

07.31.2024

Living Donor Liver Transplant (LDLT)





2004 – 2006



UPMC
LIFE CHANGING MEDICINE
CHILDREN'S
HOSPITAL OF PITTSBURGH



2006 – 2008



2009 – 2010



2010 – 2014

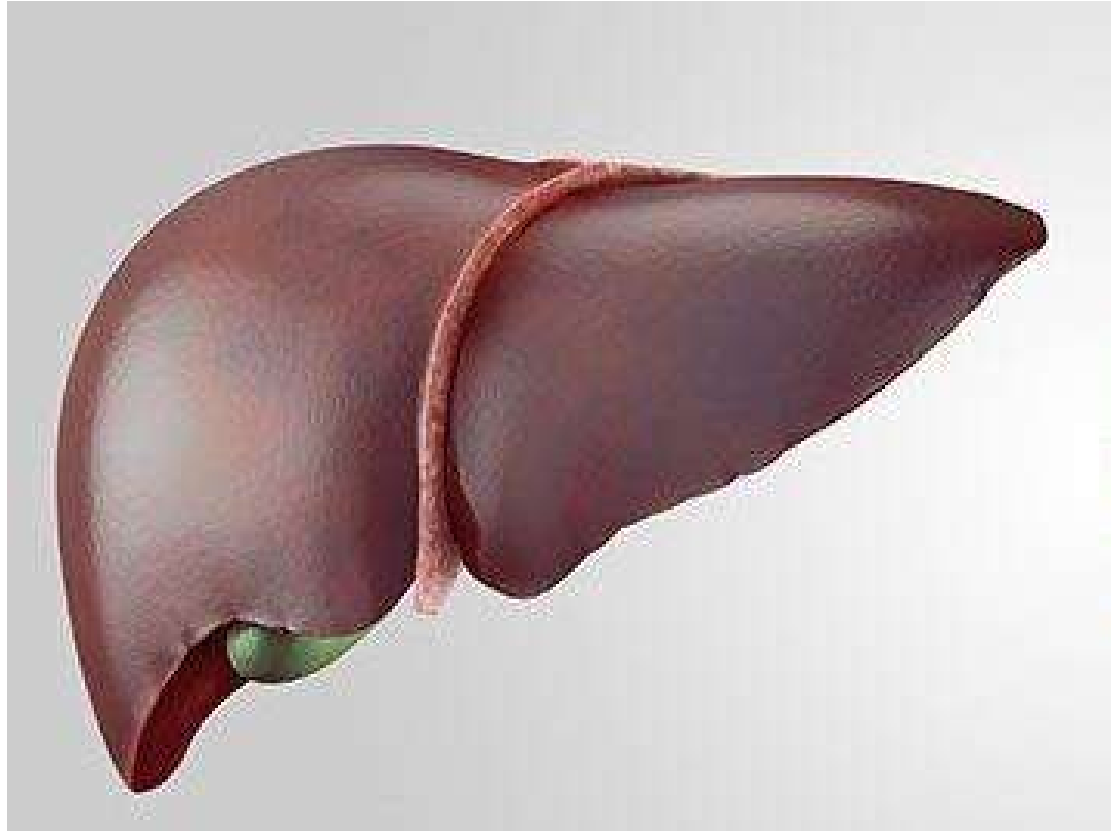


2014 – 2022



Outline

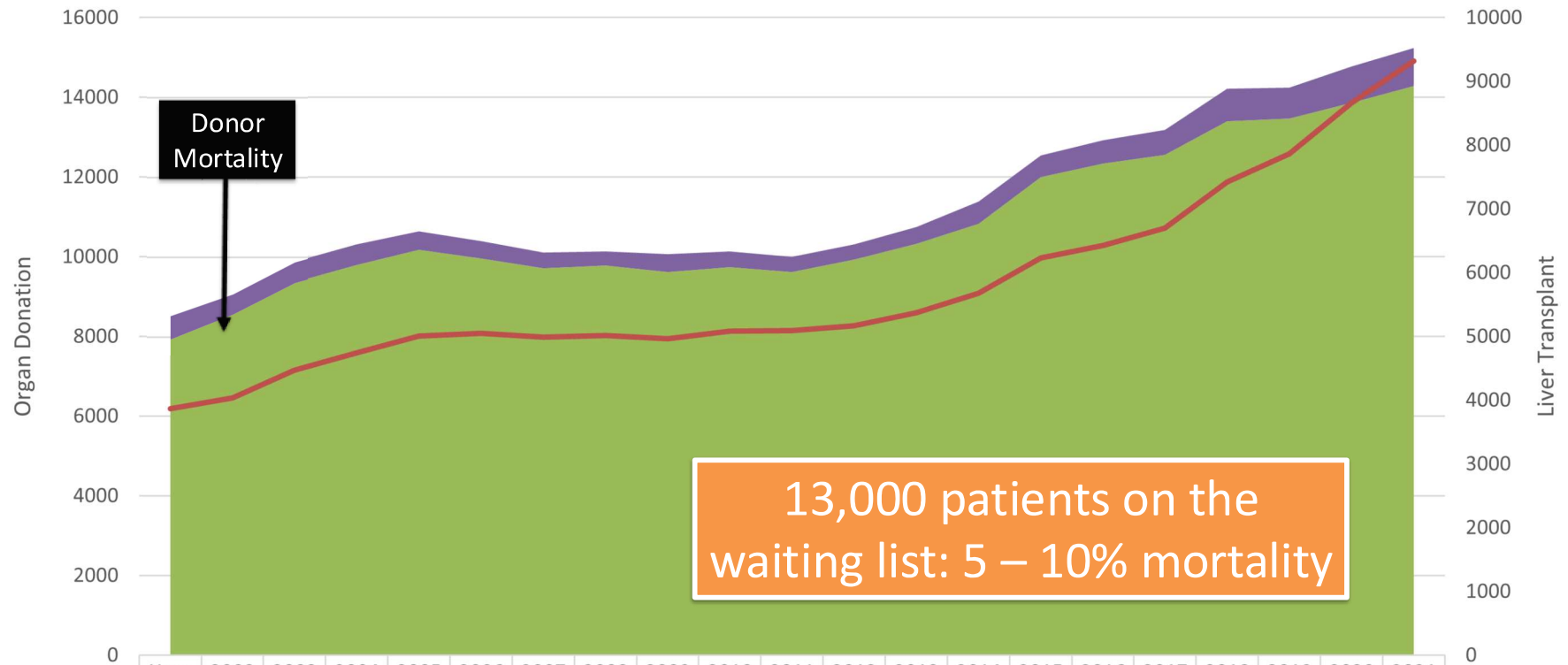
- Need
- Techniques
- Preparation
- Outcomes
- Complex LDLTs





Need

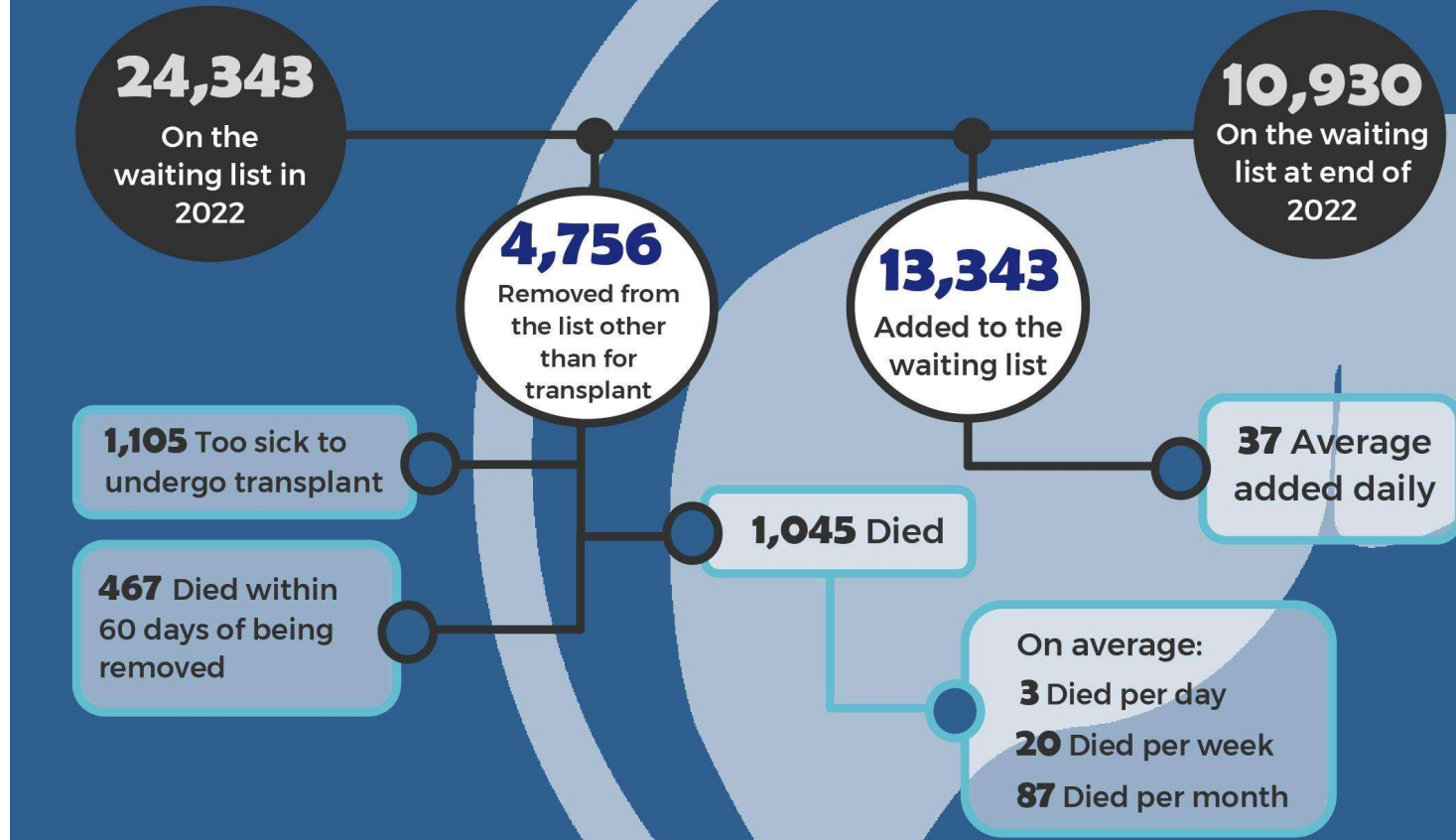
Organ Donation & Liver Transplant in the US



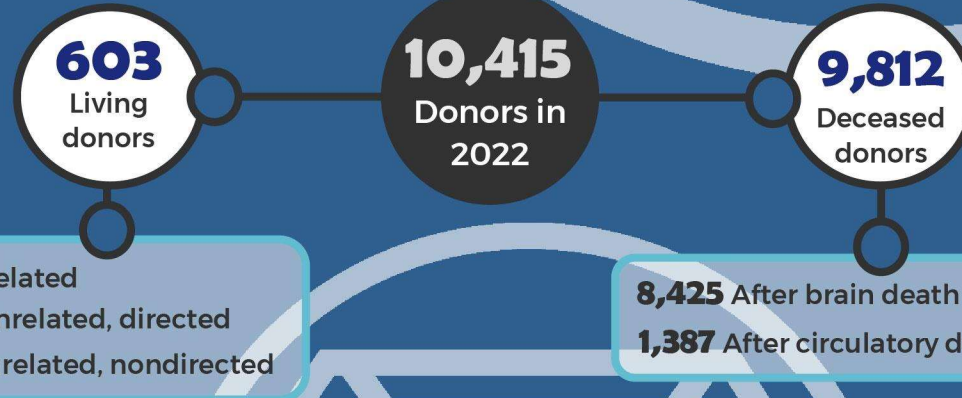
Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
LD Liver Tx	358	320	323	323	288	266	249	219	282	247	236	244	268	344	345	359	392	516	486	567	597
DD Liver Tx	4968	5351	5845	6121	6362	6227	6069	6111	6009	6084	6010	6203	6449	6768	7496	7715	7849	8372	8415	8667	8925
TOTAL Actual DD	6190	6457	7150	7593	8017	8085	7989	8022	7943	8126	8143	8269	8596	9079	9970	10286	10722	11870	12588	13863	14905

THE NEED

2022 |



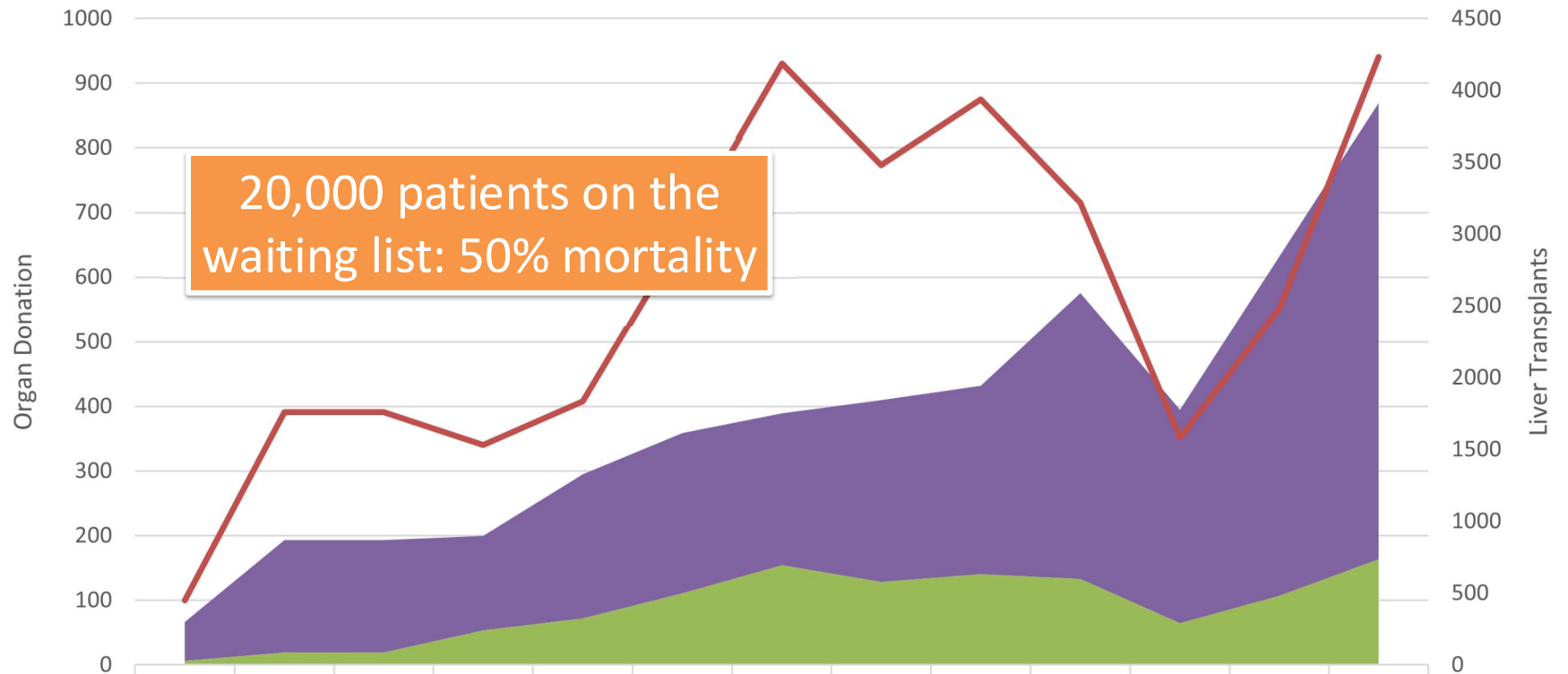
THE SOLUTION



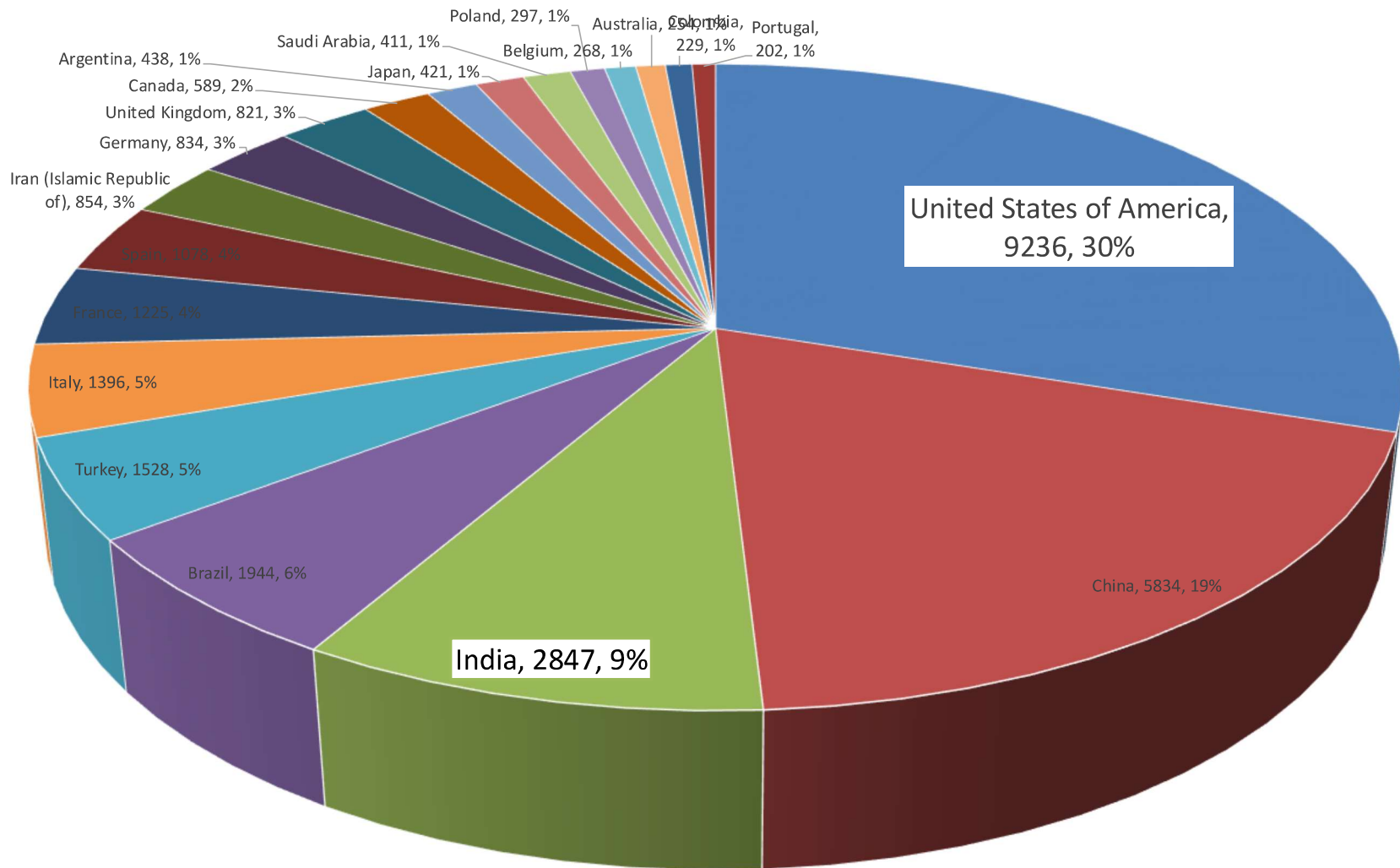
THE SUCCESS



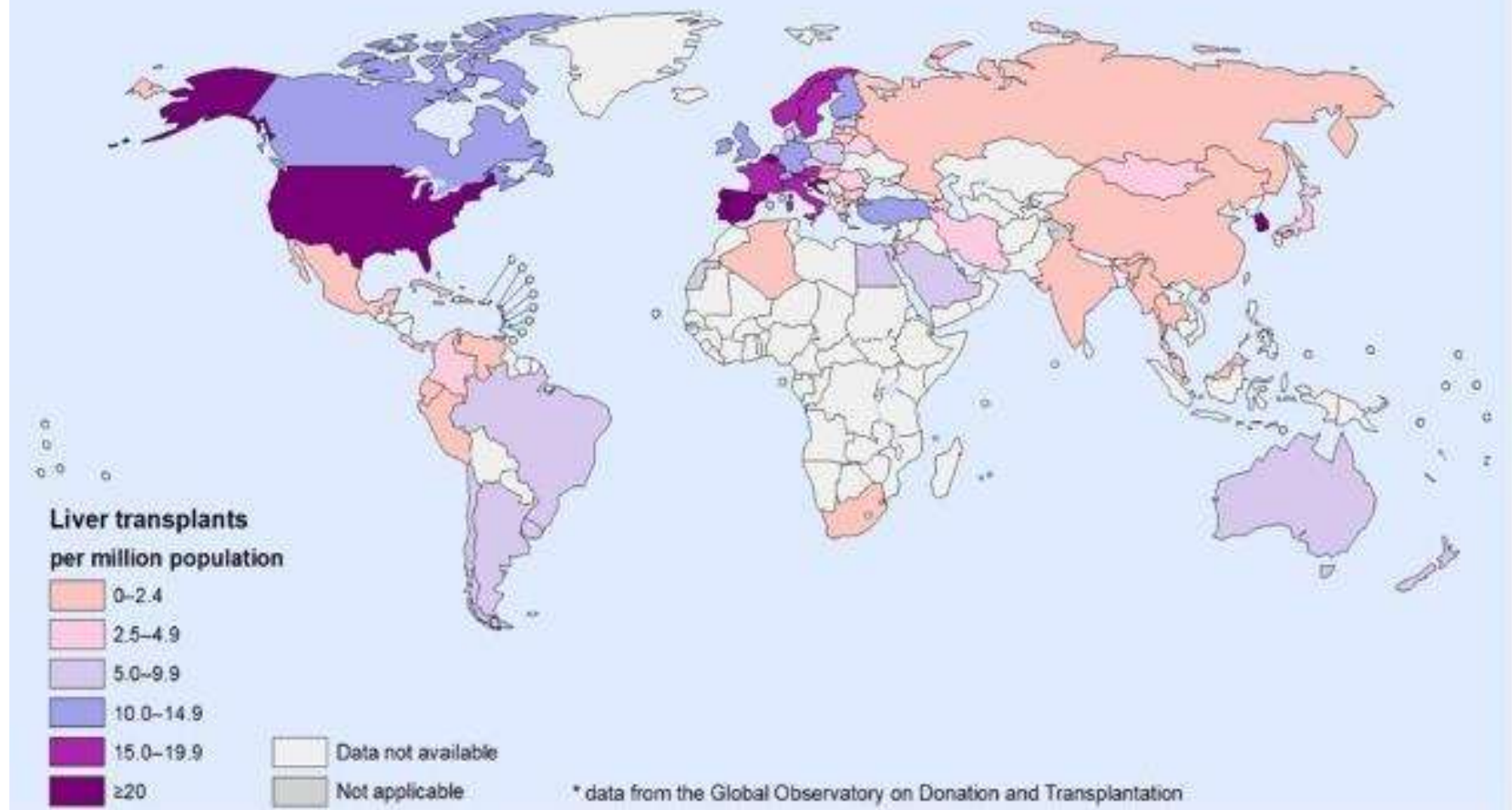
Organ Donation & Liver Transplant in India



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
LD Liver Tx	270	783	783	658	1002	1118	1059	1264	1313	1991	1487	2363	3174
DD Liver Tx	30	87	87	240	325	498	694	579	631	599	291	482	737
TOTAL Actual DD	100	391	391	340	408	666	930	773	875	715	351	552	941



