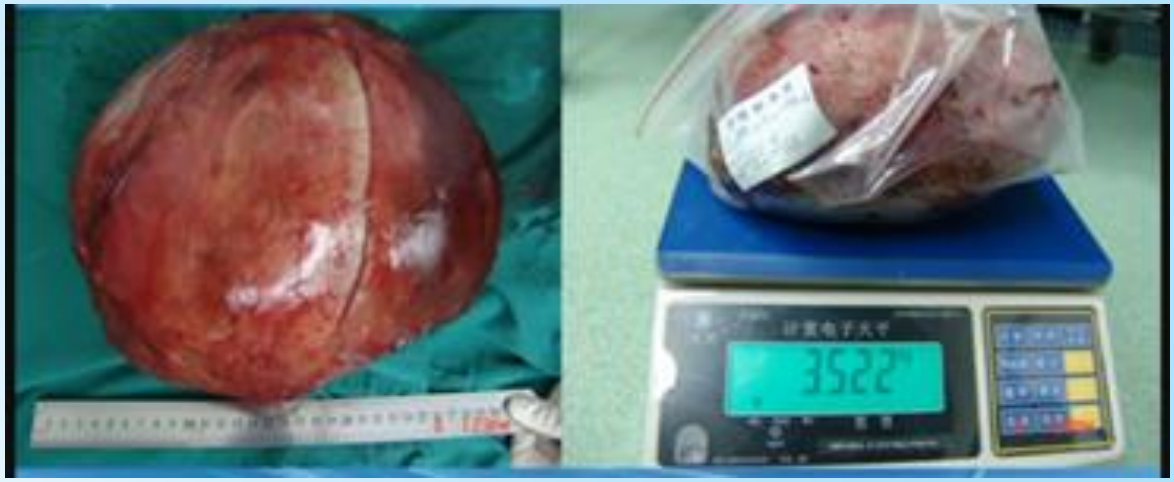
扩展度(mm)	体积(ml)	百分比(%)
0	3376.99668103409	73.66
1	3389.0919939909	73.92
2	3404.97953069687	74.27
3	3423.97739071083	74.69
4	3441.20817068481	75.06
5	3455.38898800564	75.37
6	3470.79057770061	75.71
7	3486.74022464561	76.05
8	3499.58217265892	76.33
9	3511.75665430069	76.60

剩余部分：3377/0.7366-3511=1073.6(ml)


VIDEO

The Tumor

size



weight

pathology

Summary

- 在现代医学理论和现代技术条件支持下的精准肝脏切除术是一种采用最小的创伤侵袭、最大保存肝脏组织并获取最佳治疗效果的肝脏外科技术。
- 采用3D成像技术可以有效地将肝脏二维局部平面图像以三维整体立体结构清楚呈现，为精准肝脏切除手术的术前计划、安全评估提供重要的保证。

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Thank you !