Liver Transplant Globally

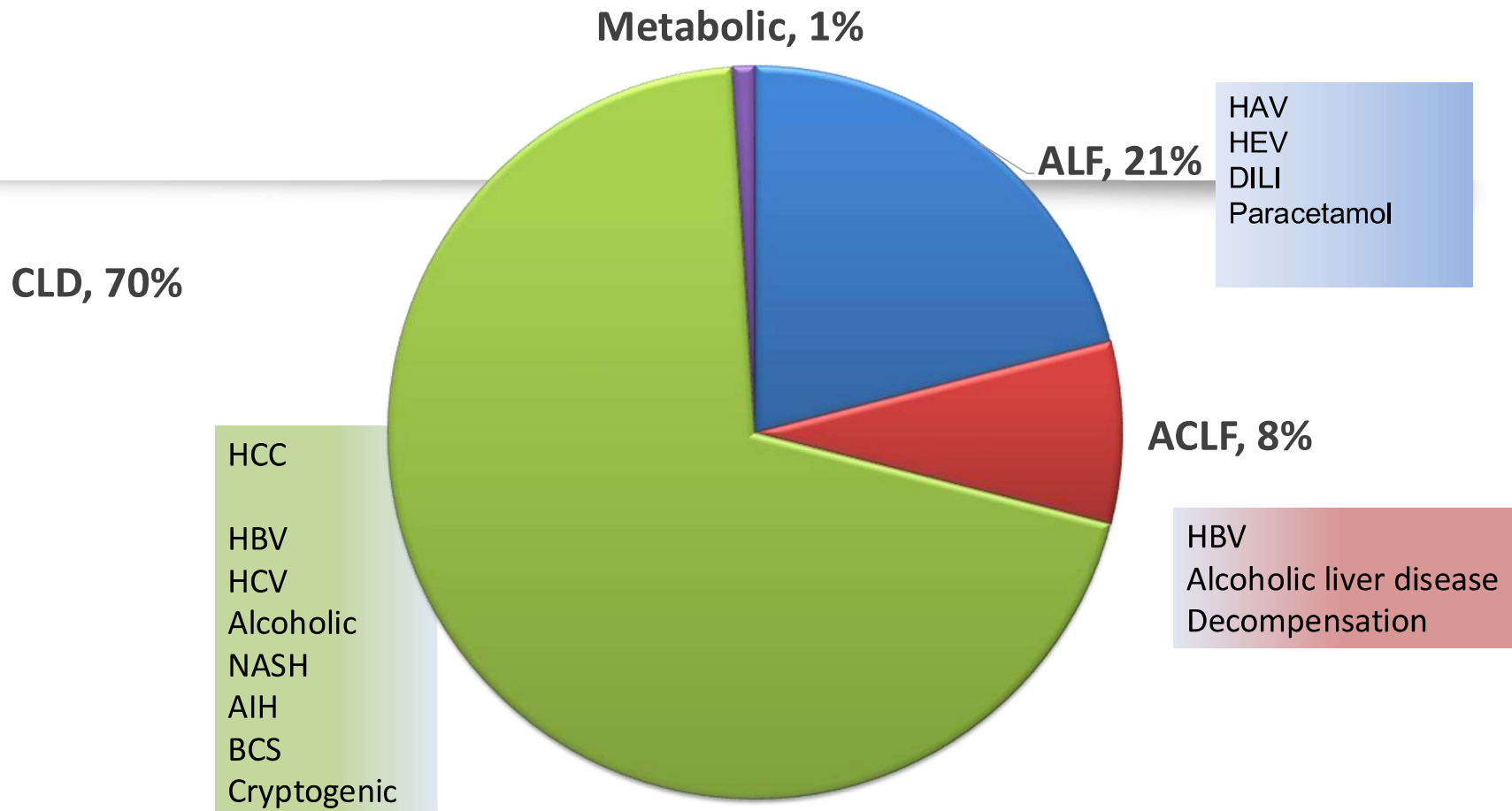


East vs. West

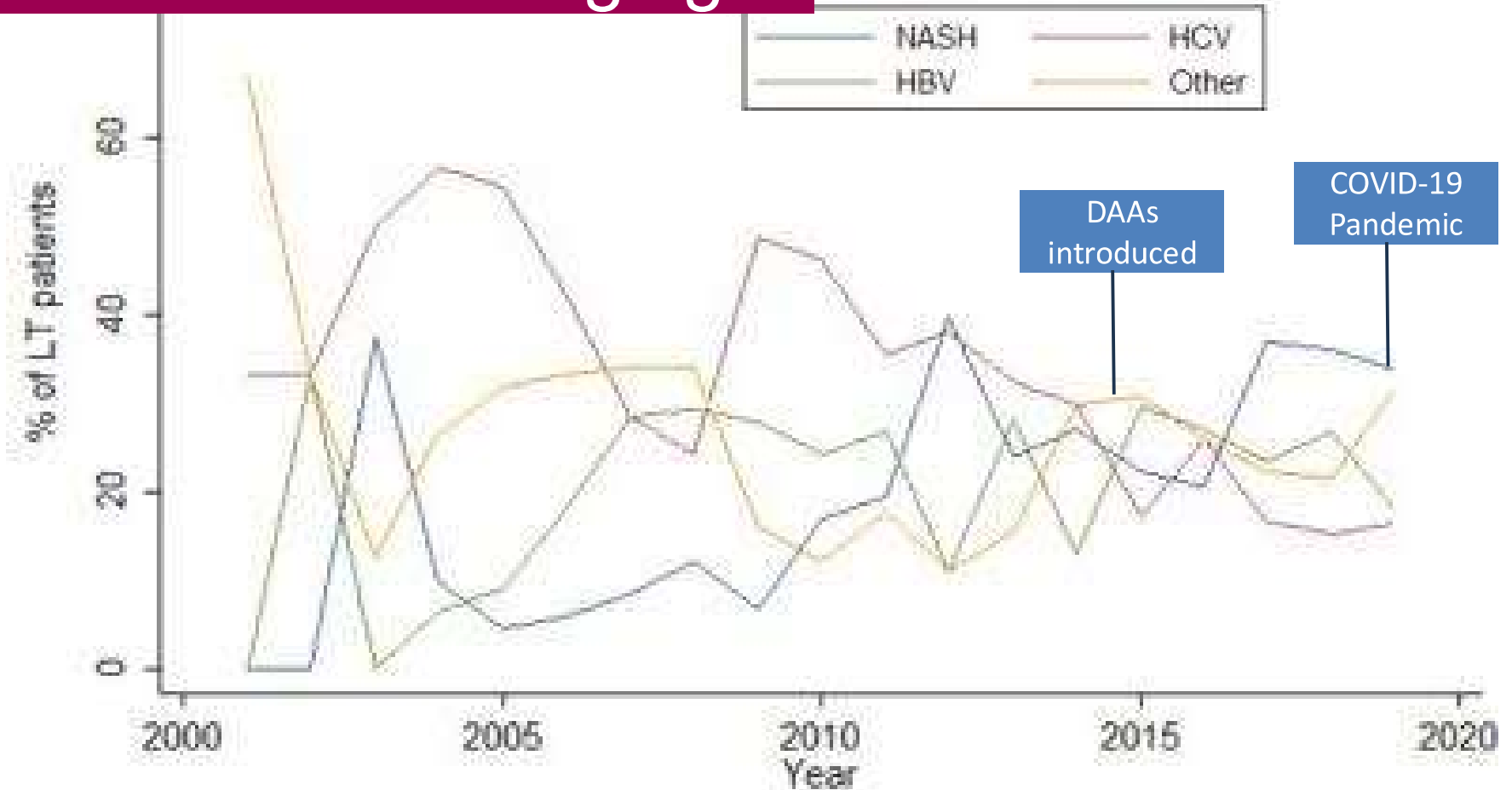
- Not as much because of religious beliefs
- Low awareness about organ donation
- Limited resources to maintain the donor
- Limited infrastructure support for organ transportation



Indications



Indications are changing



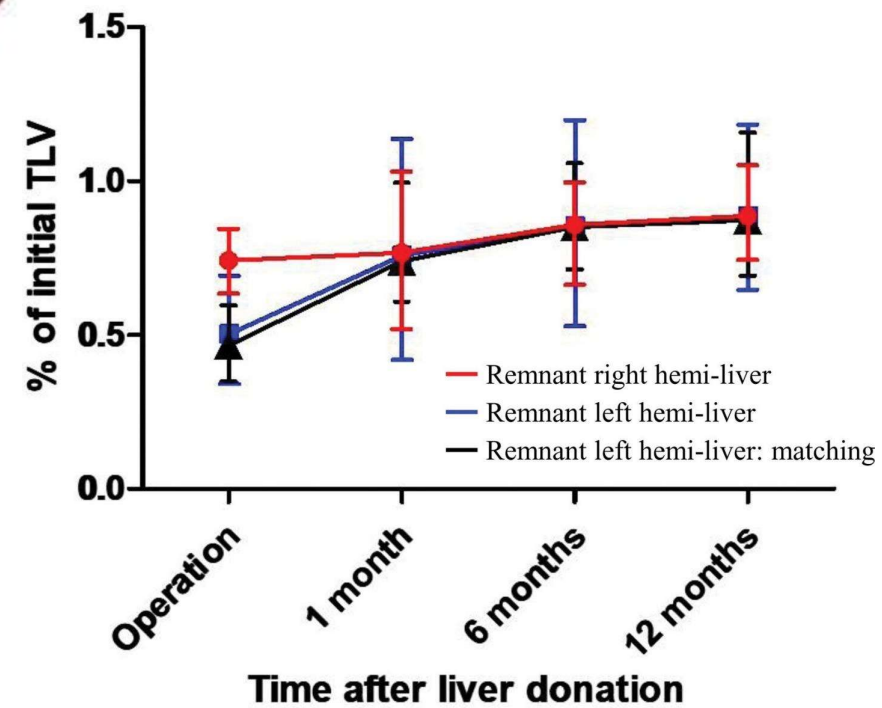
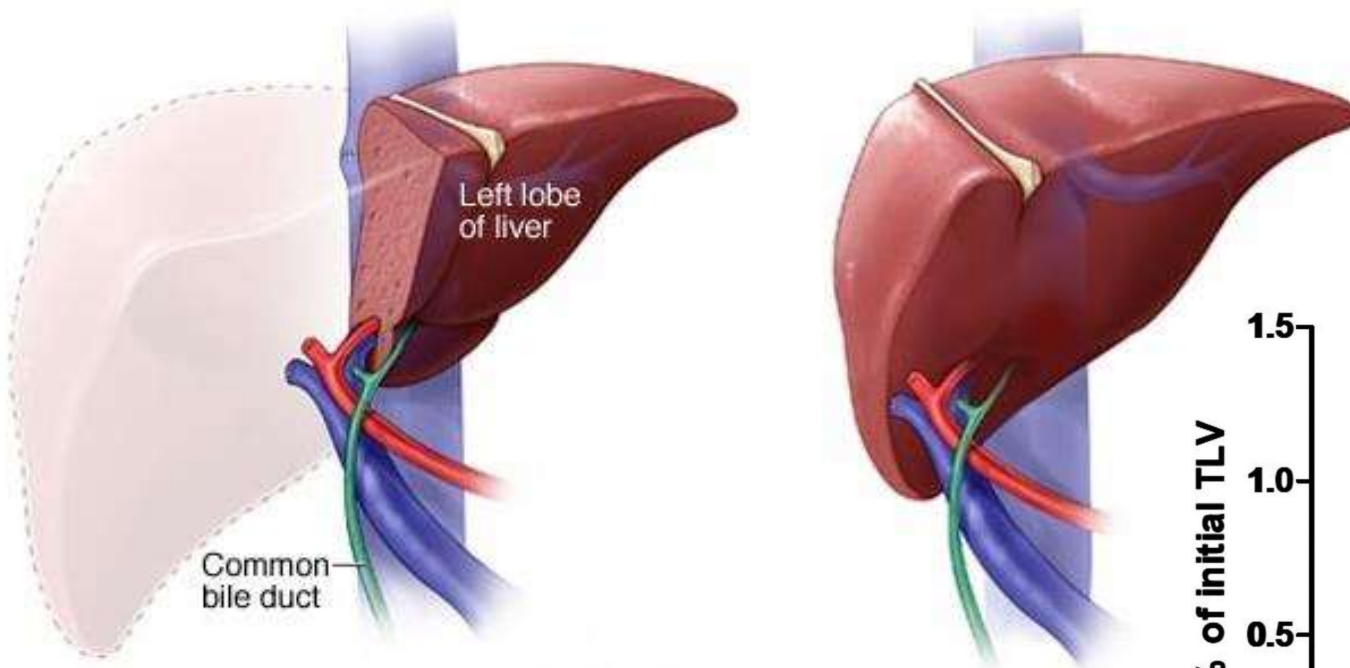
Patients at a disadvantage in the MELD allocation system

- MELD doesn't take into account all decompensations:
encephalopathy, ascites (without hyponatremia, HRS)
- Cholestatic liver diseases
- Borderline HCC
- Non-HCC liver tumors

A stylized, multi-pointed starburst or sunburst graphic in a lighter shade of maroon, positioned on the left side of the slide. The points of the starburst radiate outwards from a central point on the left edge.

Techniques

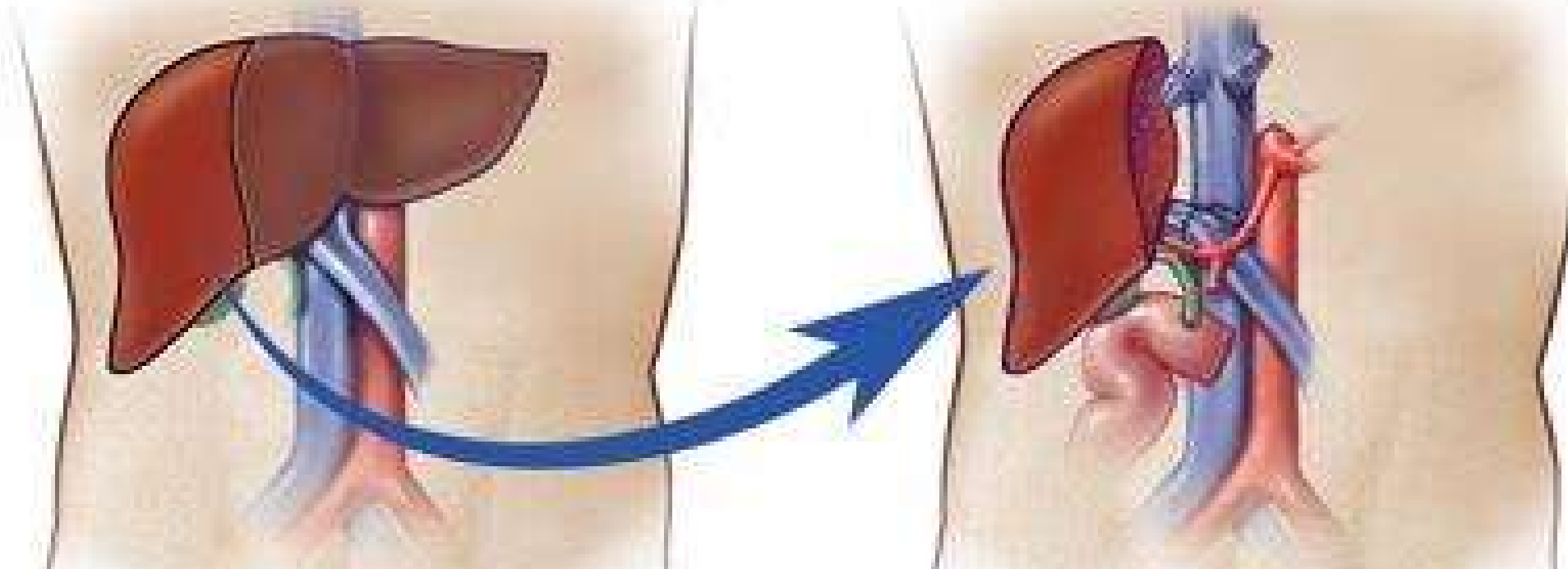
	DDLT	LDLT
Waiting time	Months – Years	None
Organ quality	Unpredictable	Excellent
Preferred for	Obese > 100 kgs	Low MELD
Donor risk	Not applicable	Minimal



Liver Regeneration

Portion of donor
liver is removed...

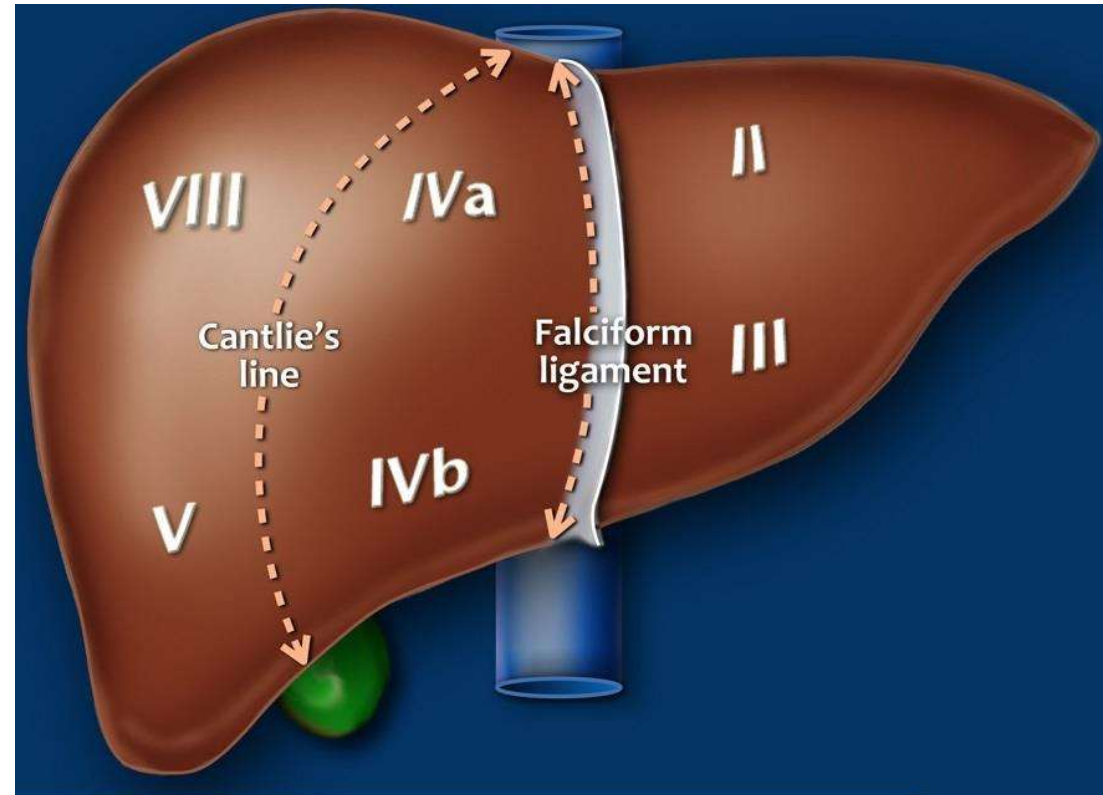
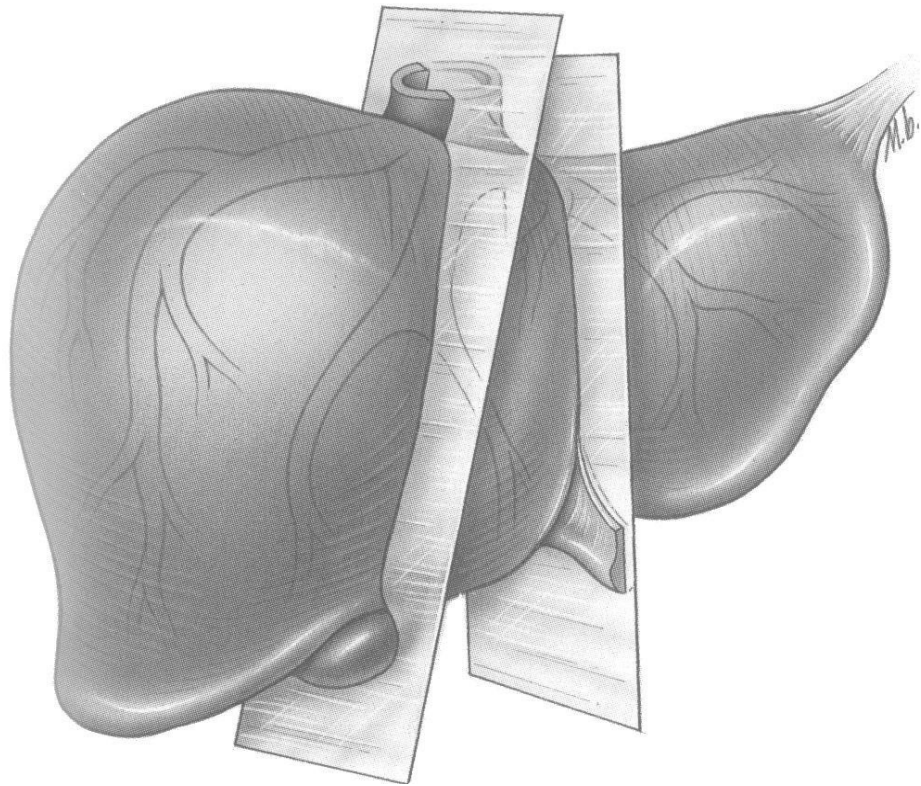
...and transplanted
to recipient.



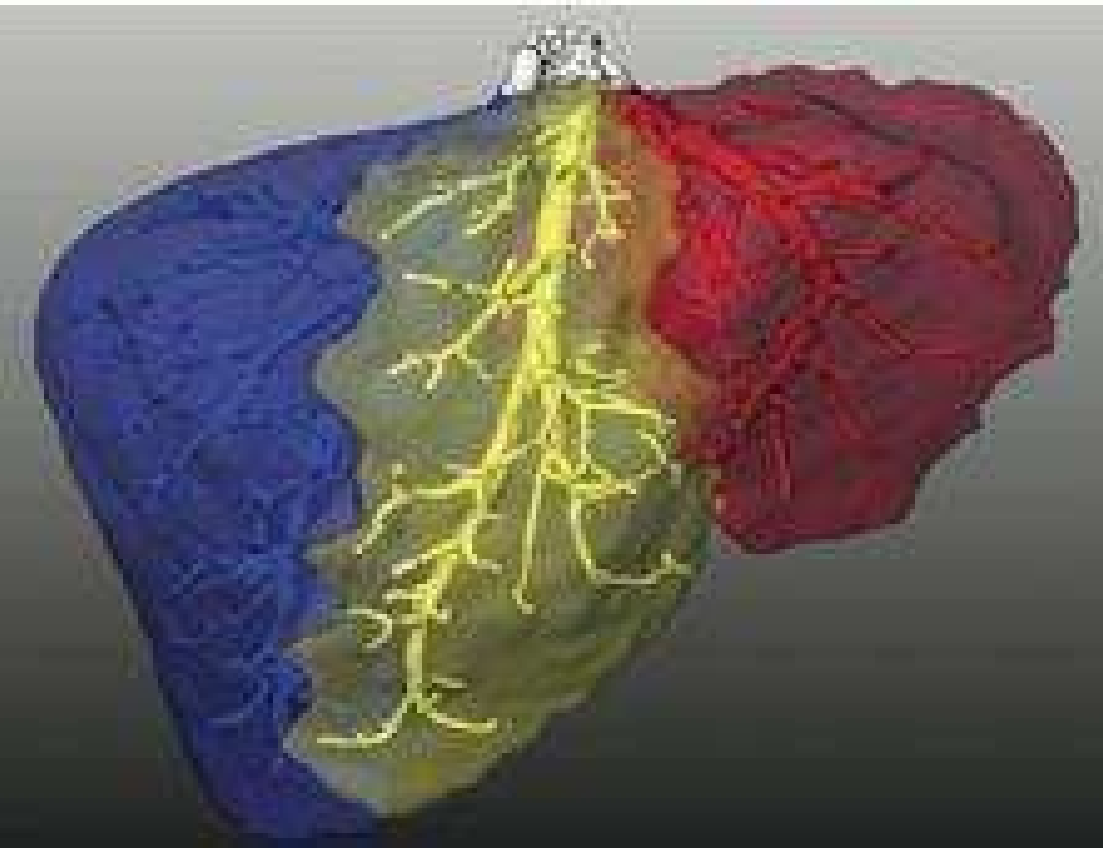
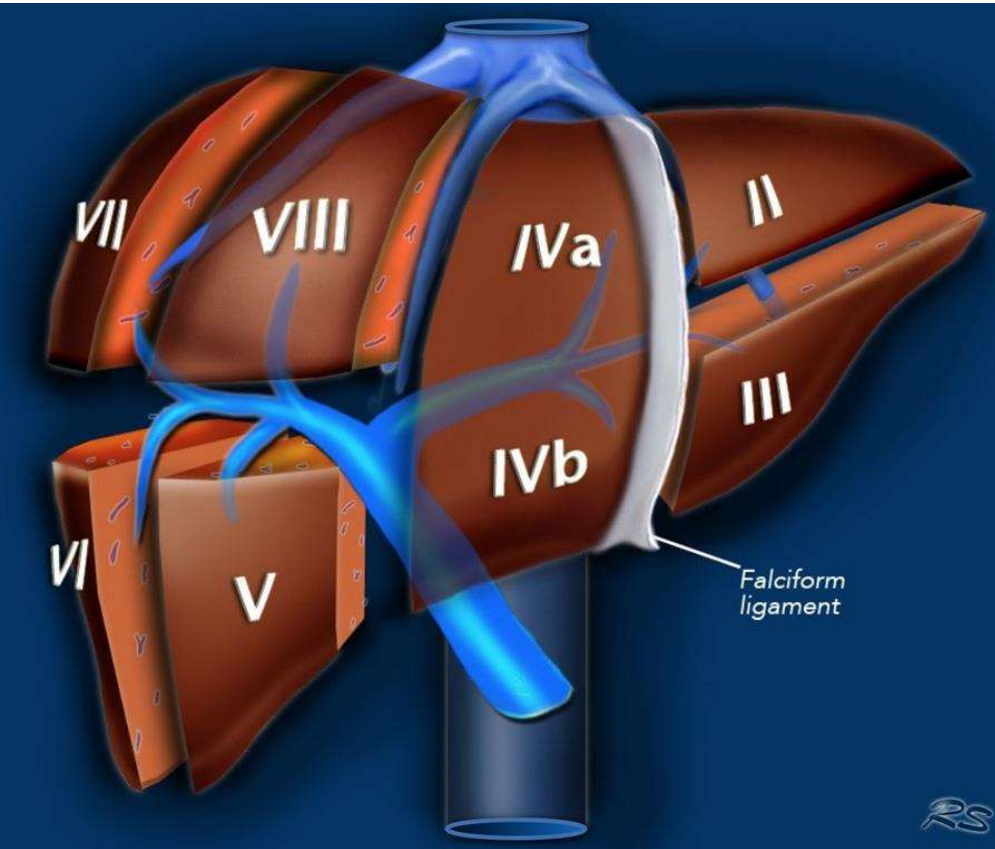
FLR: Donor can safely donate
upto 70% of their liver

GRWR: Recipient needs 0.8% liver graft of his /
her body weight for a successful transplant

Avascular planes



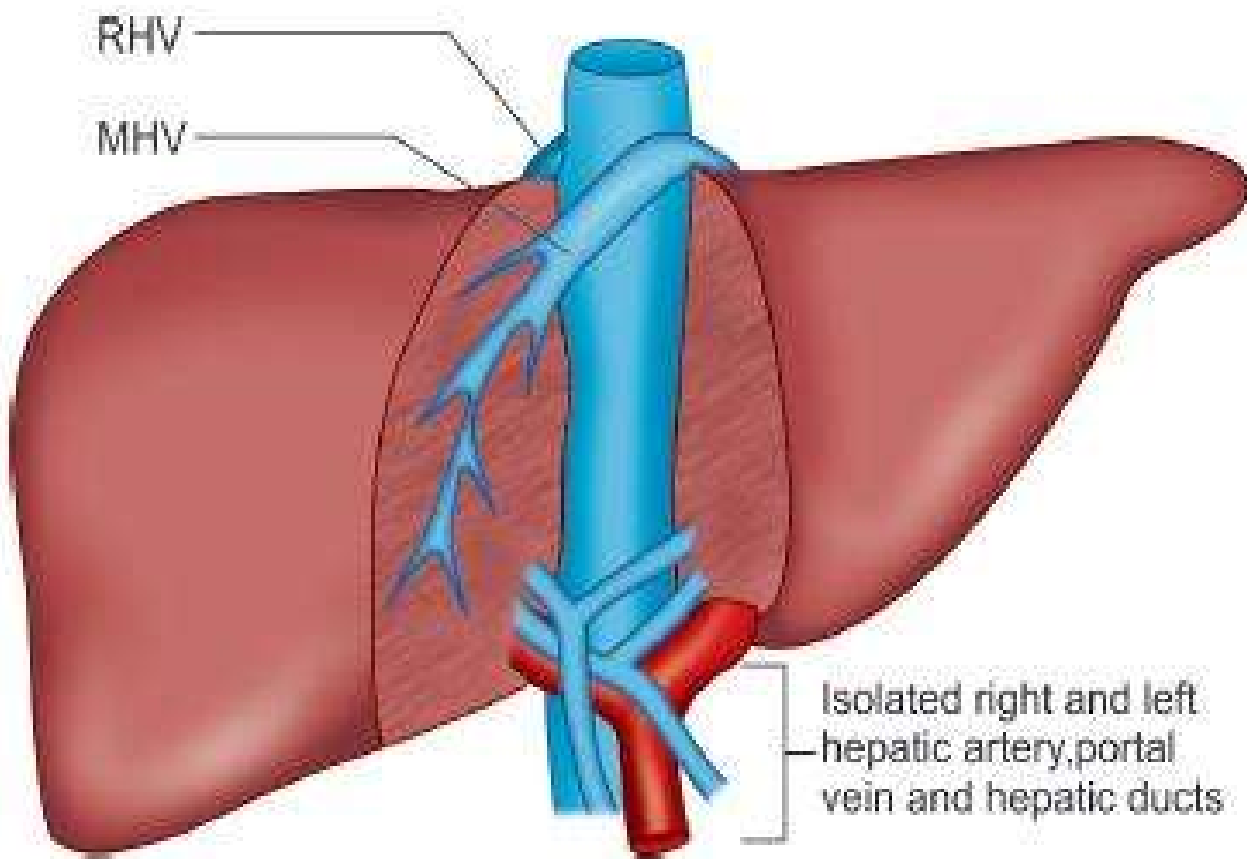
Outflow divides the liver into 3 parts





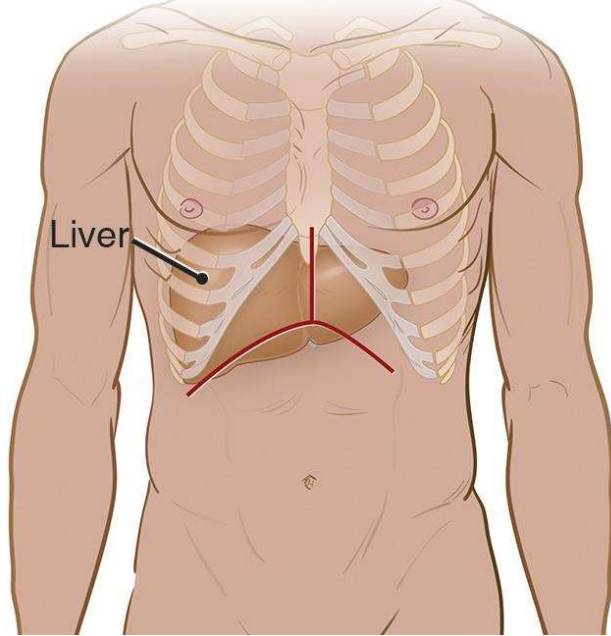
Donor hepatecmomy

Donor hepatectomy

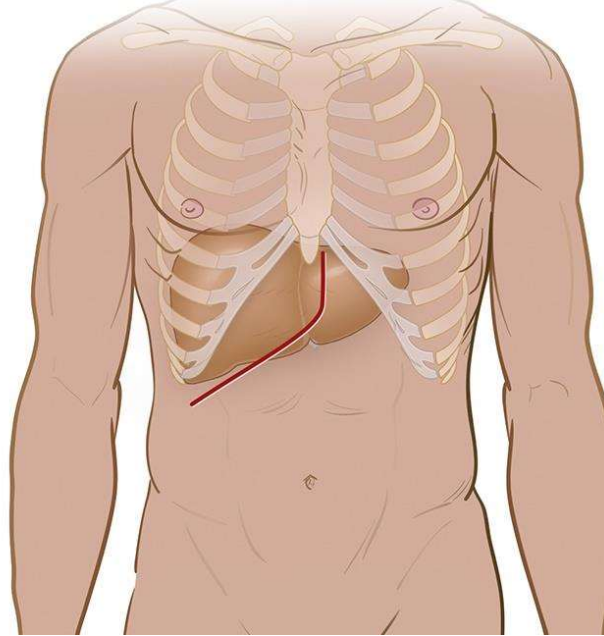


Incision

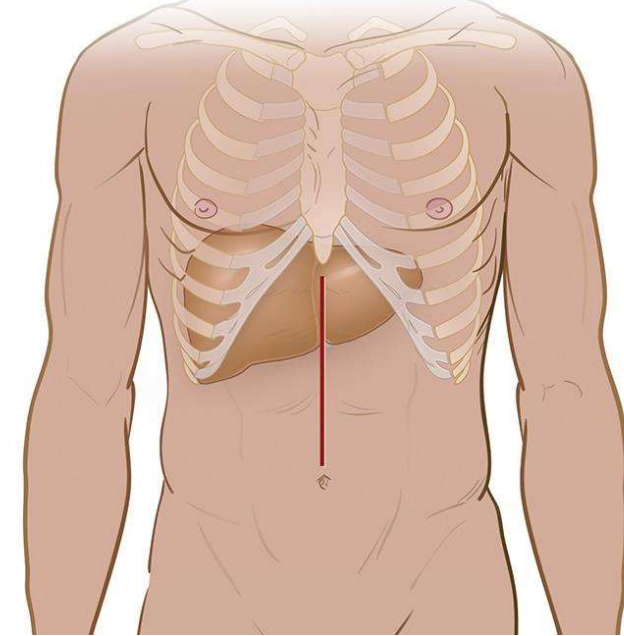
chevron incision



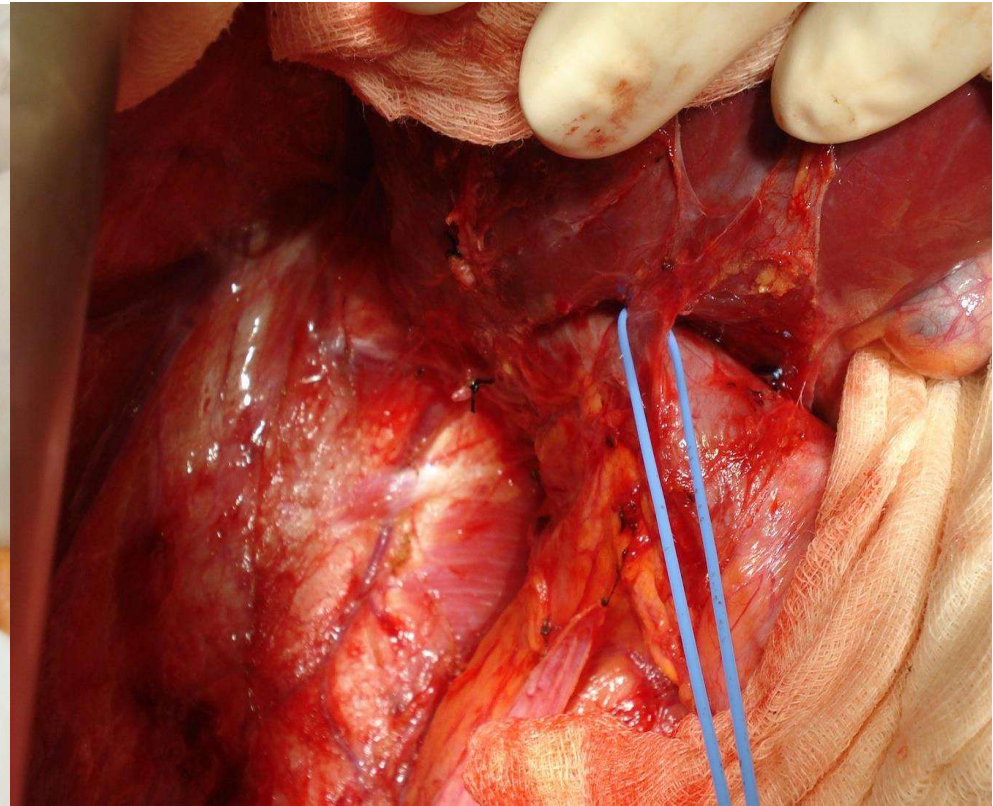
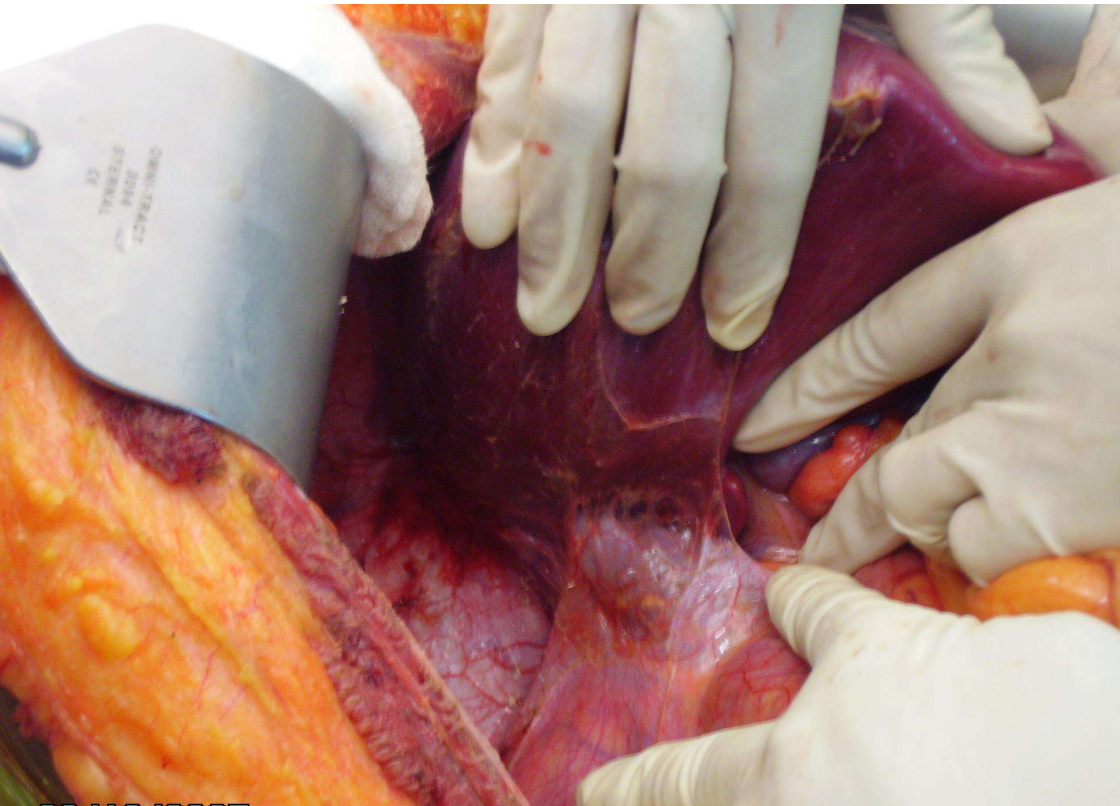
hockey stick incision



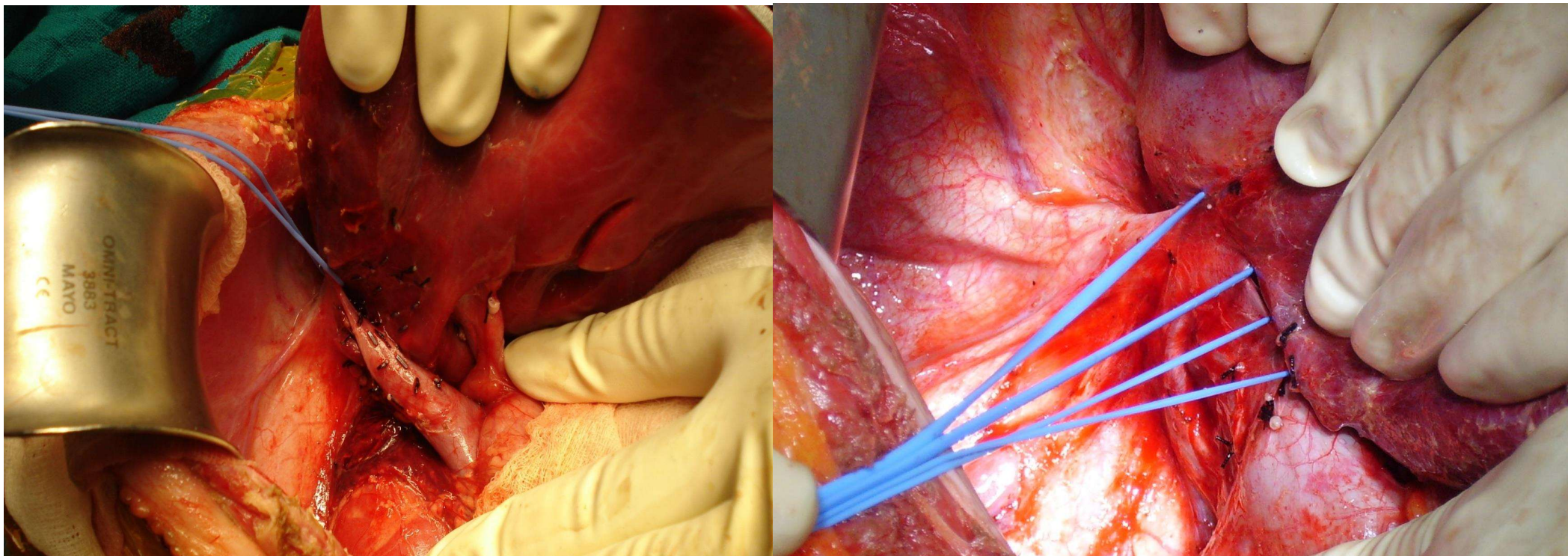
upper midline incision



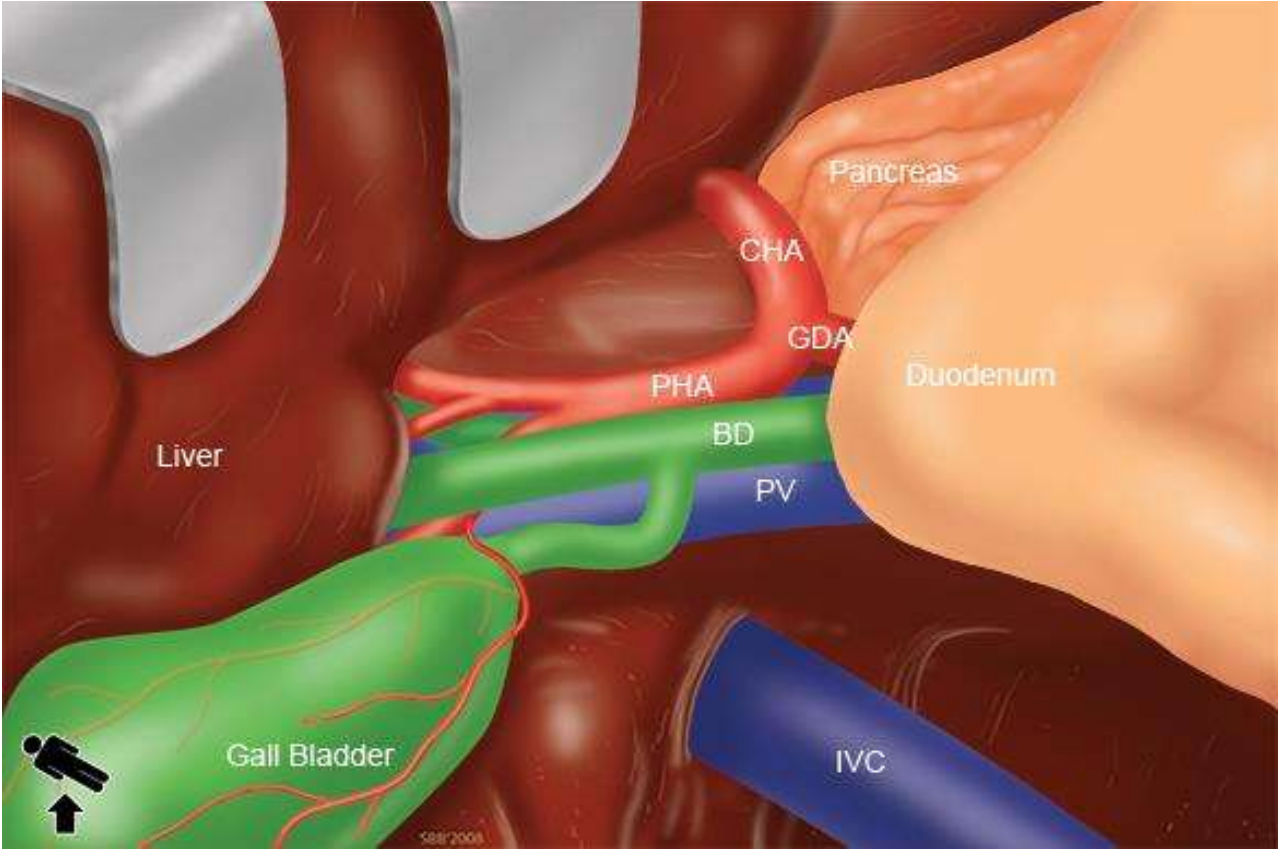
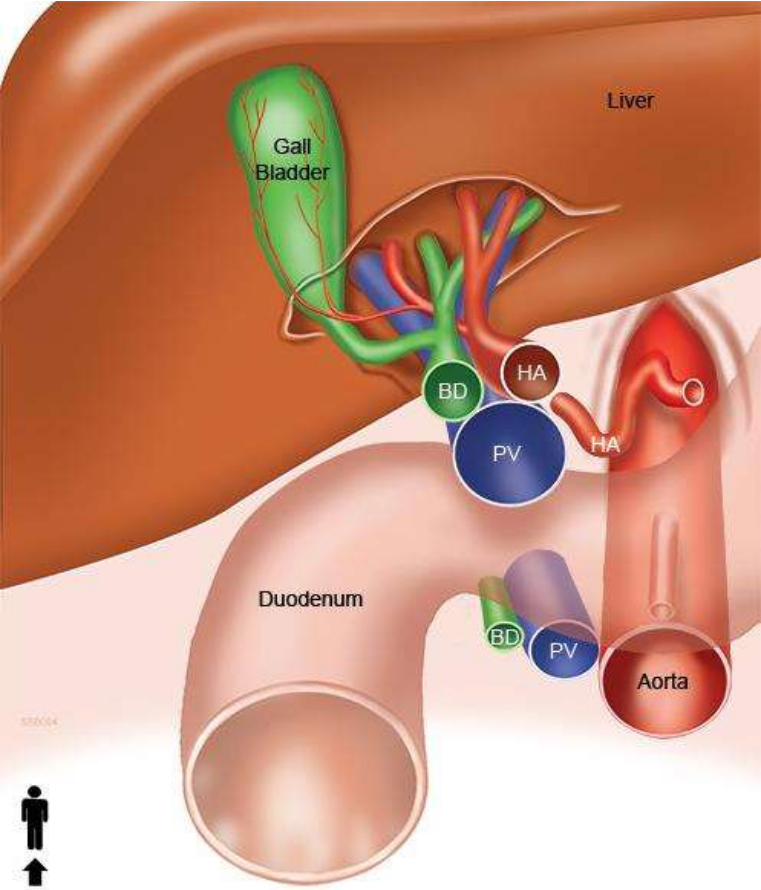
Piggyback the liver (caudate) off the IVC



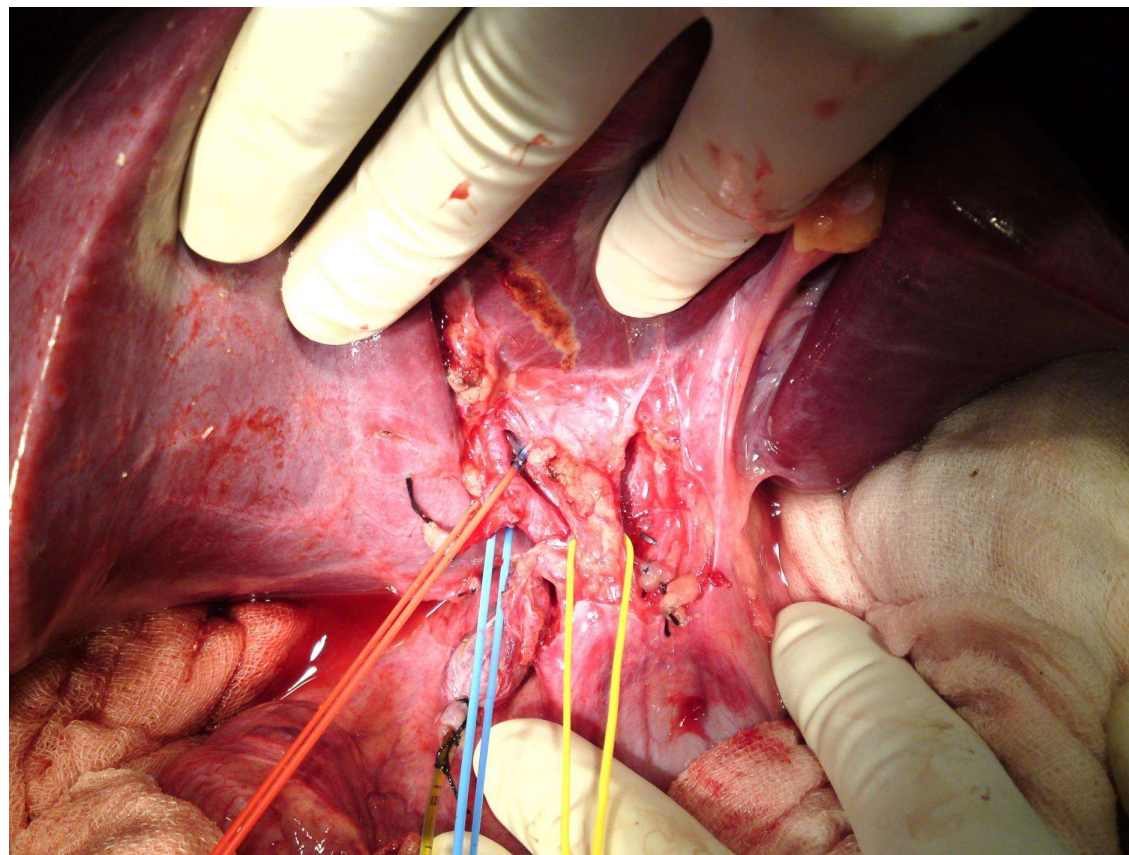
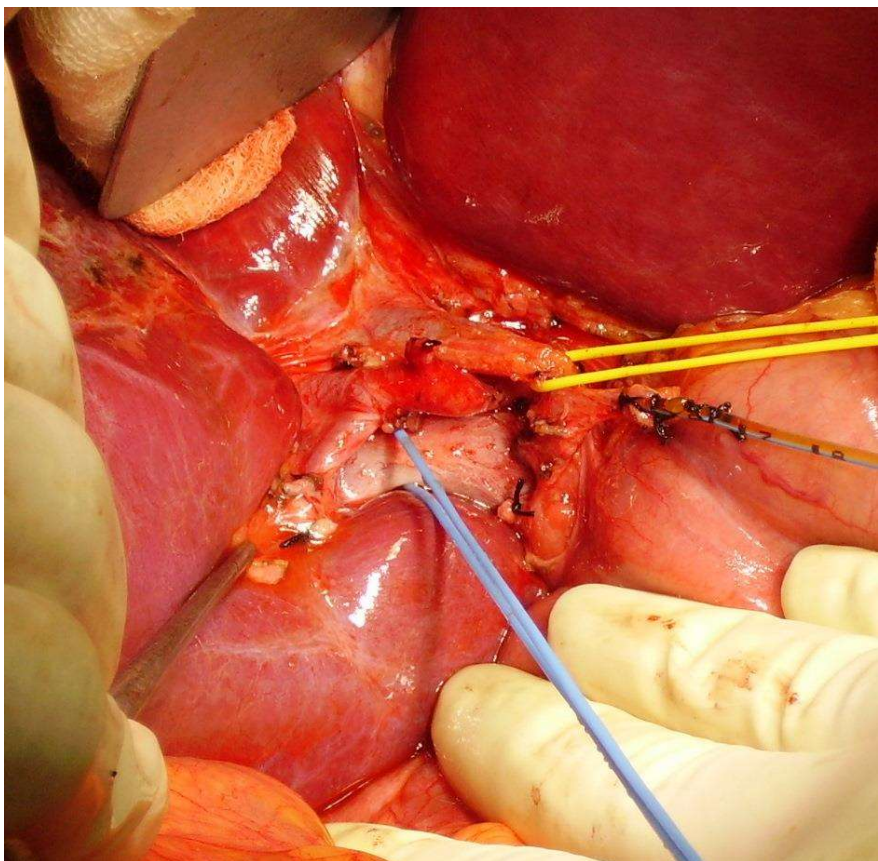
Piggyback the liver (caudate) off the IVC



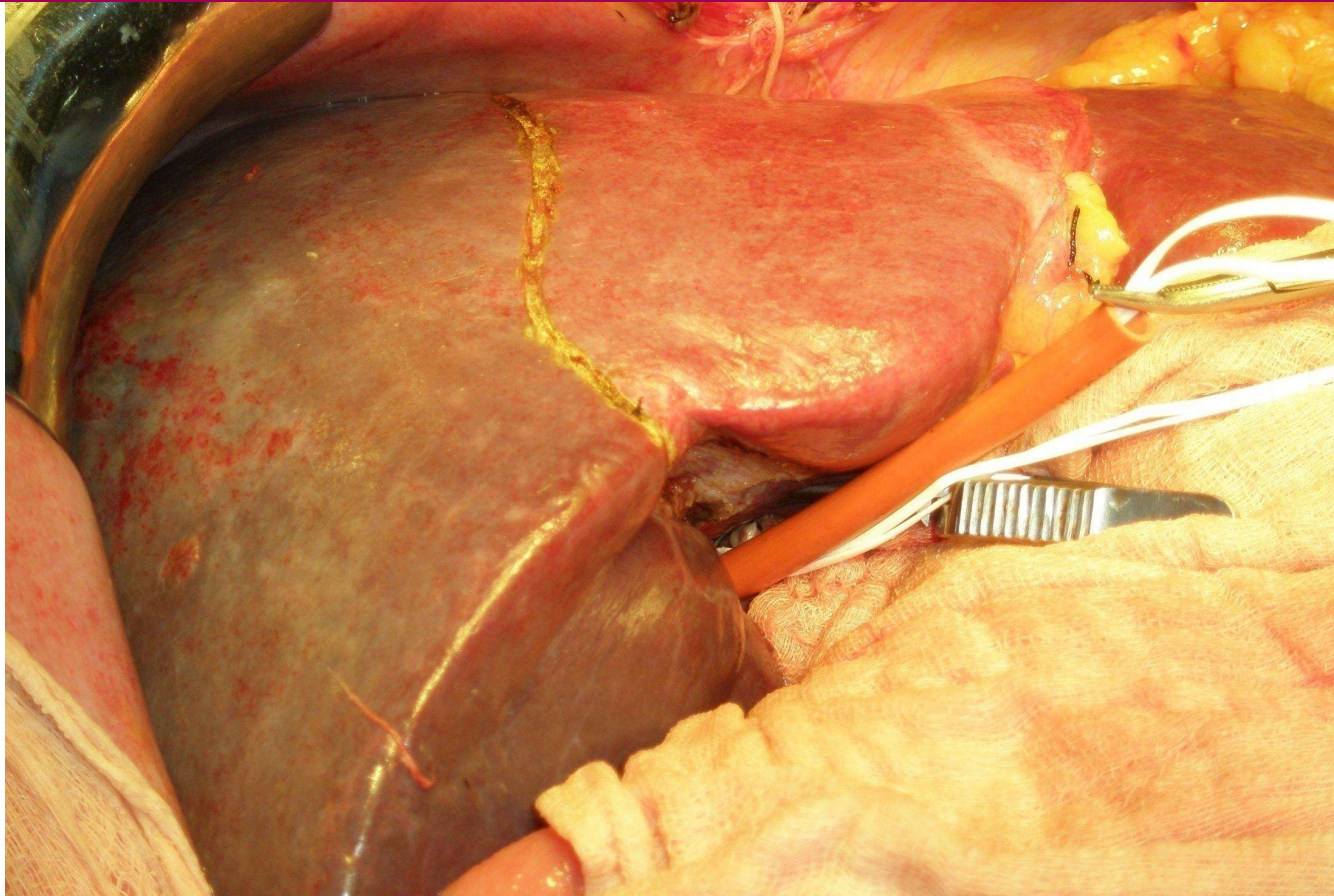
Hilar Dissection: Intra-fascial Approach



Hilar Dissection: Intra-fascial Approach



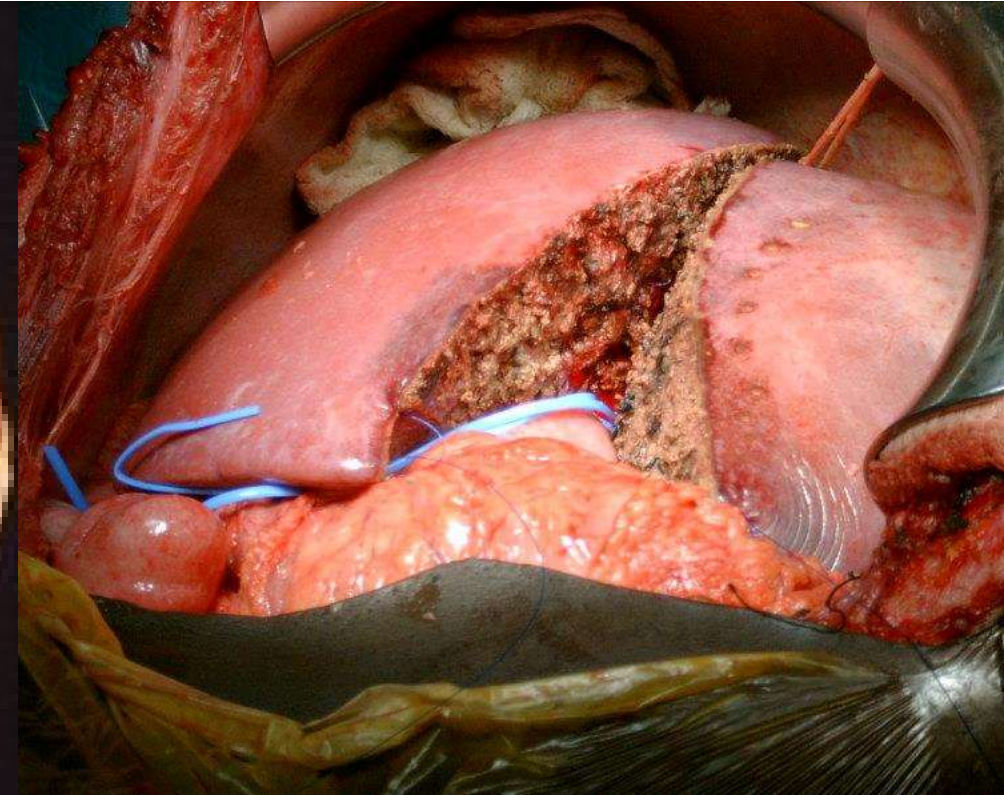
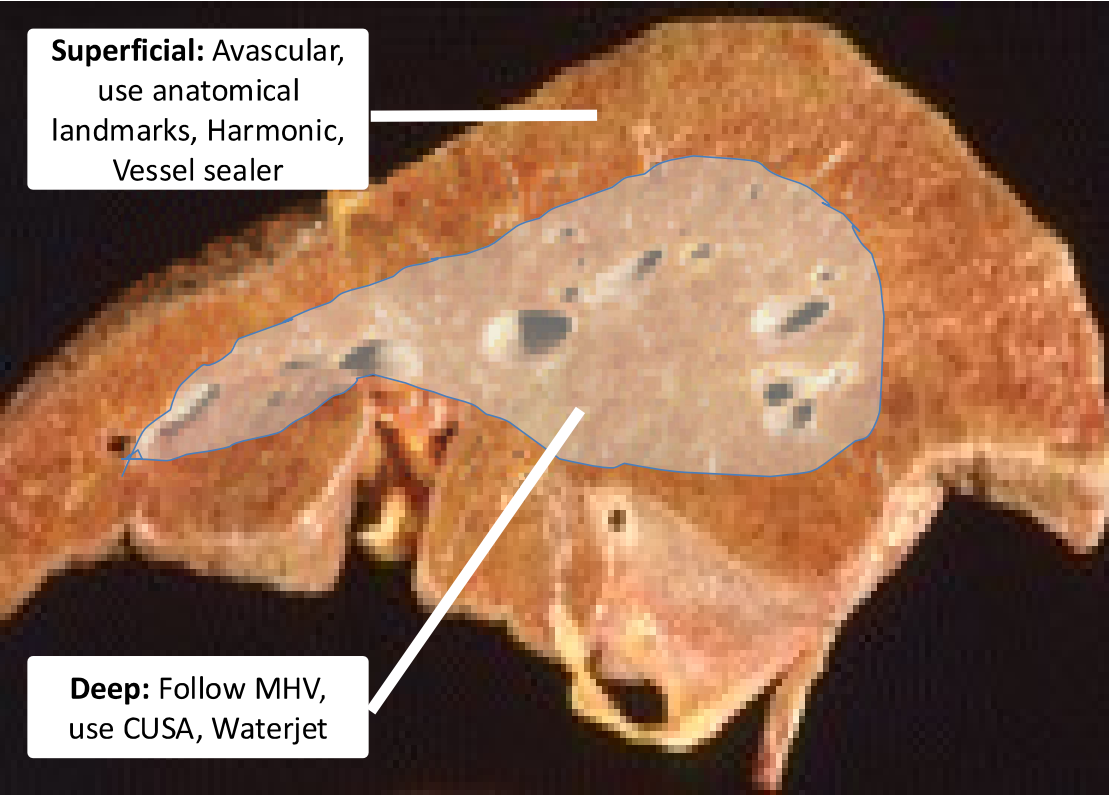
Ischemic plane



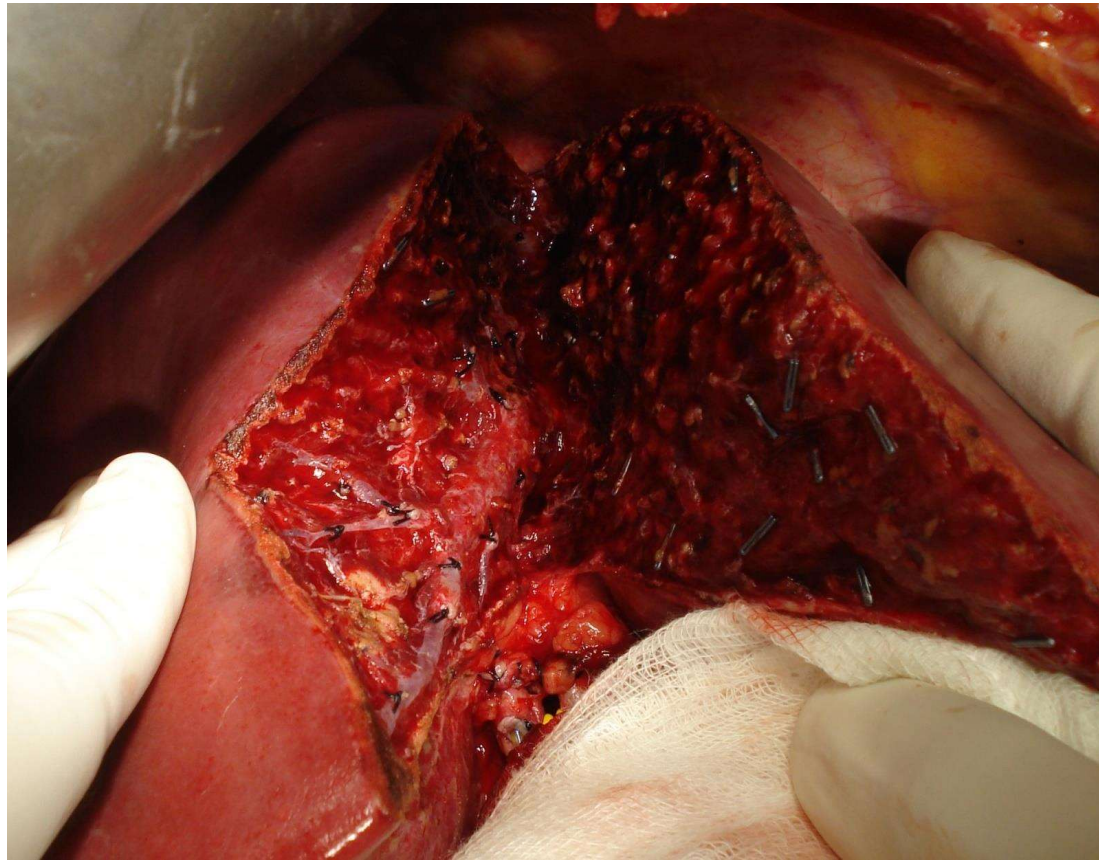
Parenchymal transection: Superficial vs. deep

Superficial: Avascular, use anatomical landmarks, Harmonic, Vessel sealer

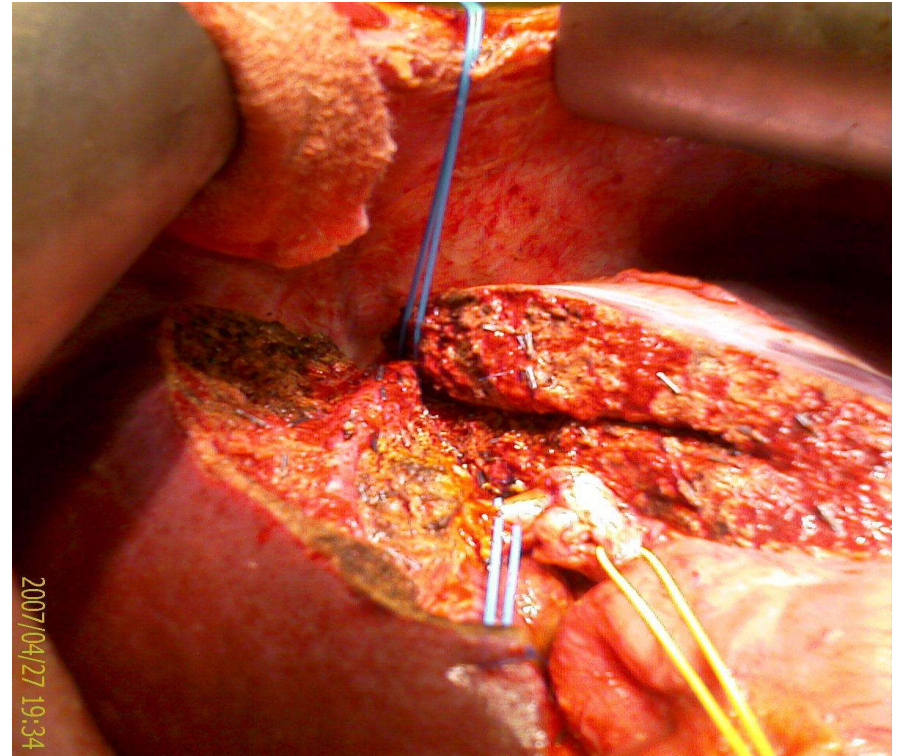
Deep: Follow MHV, use CUSA, Waterjet



Parenchymal transection without vascular occlusion

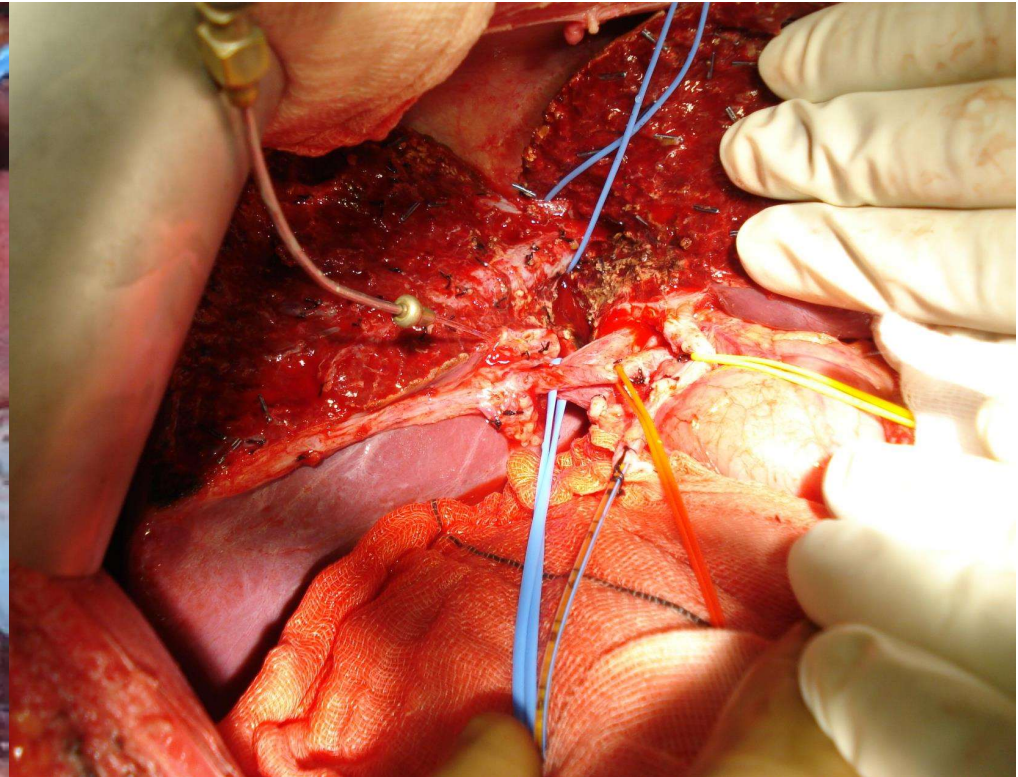
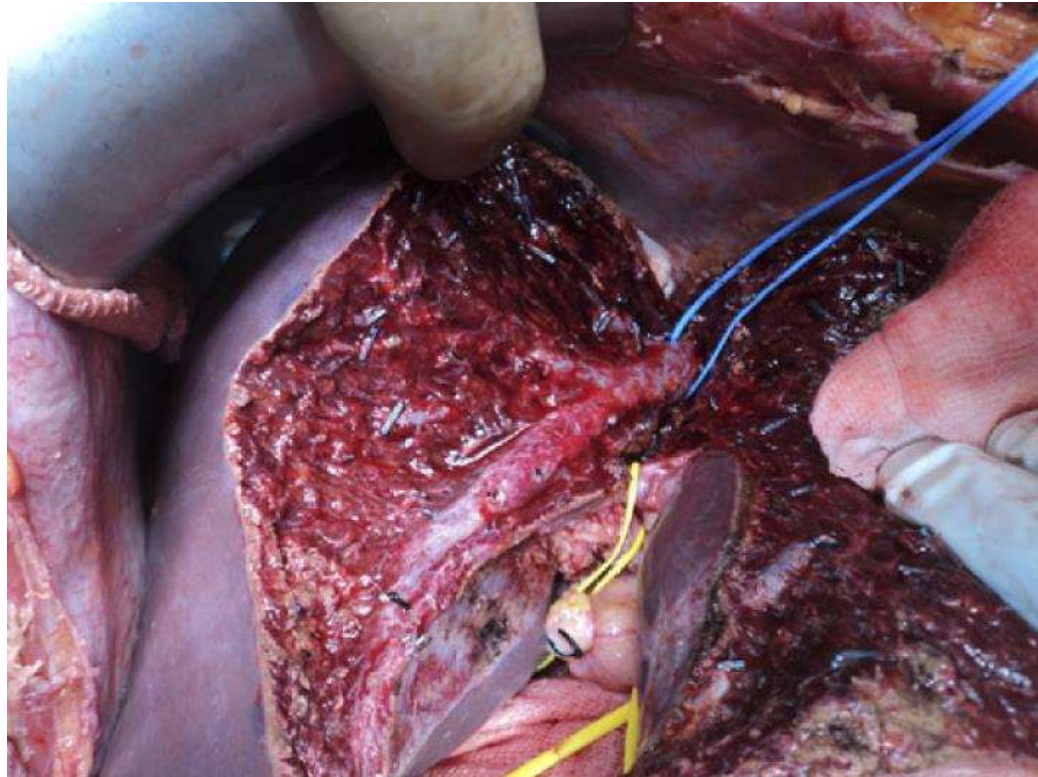


“Coring out” the MHV out of segment IV

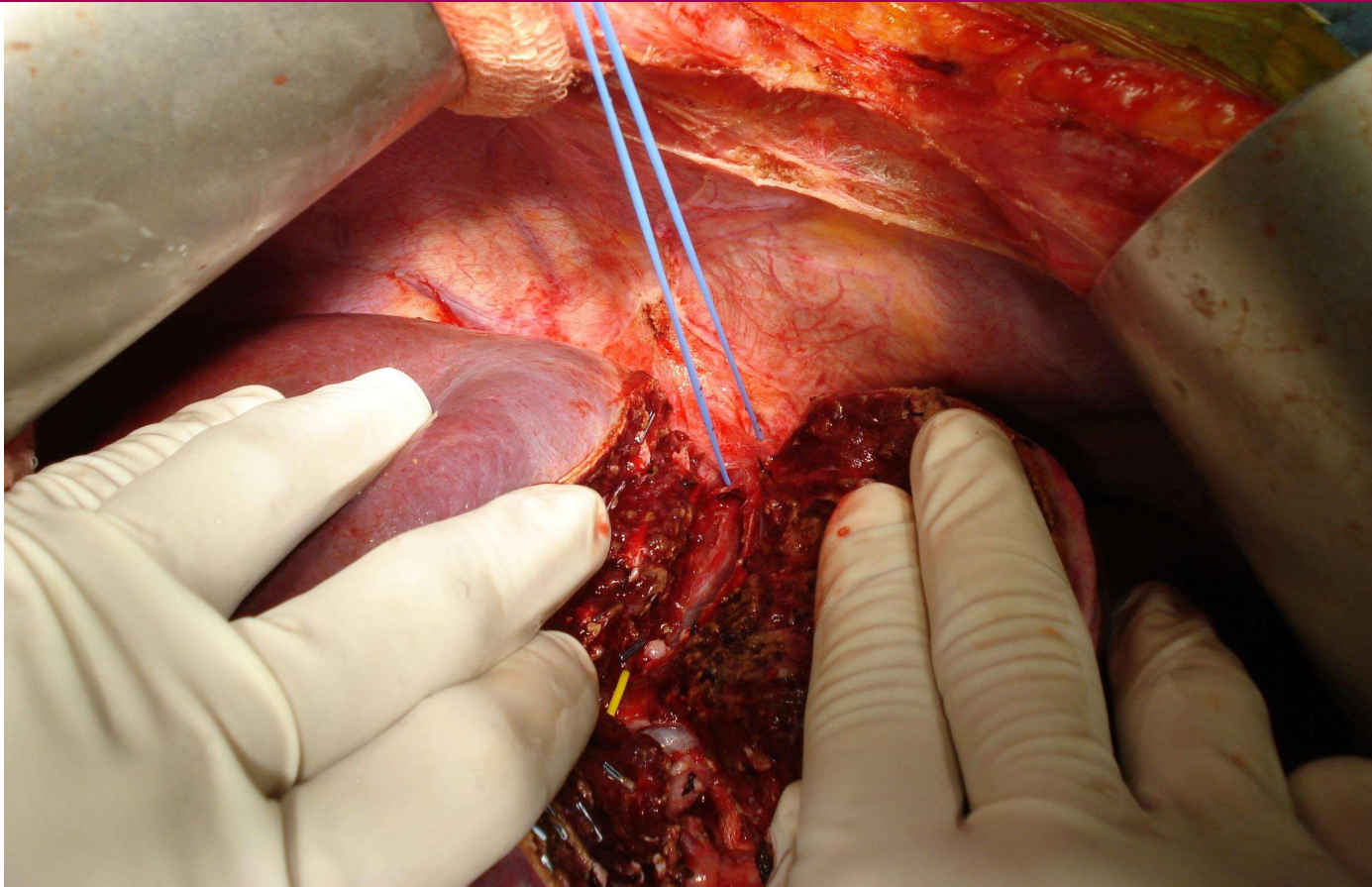


2007/04/27 19:34

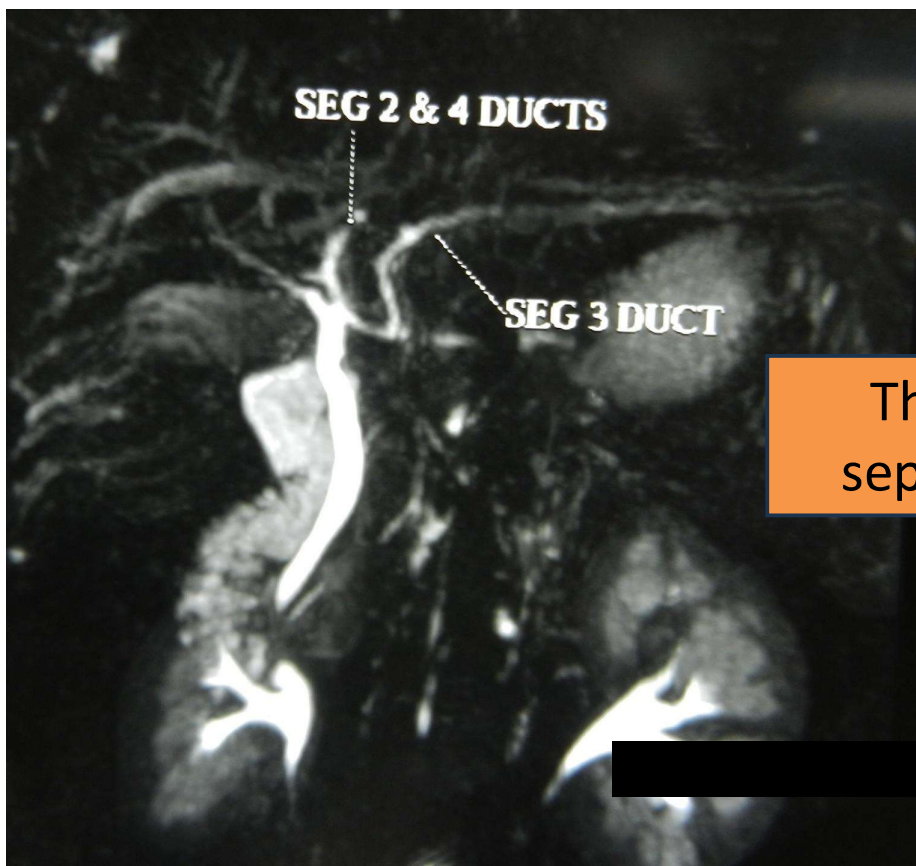
Parenchymal transection without vascular occlusion



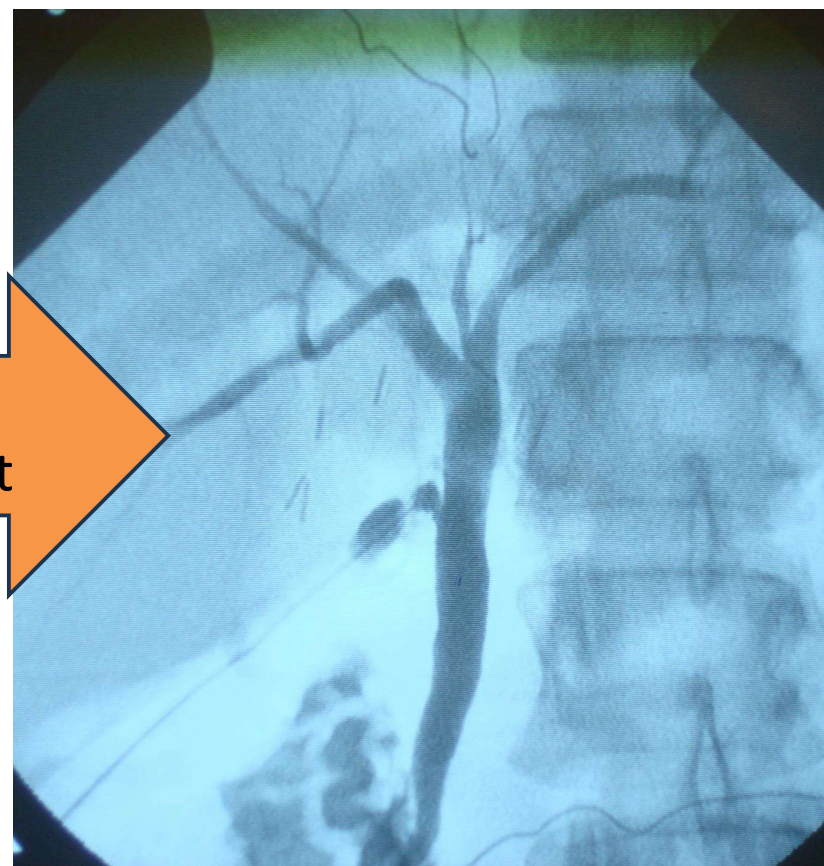
Parenchymal transection for left lobe



Cholangiogram



The lobes are separated apart



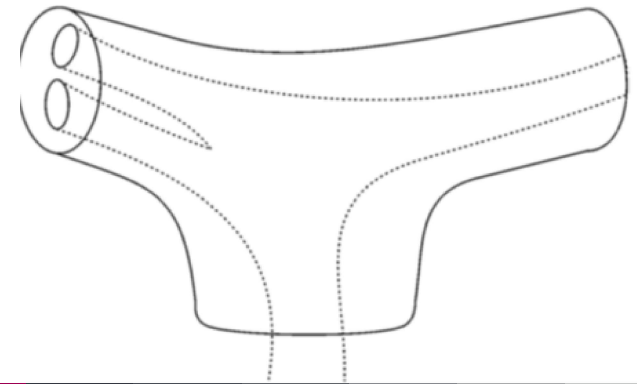
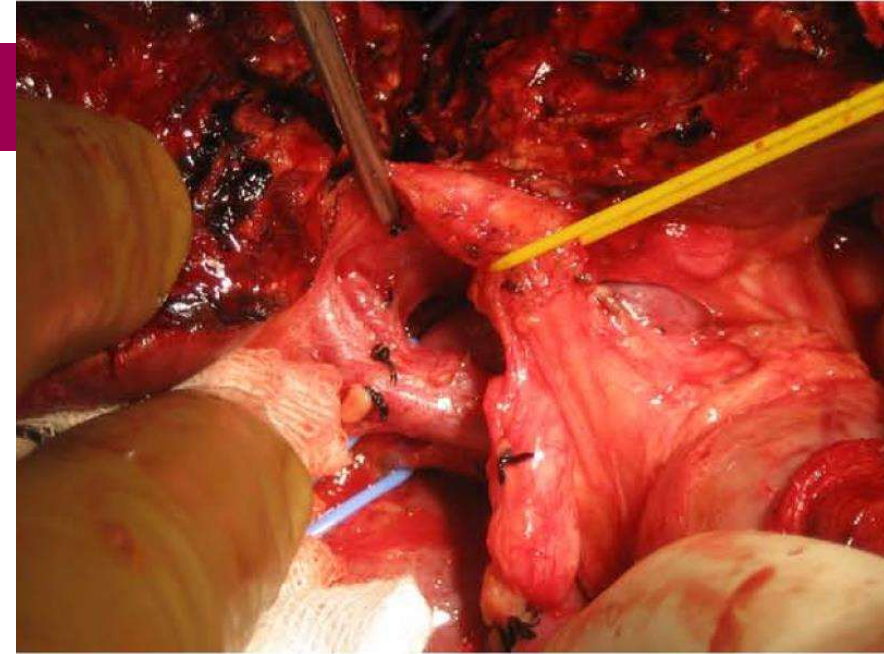
Hilar Plate Glissonian Sheath

Evolution of a Reliable Biliary Reconstructive Technique in 400 Consecutive Living Donor Liver Transplants *J Am Coll Surg* Vol. 211, No. 1, July 2010

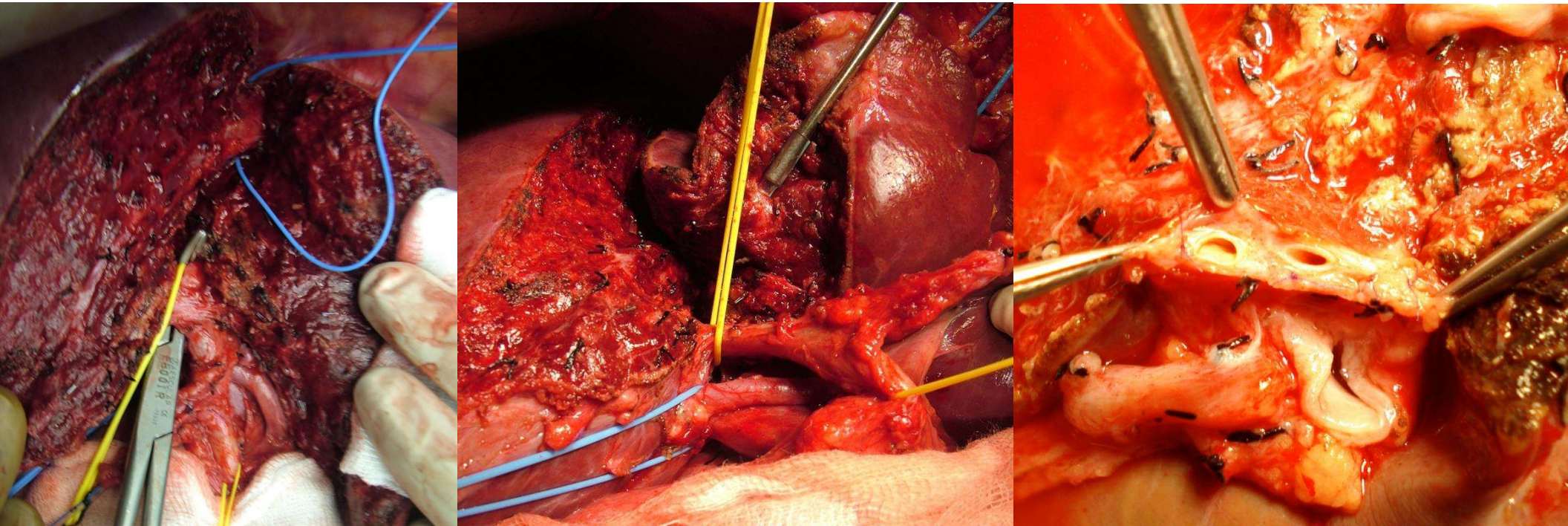
Arvinder Singh Soin, MBBS, MS, FRCS, Vinay Kumaran, MBBS, MS, M Ch,
Amit Nath Rastogi, MBBS, MS, DNB, Ravi Mohanka, MBBS, MS, DNB, Naimish Mehta, MBBS, MS FACRSI,
Sanjiv Saigal, MBBS, MD, DNB, DM, MRCP, Neeraj Saraf, MBBS, MD, DNB, Neelam Mohan, MBBS, DNB,
Samiran Nundy, MA, FRCS, FRCP, M Ch

Of the 460 LDLTs done at our center before November 2009, the first 402 partial liver grafts had at least 3 months of follow-up. In the first 158, conventional hepatic duct isolation was used in the donor (group C). In the last 244 cases, the complete hilar plate and Glissonian sheath approach (HPGS) was used (group H). We compared the incidence and outcomes of BCs in the 2 groups.

The rate of BC was significantly lower in group H (5.3%) than in group C (15.8%, $p = 0.000$). The incidence of early (within 3 months of transplant) BCs was similarly significantly lower in group H (3.3%) than in group C (13.2%, $P=0.000$). The incidence of late BCs in the 145 patients in group H who had completed at least 12 months of follow-up was 2.8%. The proportion of BCs needing surgical correction was much higher in group C (44%) than in group H (7.7%, $p = 0.022$).

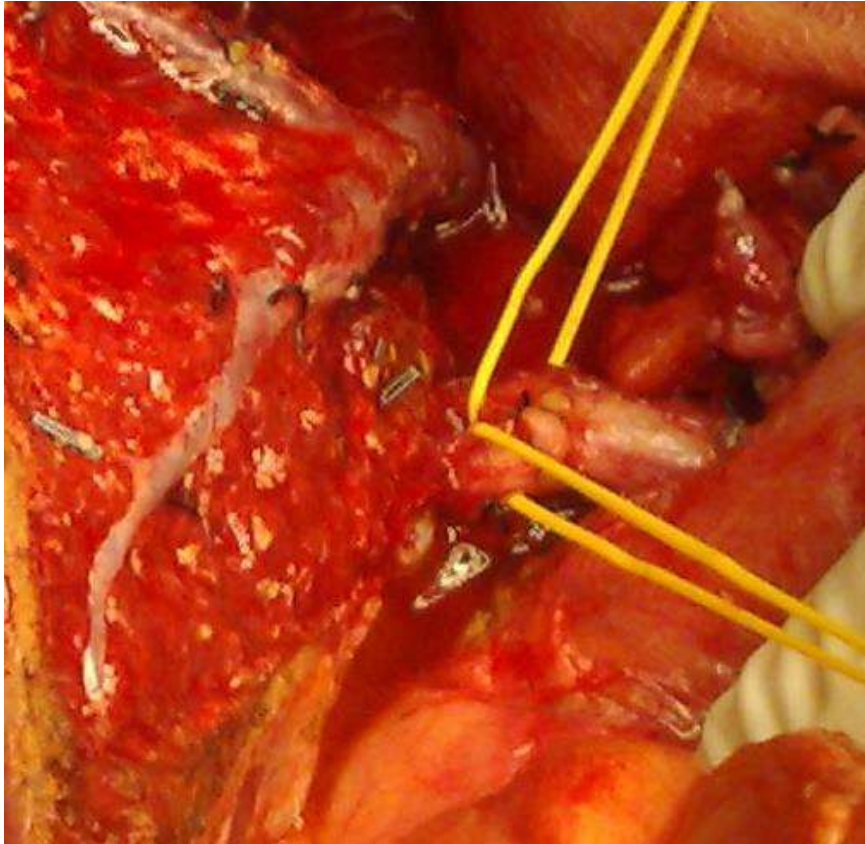


Bile duct division



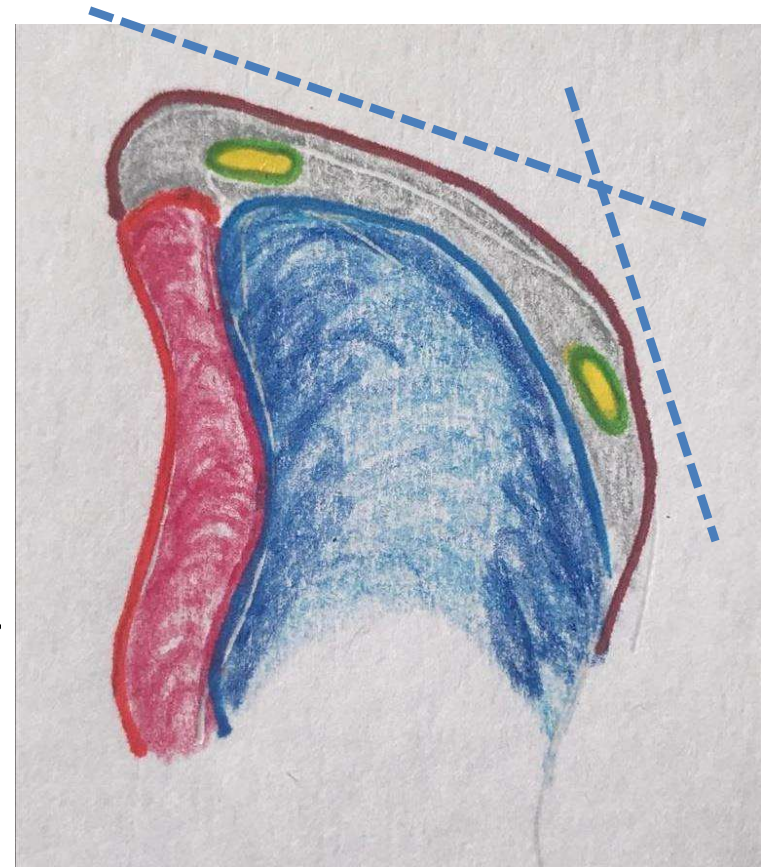
All soft tissue (containing peri-ductal plexus) other than PV or HA stays with the bile duct
Sutures hold well on fibrous tissue

Bile duct division



The anterior and posterior hepatic ducts may be on **different axes**

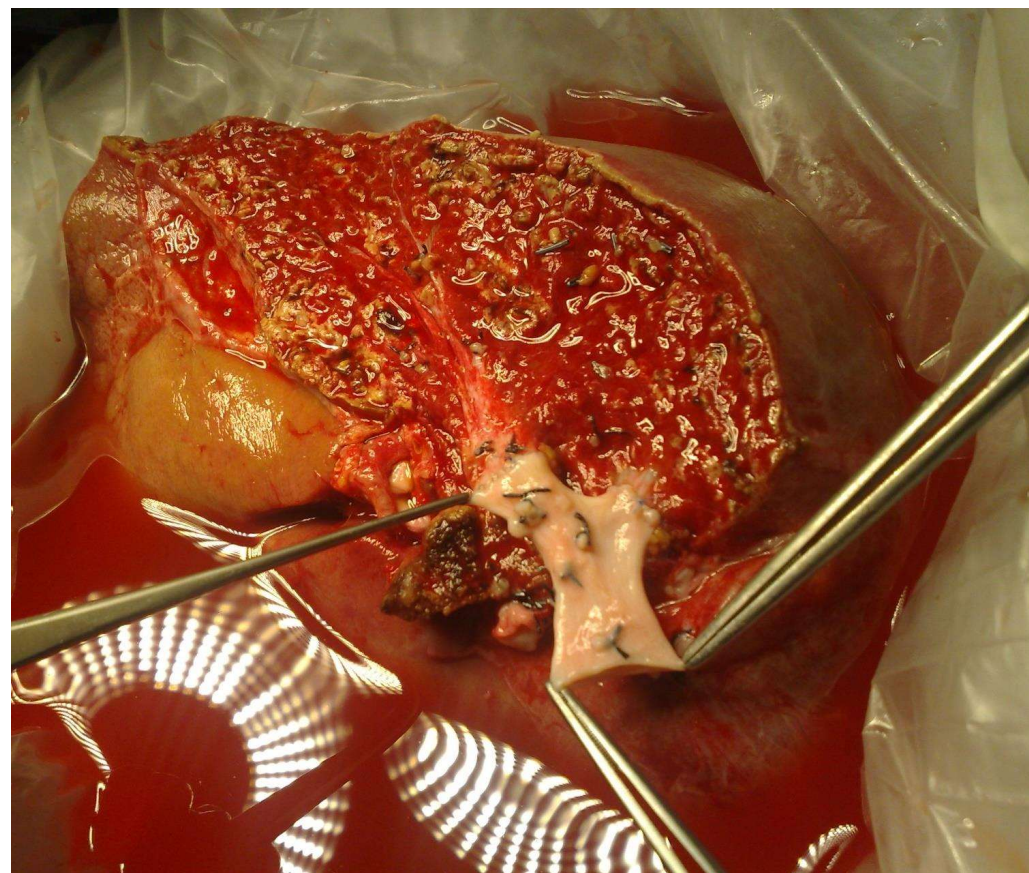
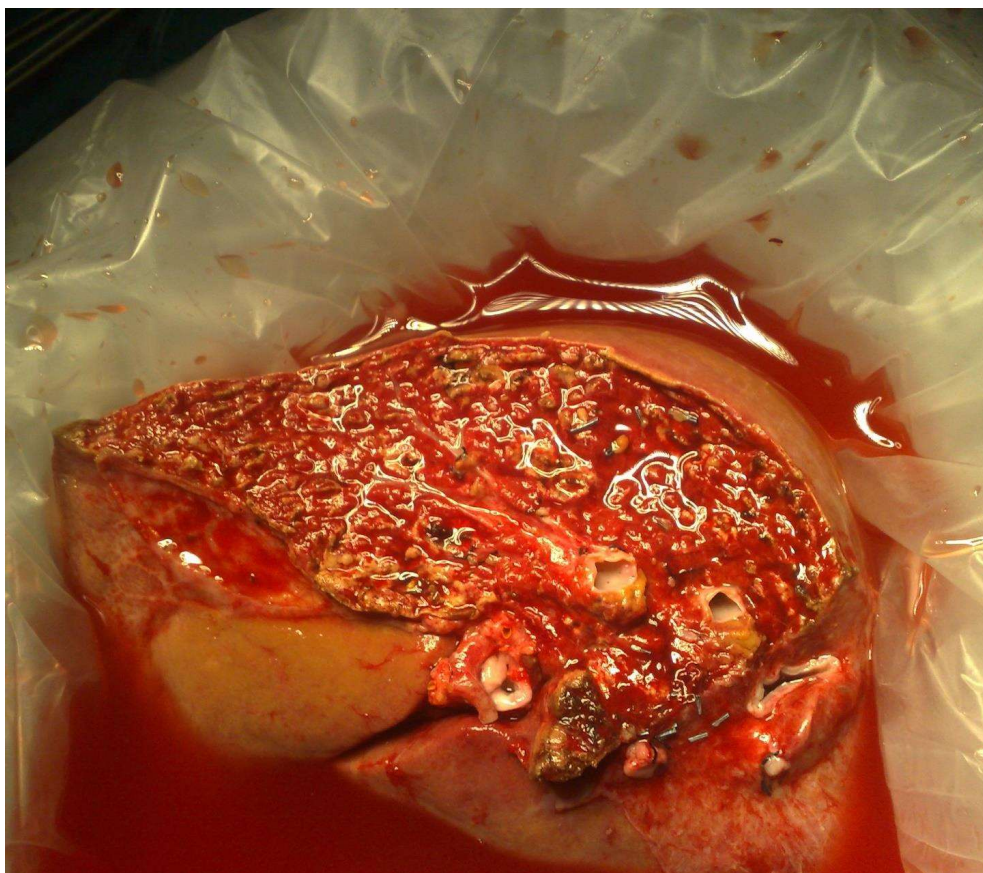
HPGS preserves their relative orientation



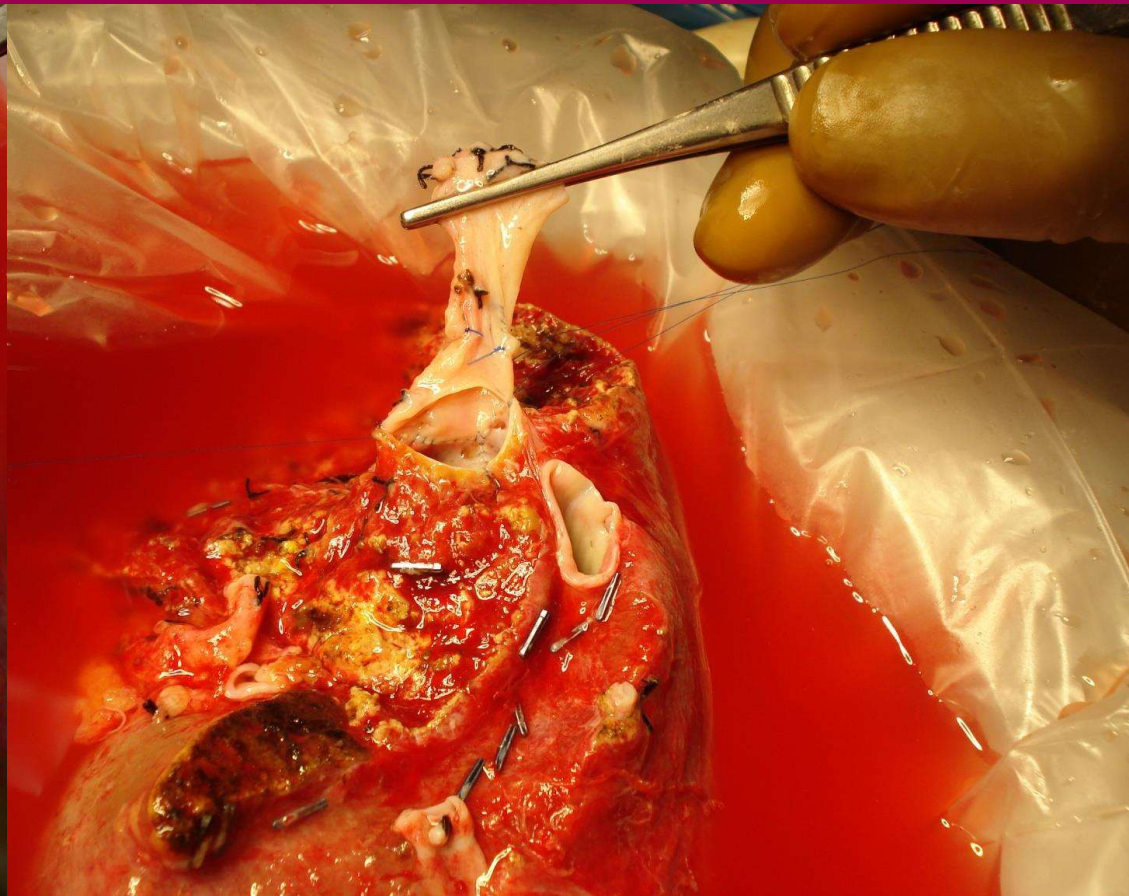
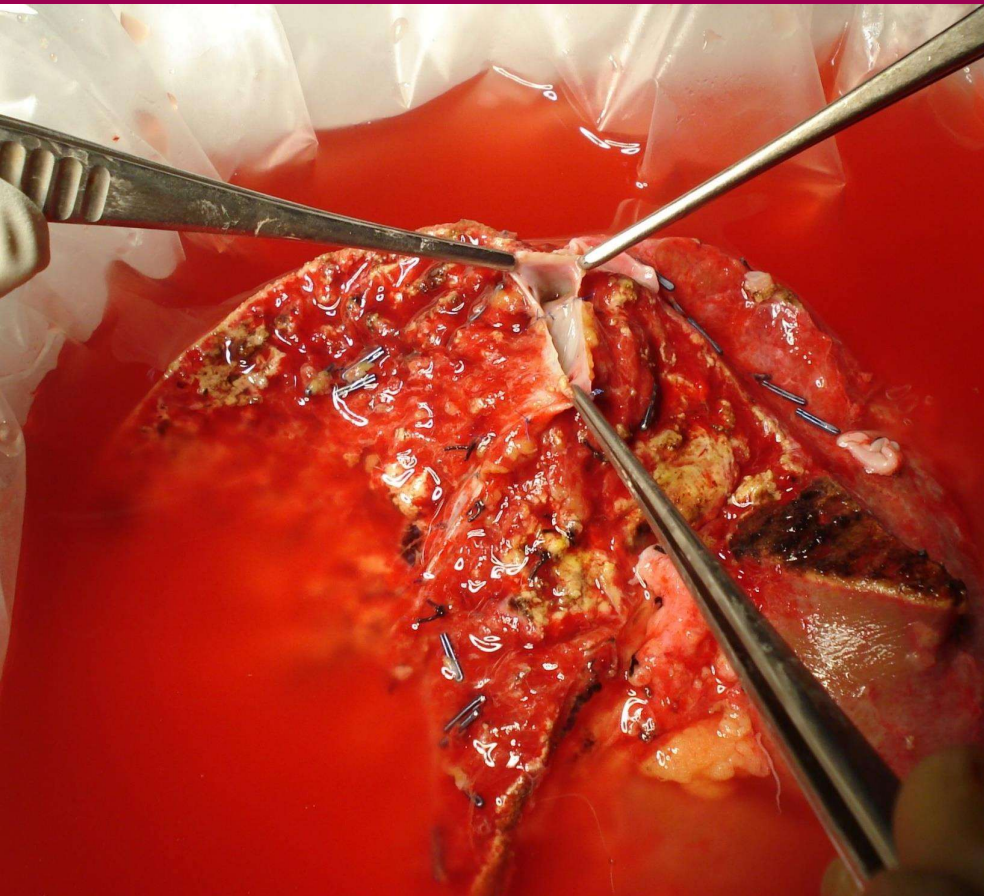


Bench surgery

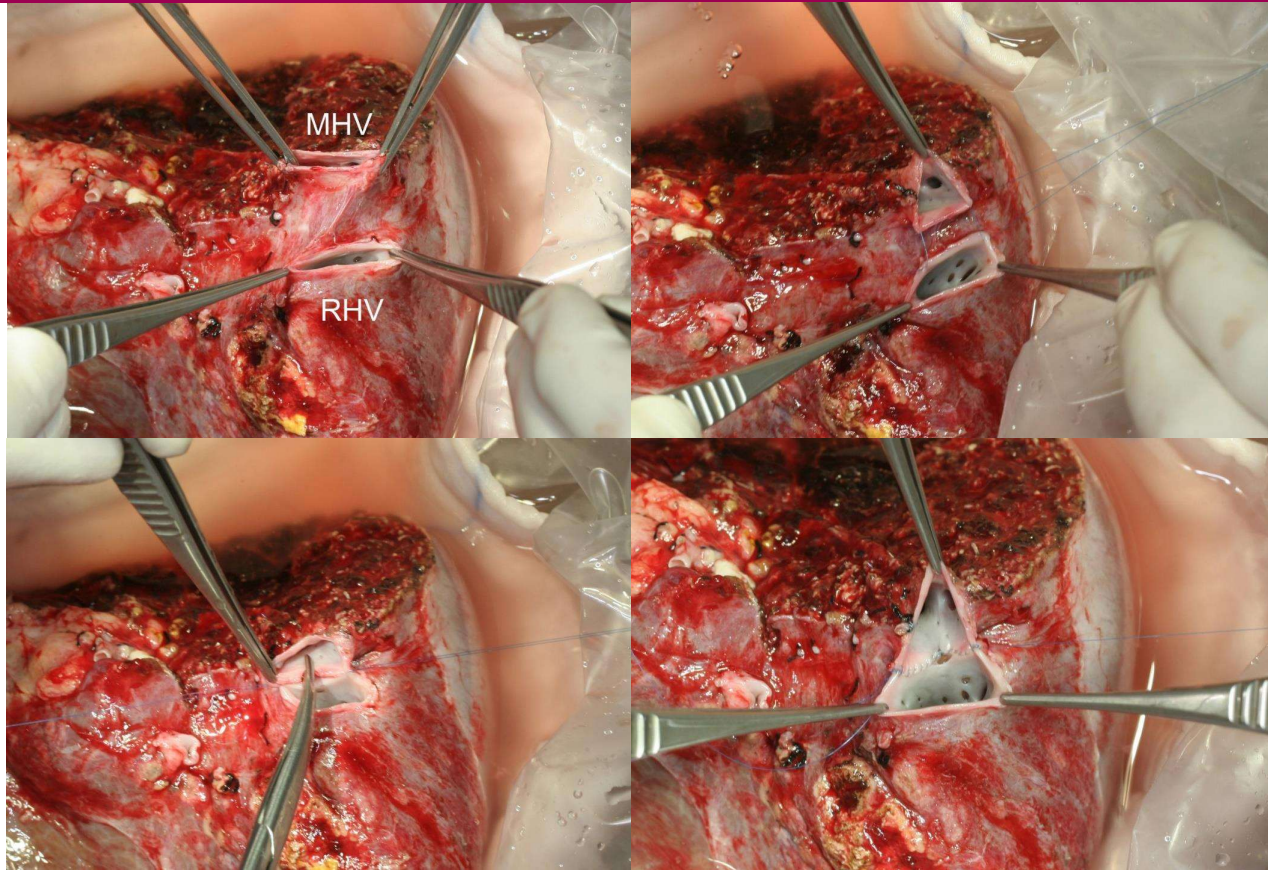
Graft flush and outflow reconstruction



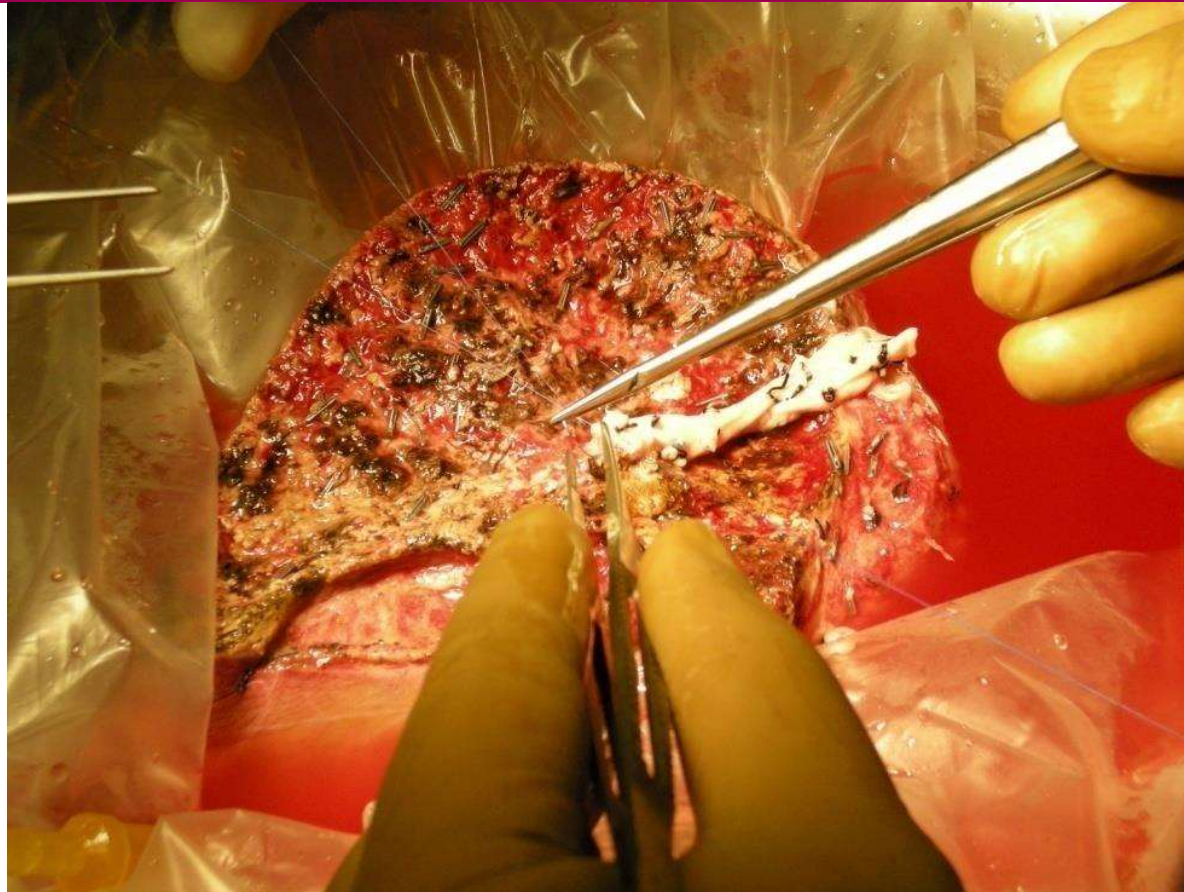
Outflow reconstruction



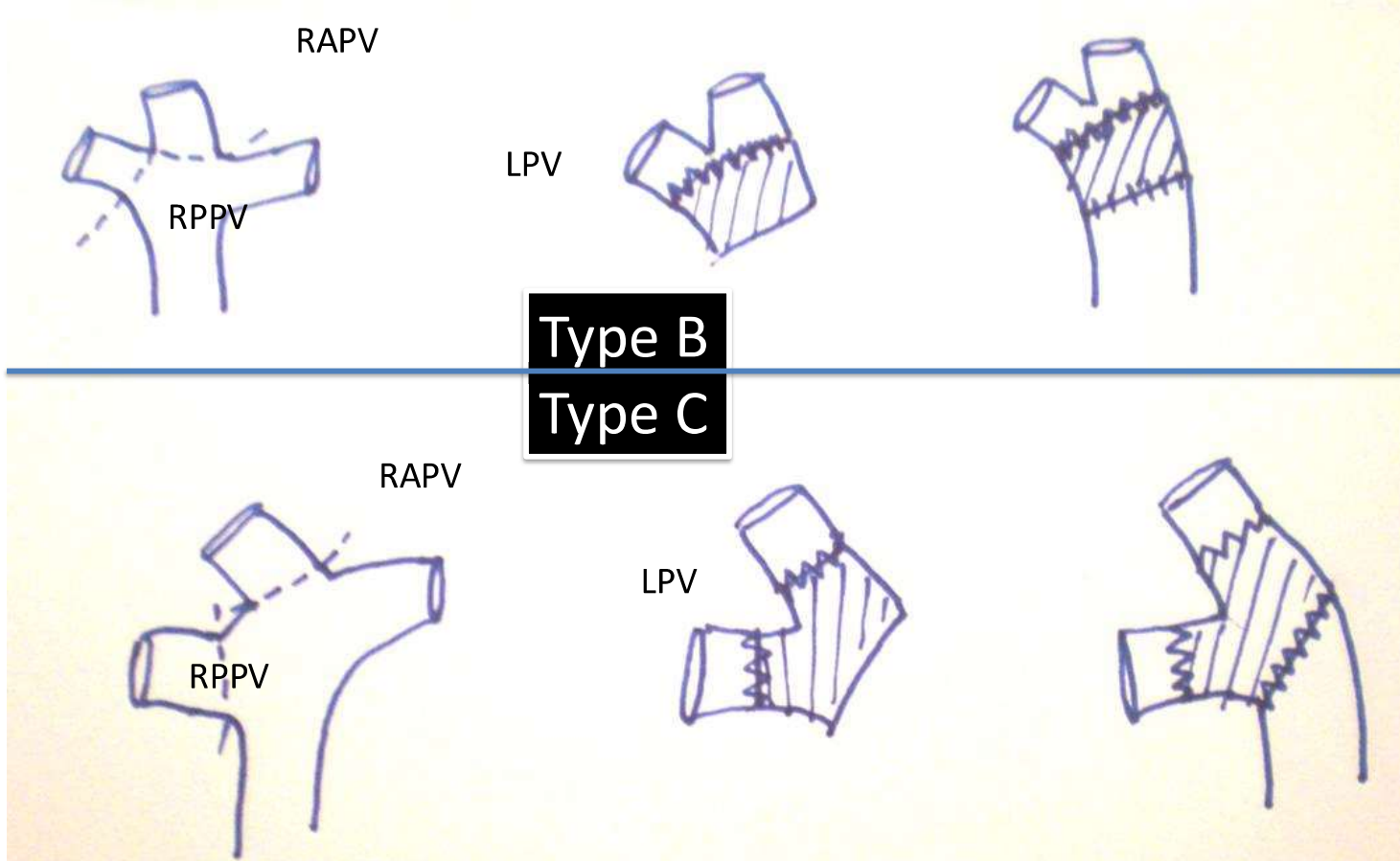
Outflow reconstruction



Outflow reconstruction: neo MHV



Portal vein reconstruction



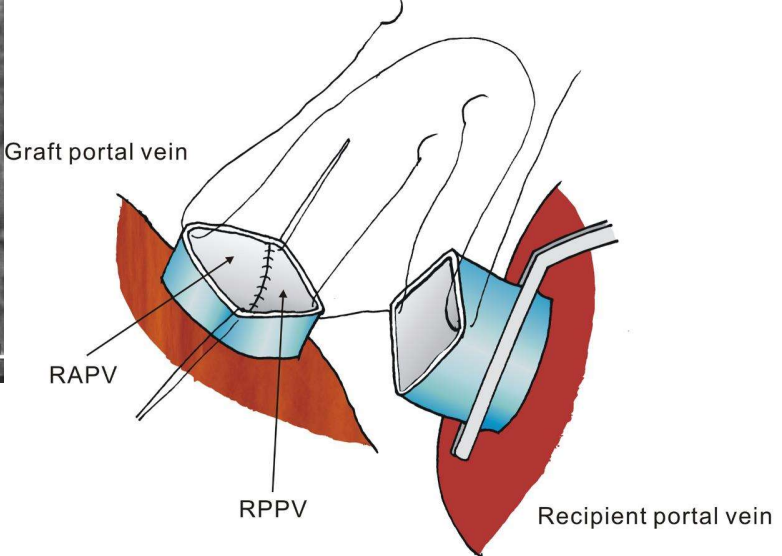
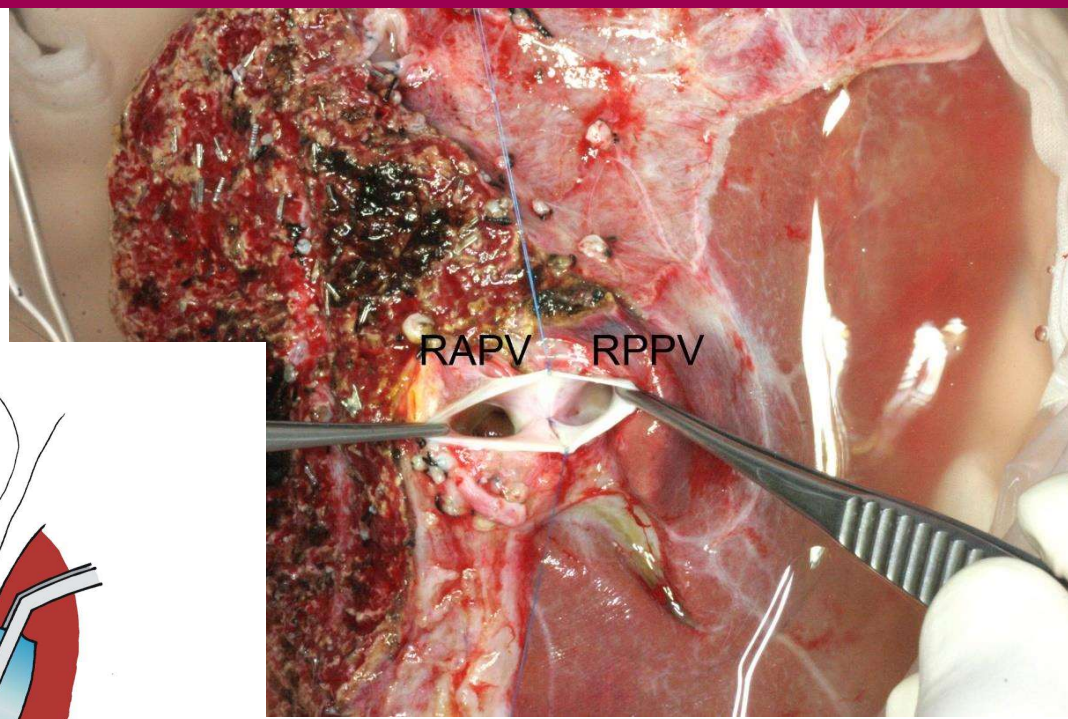
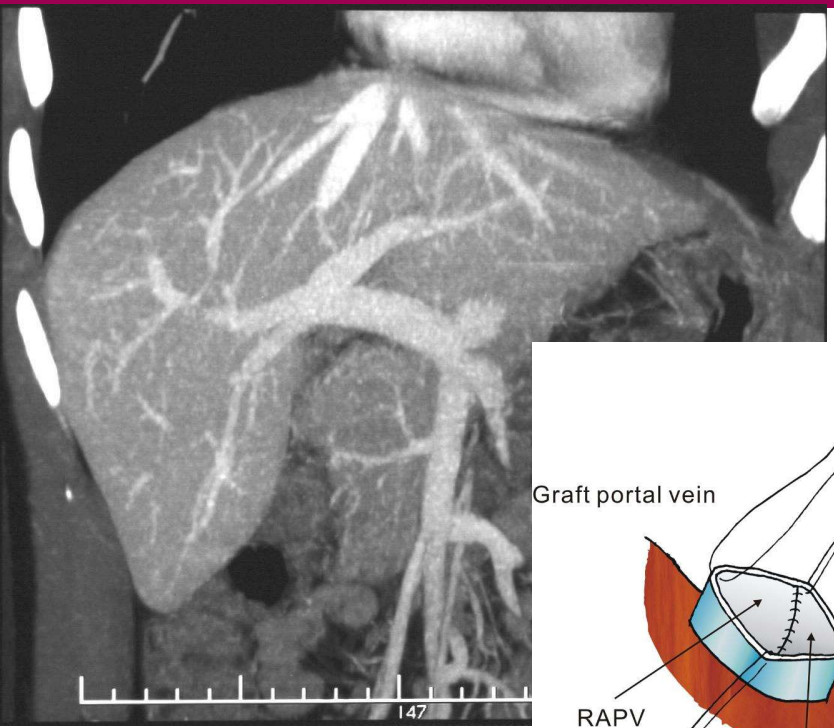
- Straight extension

- Y graft extension

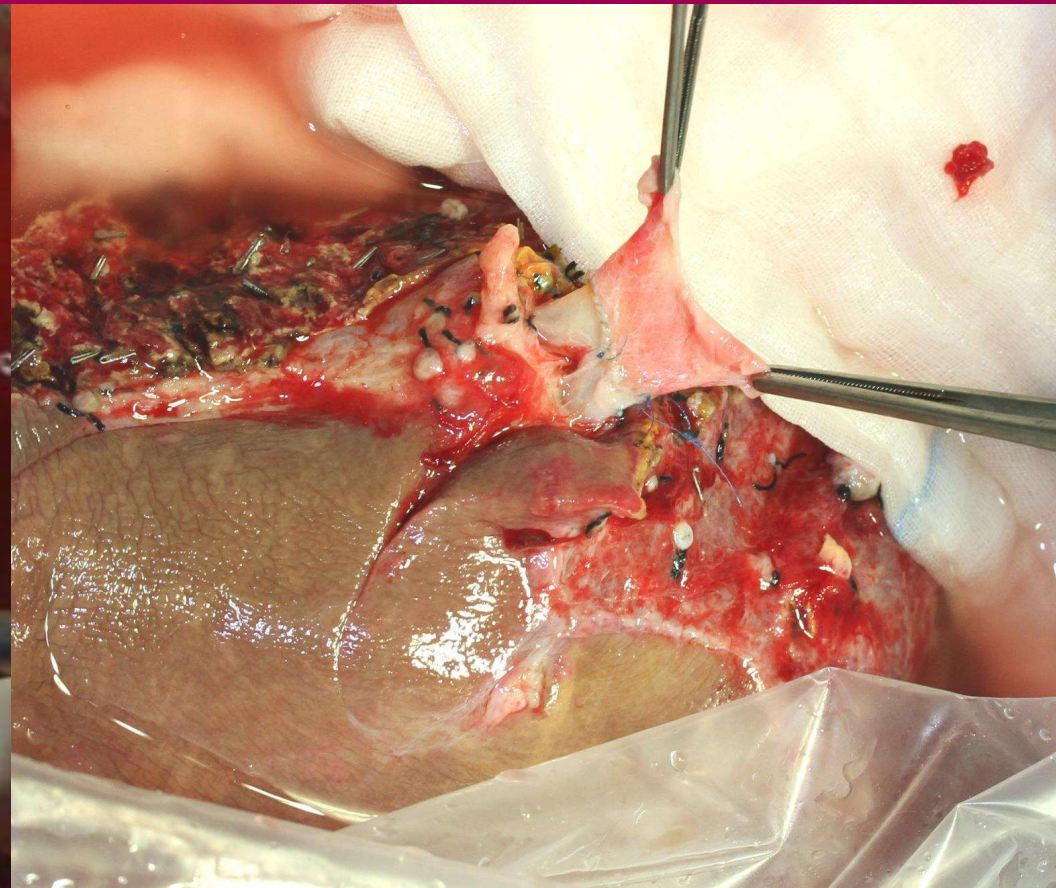
- Single in vivo

anastomosis

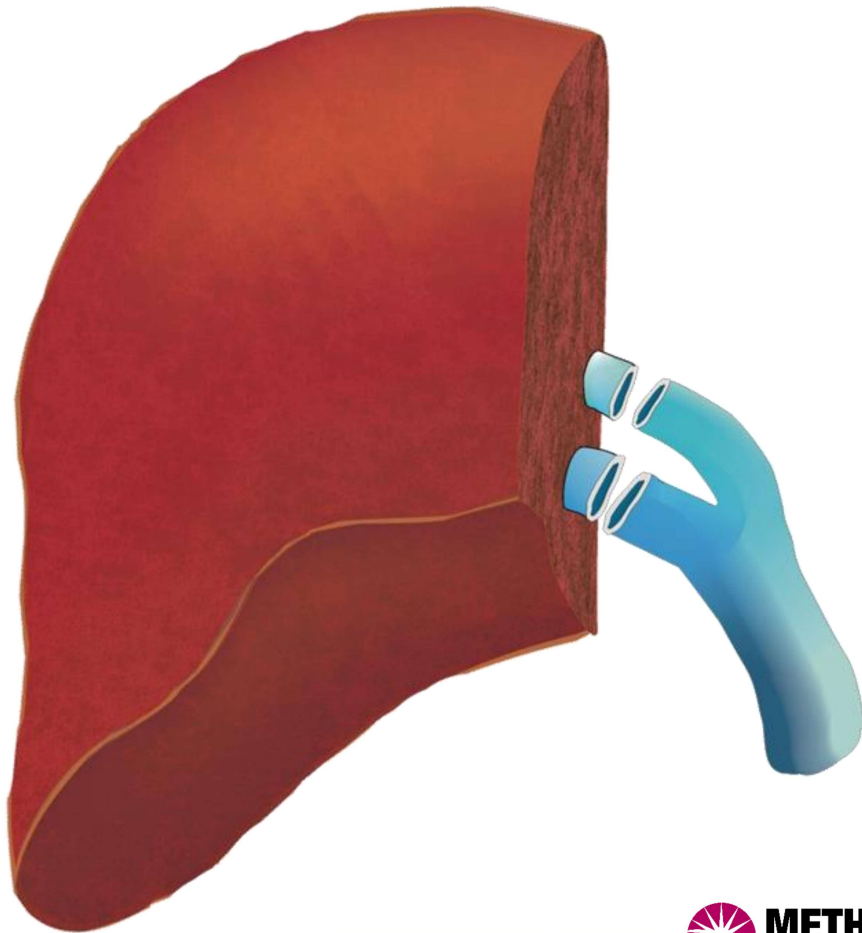
PV reconstruction



PV reconstruction: straight extension



PV reconstruction: Y extension

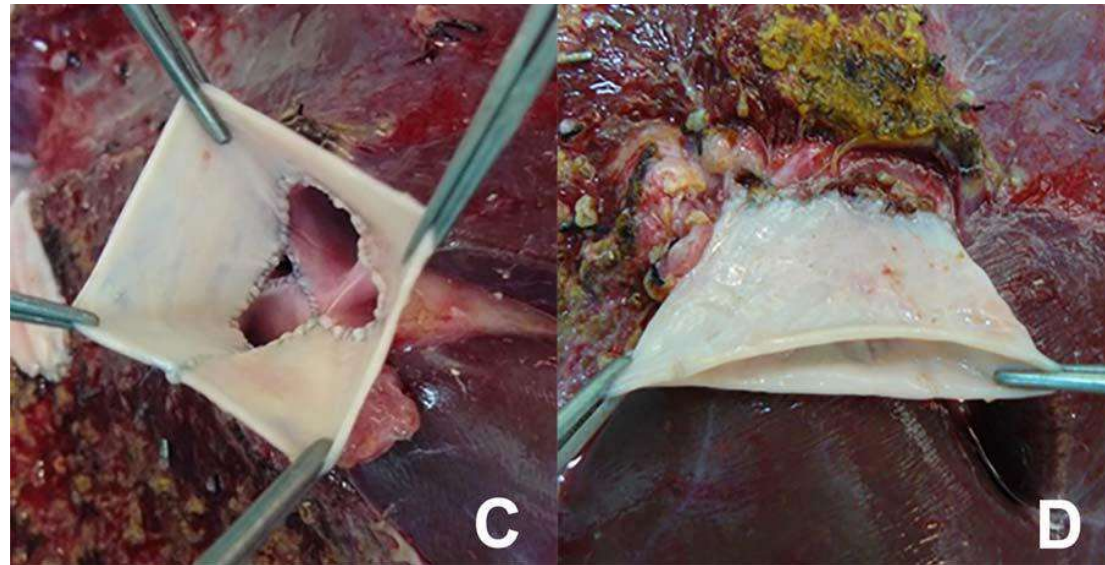




Reconstruction of Anomalous Portal Venous Branching in Right Lobe Living Donor Liver Transplantation: Malatya Approach

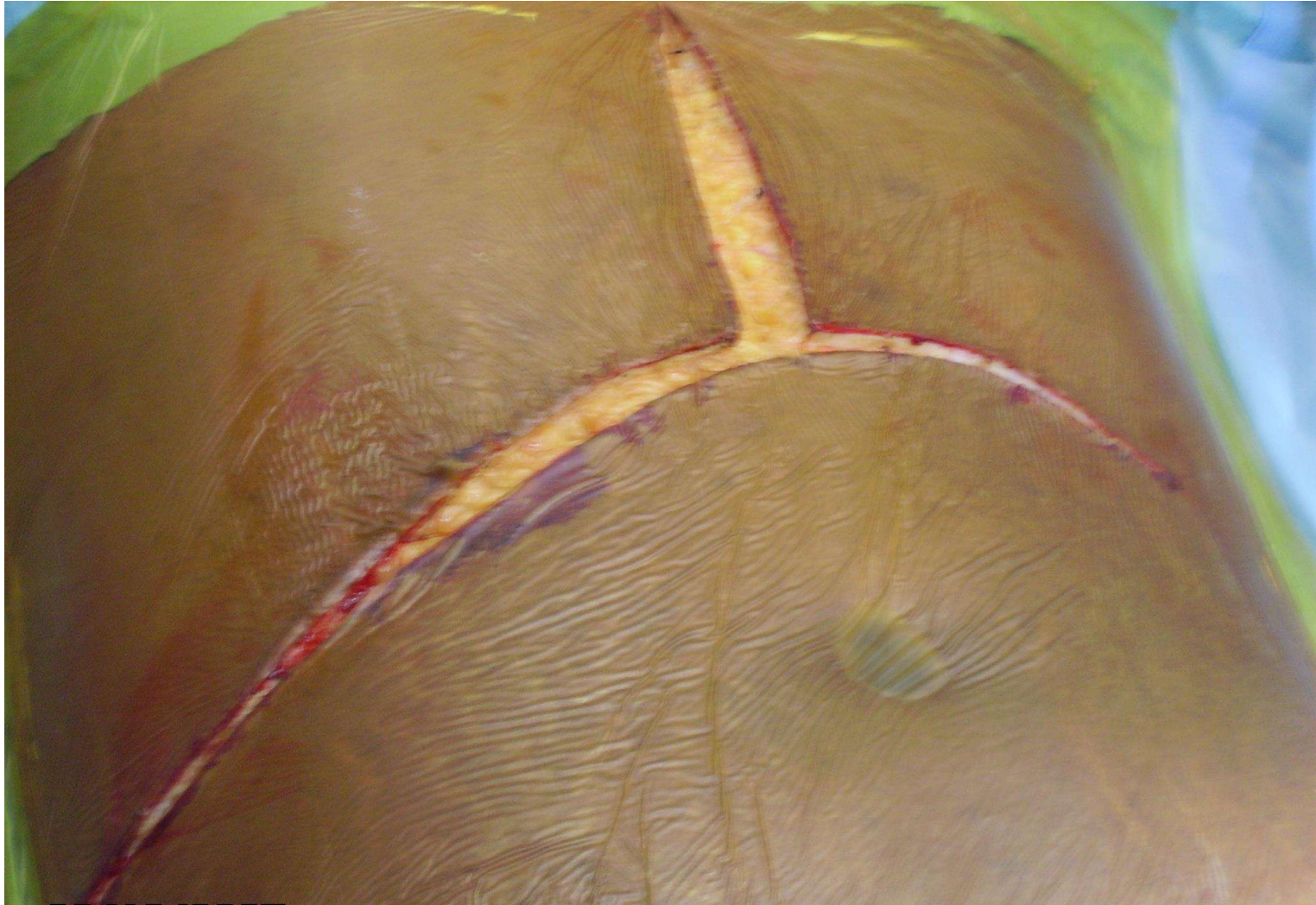
Chetan Ramesh Kalal, Hunaid Hatimi, Ravi Mohanka

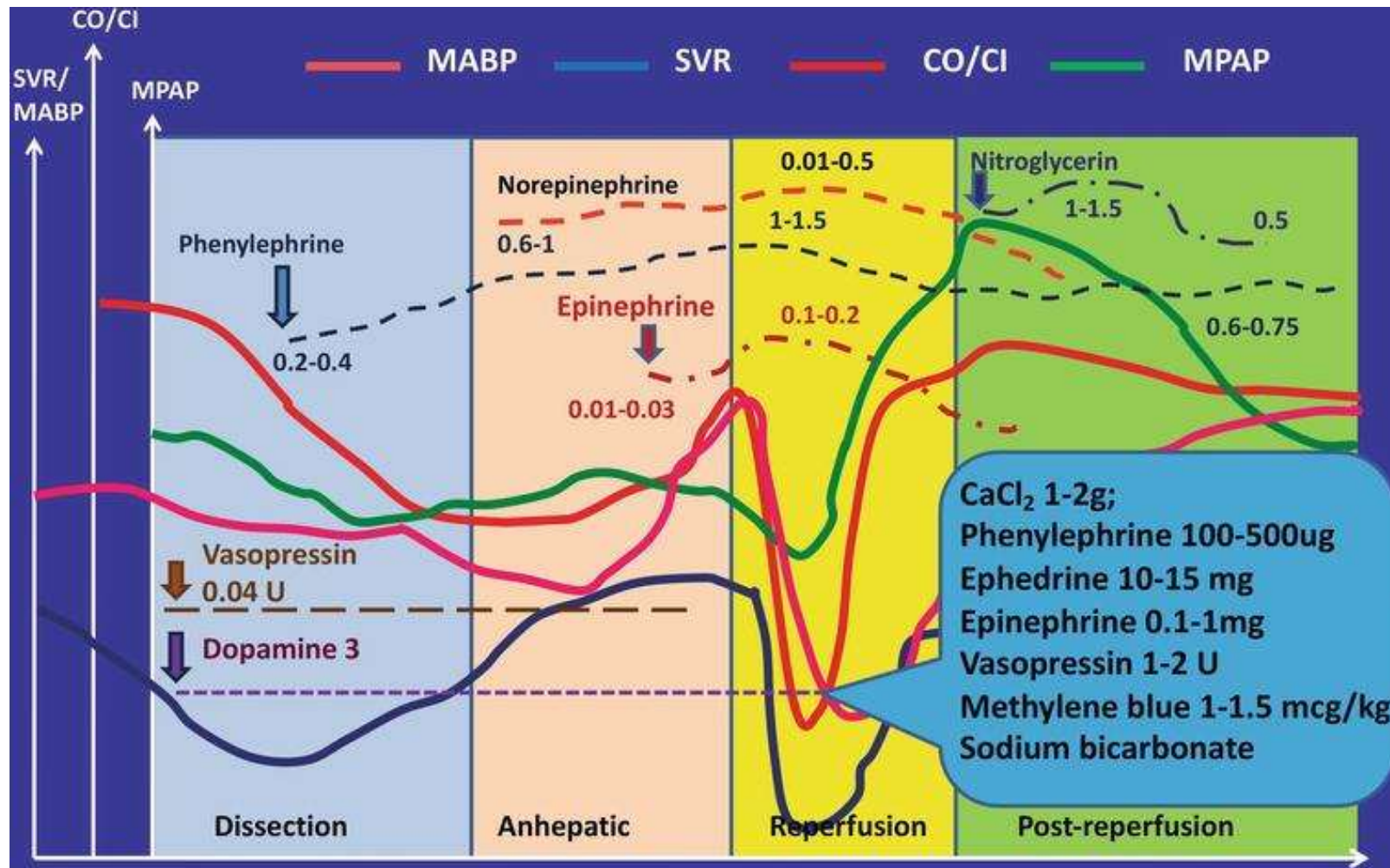
Liver Transpl. 2017 Jun;23(6):751-761

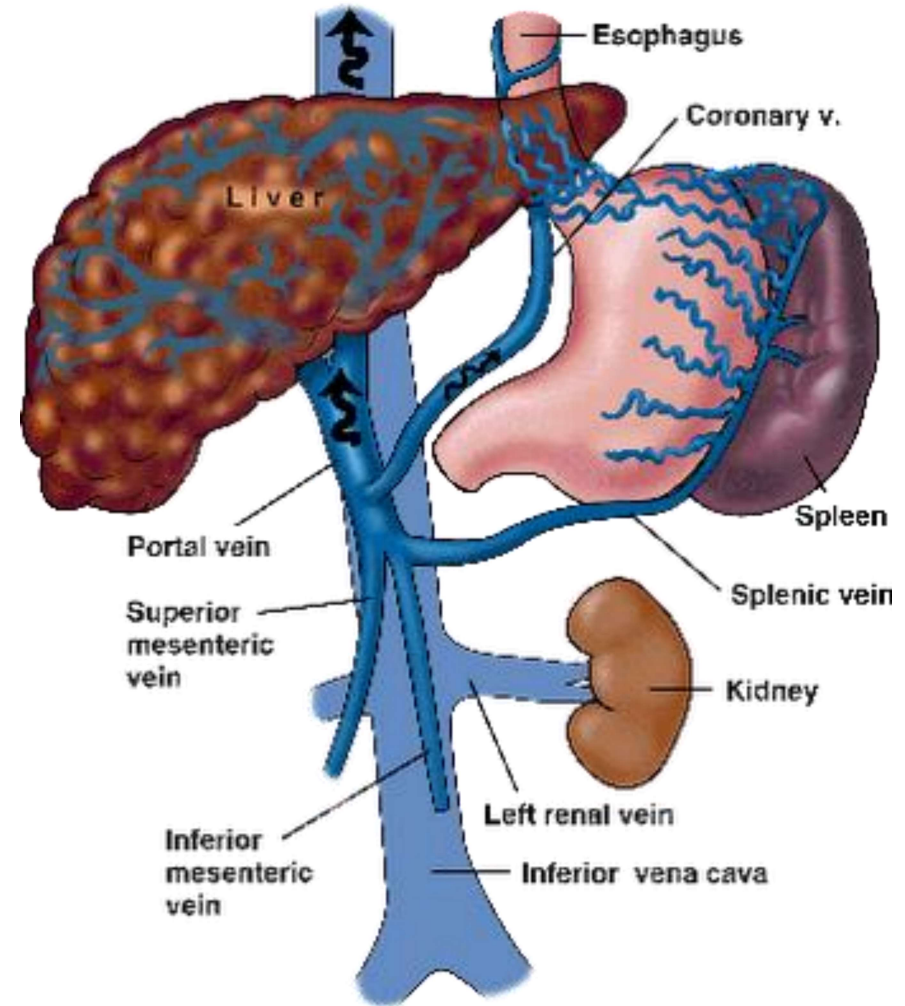
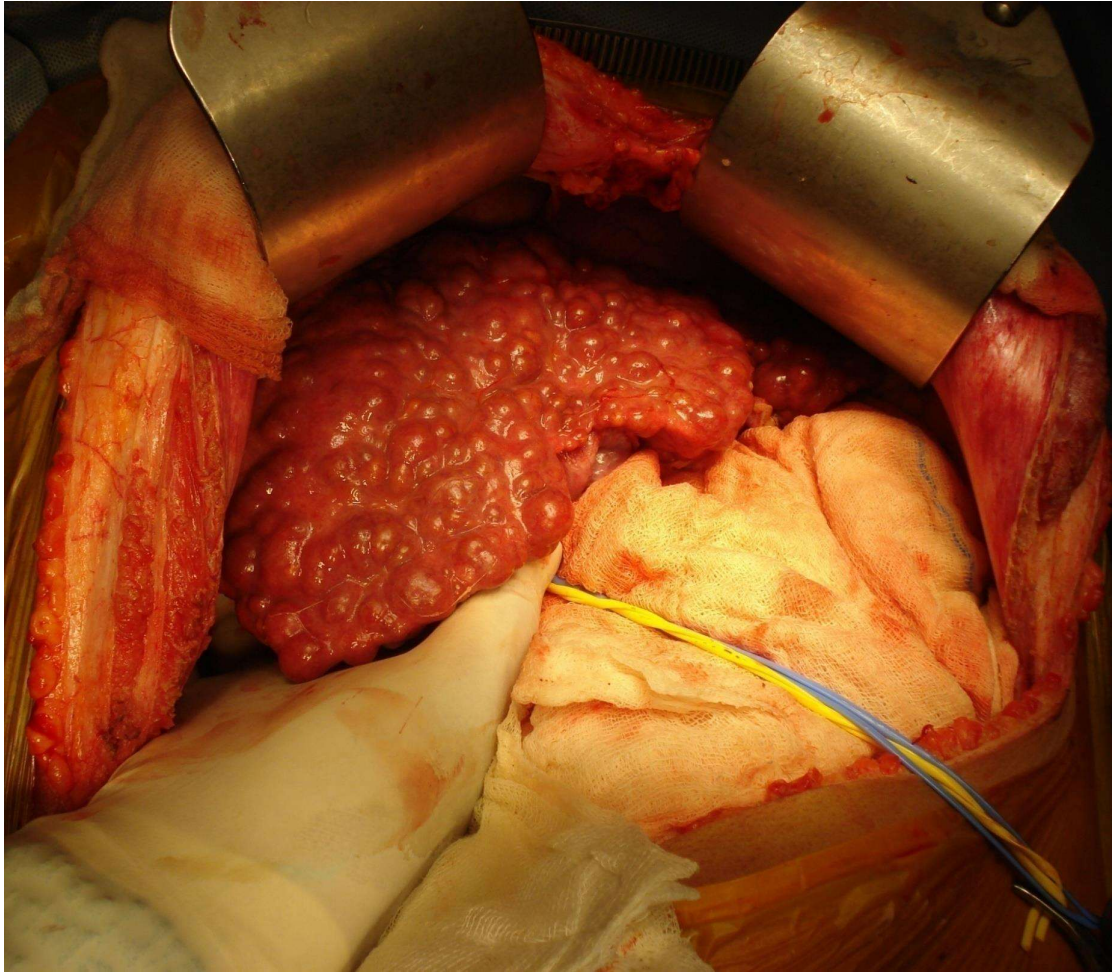


A stylized sunburst graphic composed of several triangular rays of varying lengths and angles, all pointing outwards from a central point. The rays are a lighter shade of the background maroon color. The background is a solid, deep maroon color.

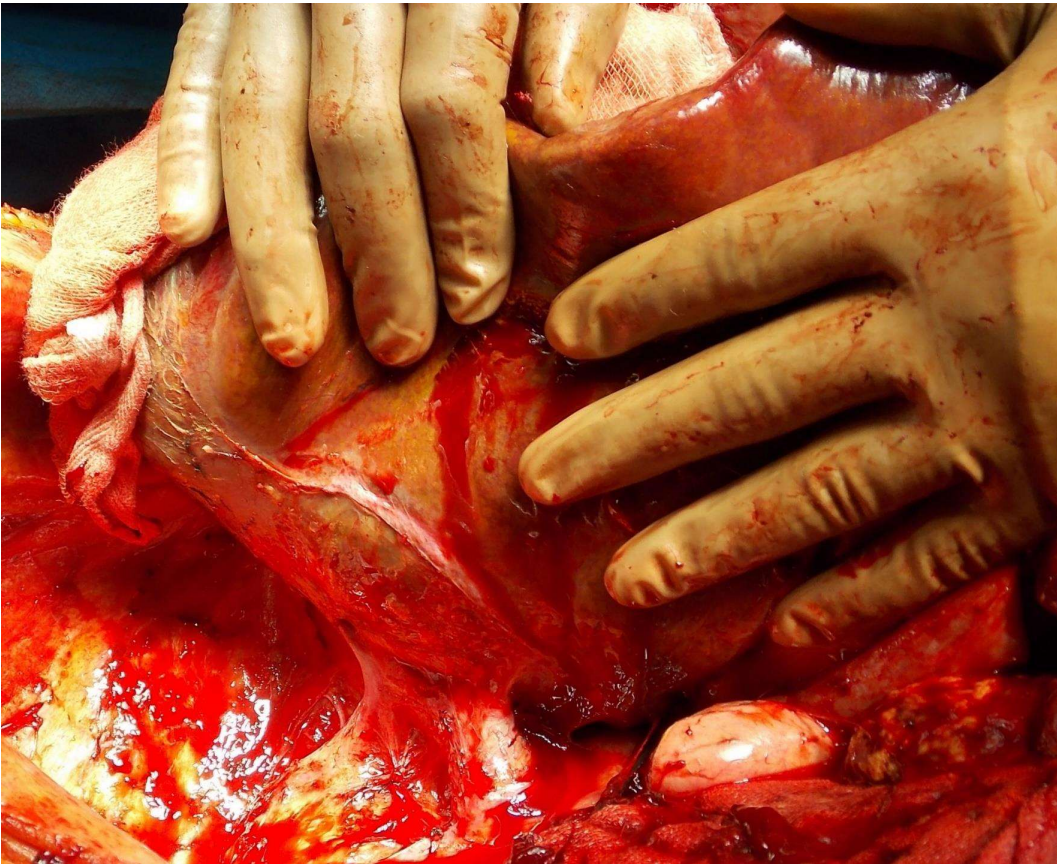
Recipient surgery





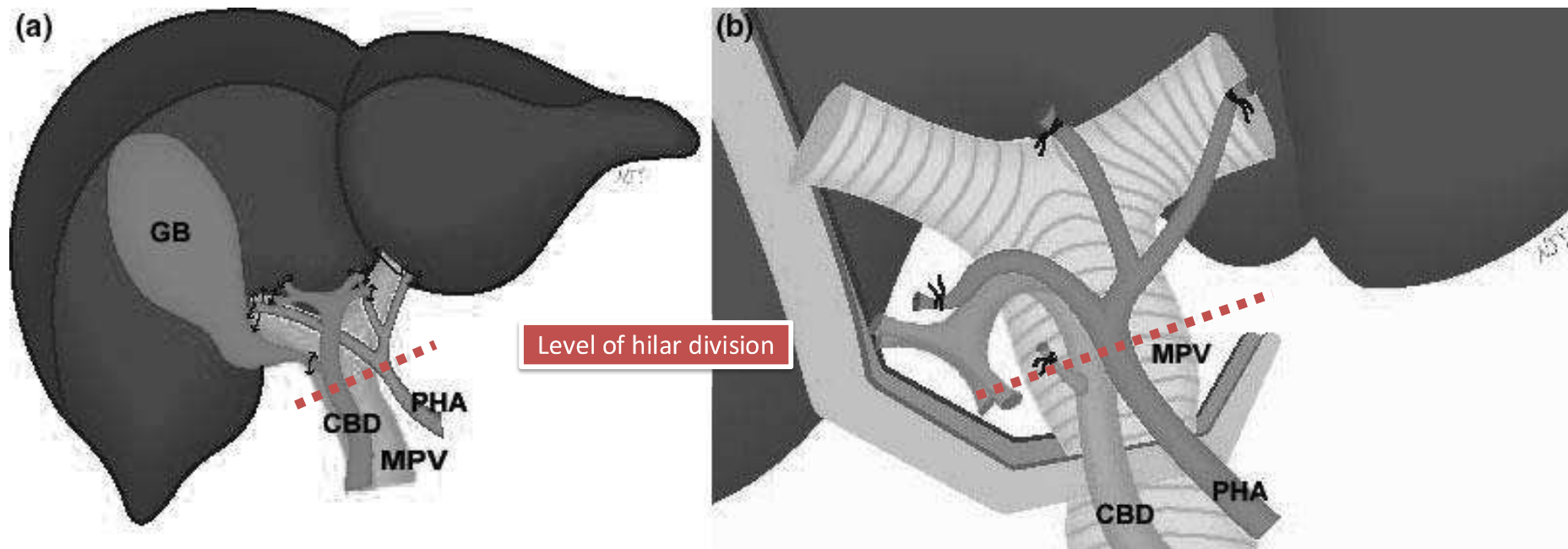


Piggyback the liver off the IVC



- Collaterals ++
- Adrenal may be stuck
- Adrenal vein
- Large RIHVs

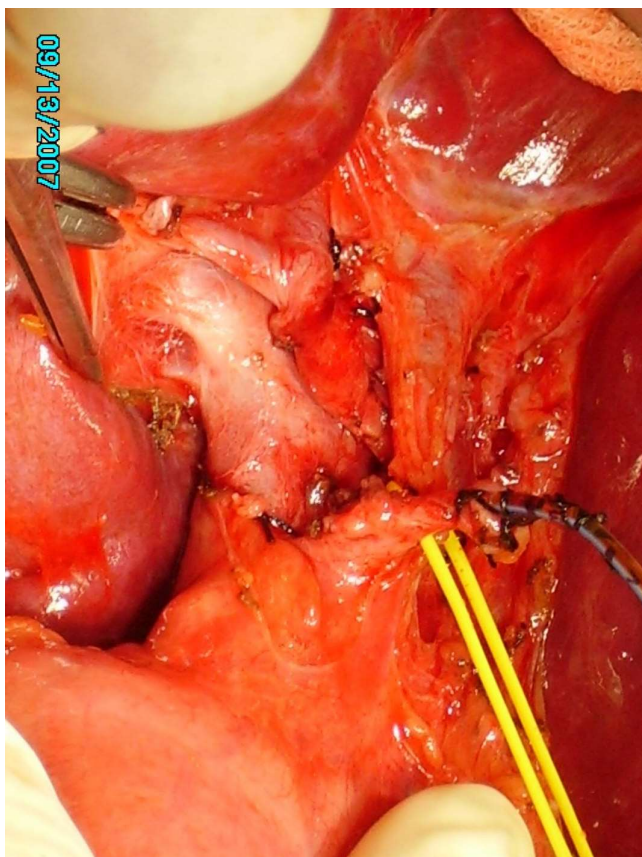
Recipient: High hilar dissection



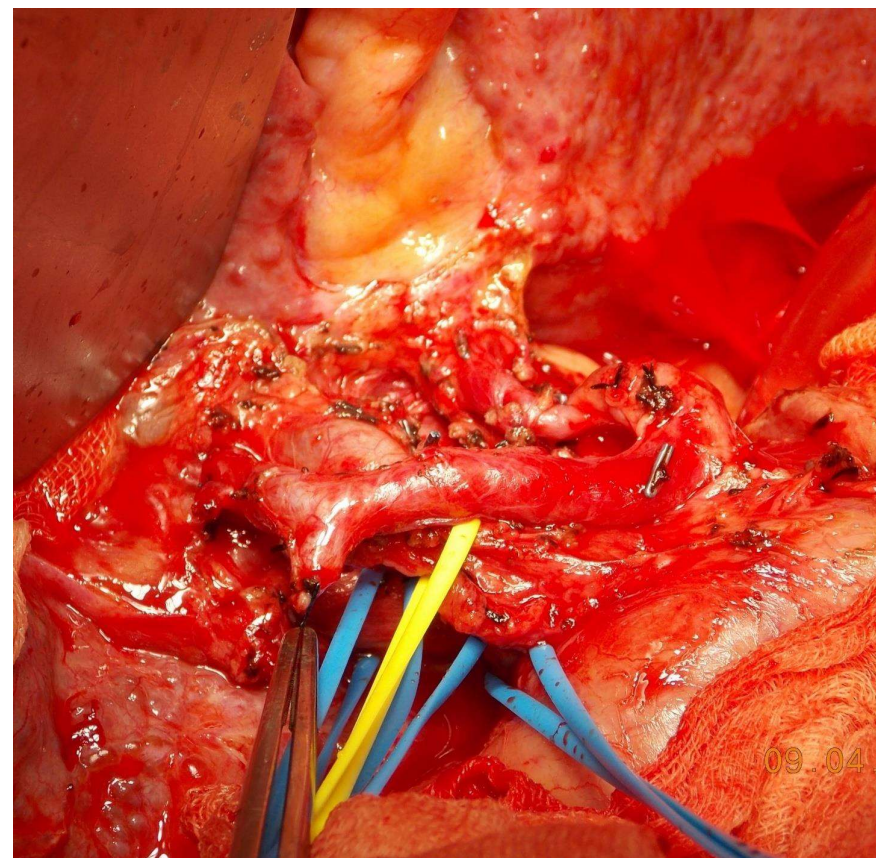
- Peri-biliary collaterals ++
- Replaced/accessory arteries

- Risk of arterial dissection
- Caudate veins

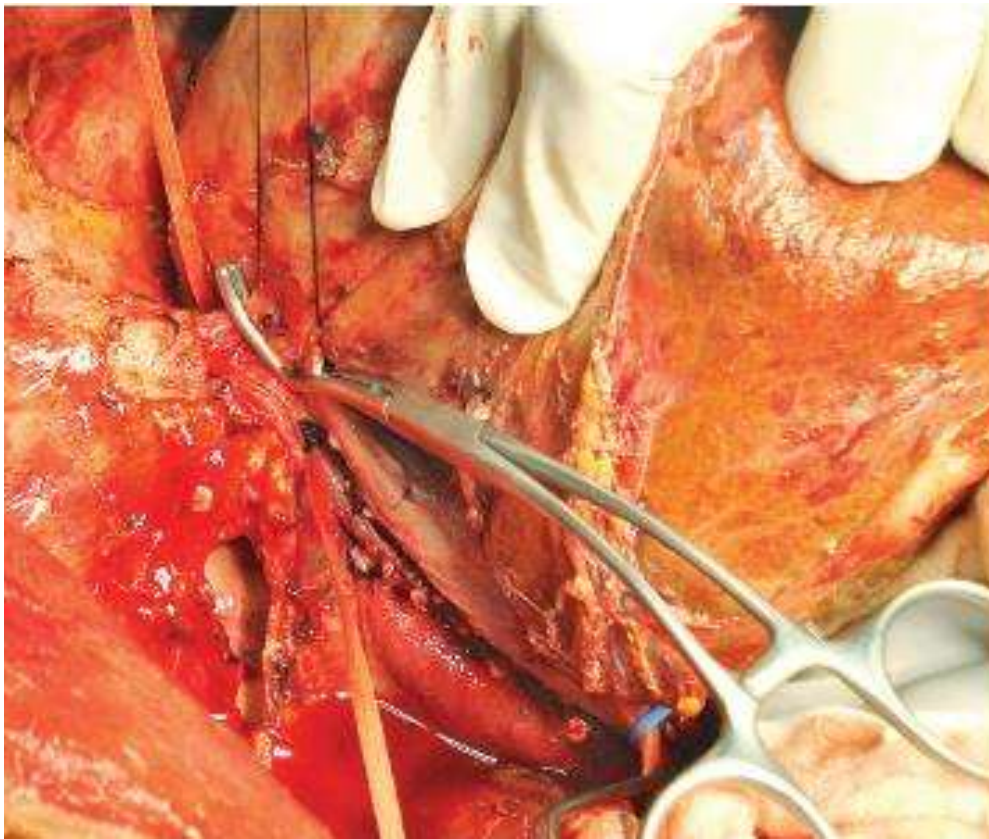
High hilar dissection



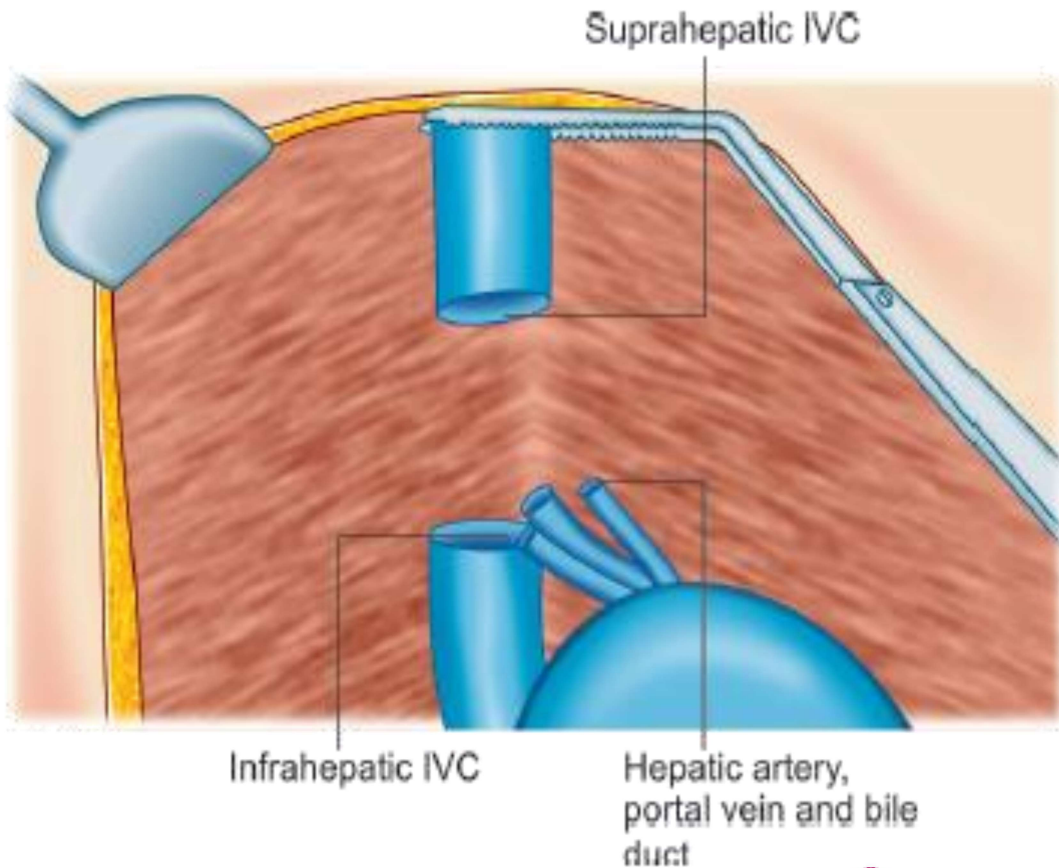
- HA: 2 – 3 mm
- Separate RPV/LPV
(tie caudate veins)
- Separate RHD/LHD



Explant



Classical technique: Anhepatic period



Portal vein clamped

- Worsening PHT
- Bleeding

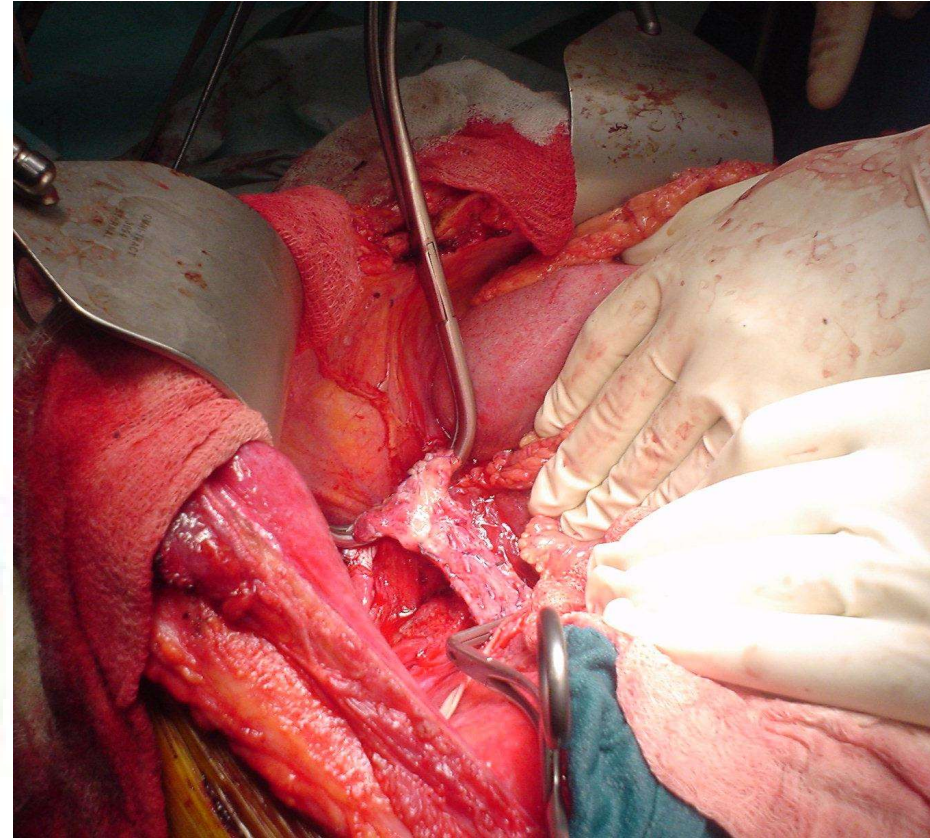
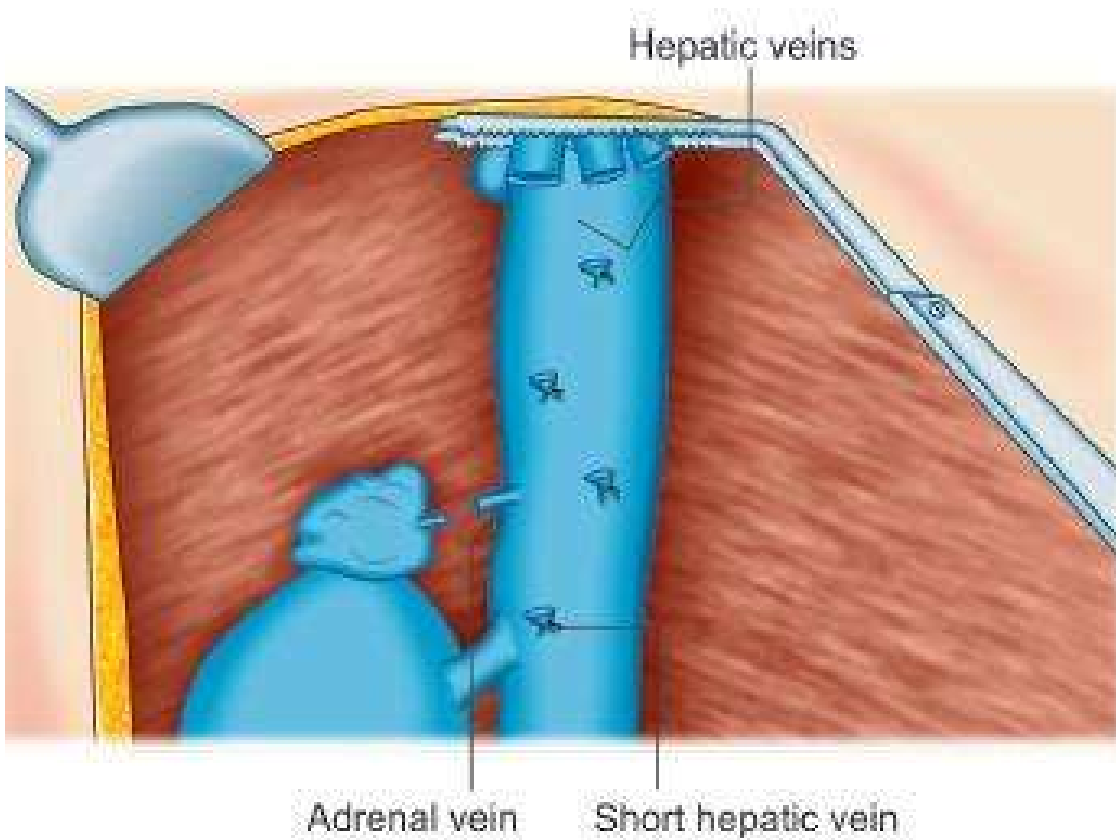
IVC clamped

- Renal/lower limbs congested

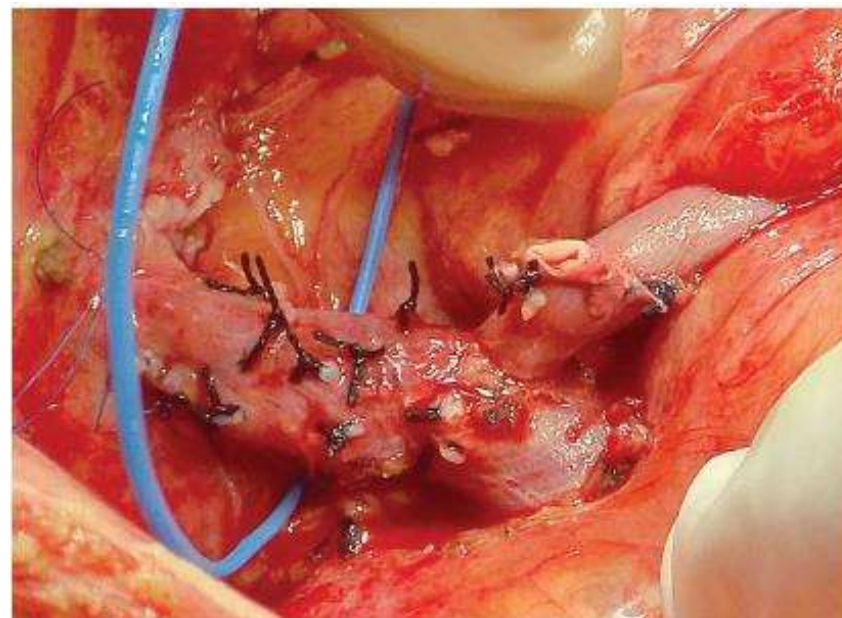
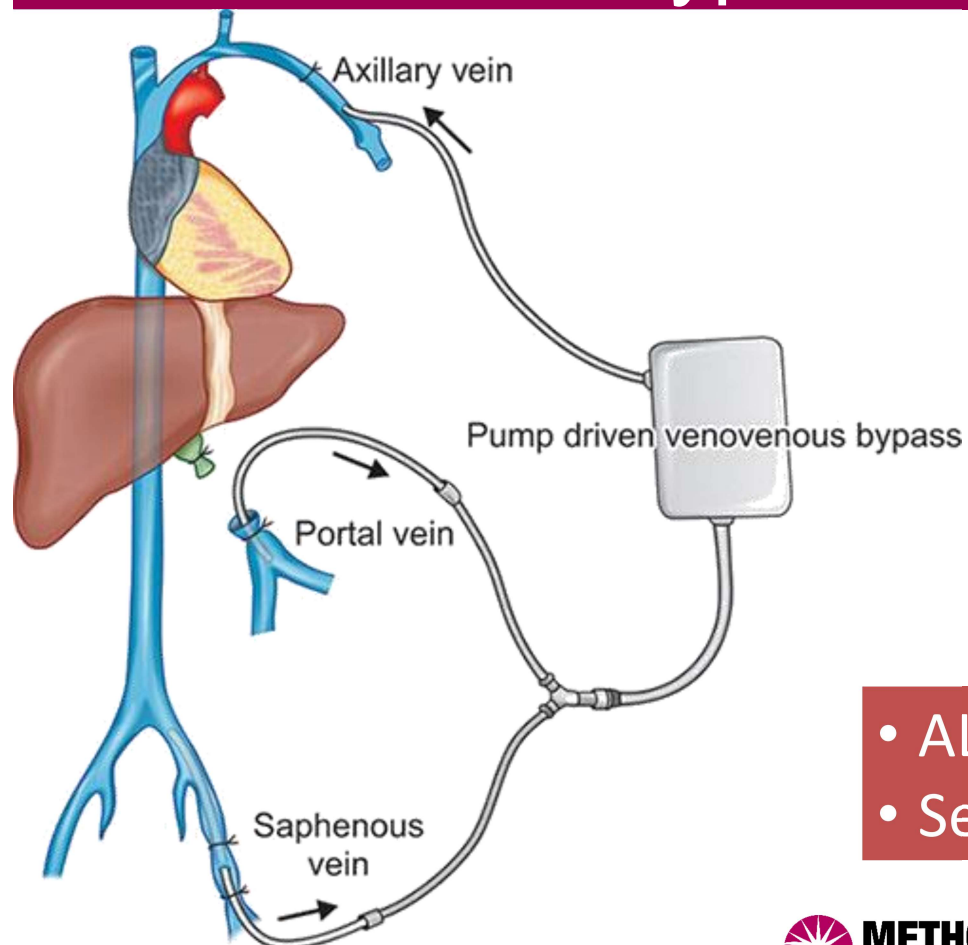
- Cardiac pre-load ↓ ½

- Instability
- Coagulopathy
- Hypothermia
- Acidosis

Piggyback technique: Anhepatic period

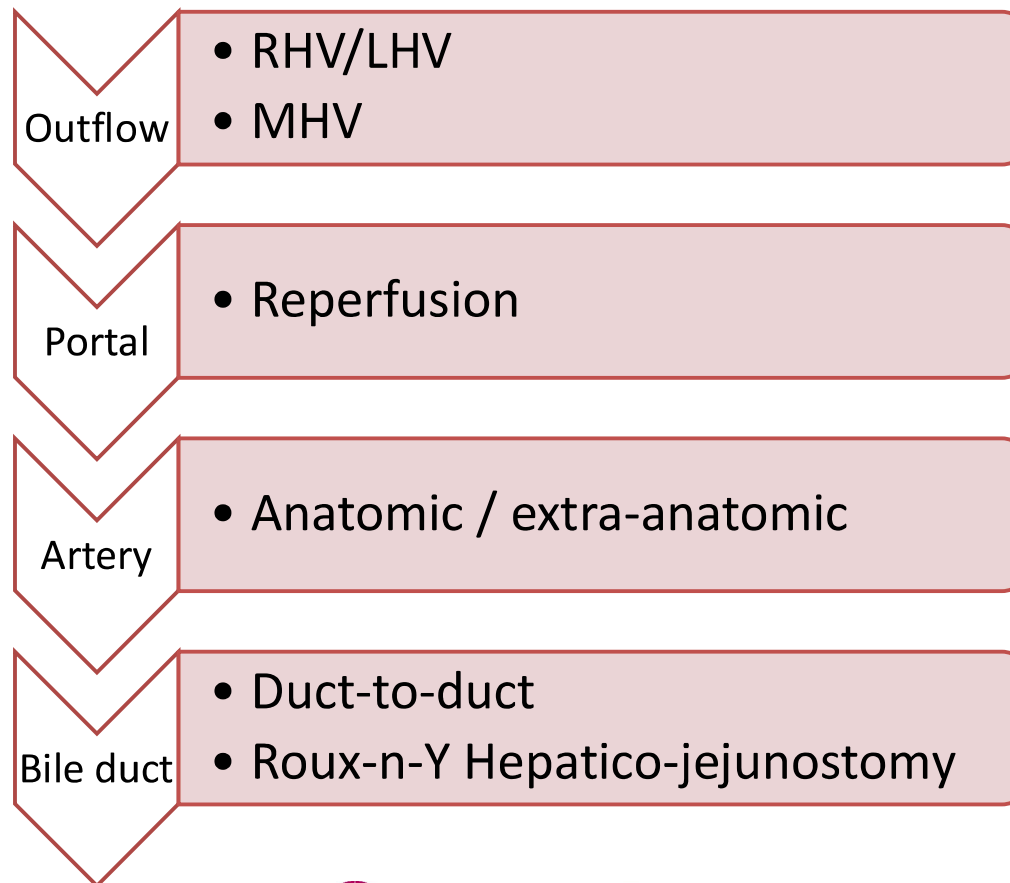


Veno-venous Bypass / Porto-caval shunt

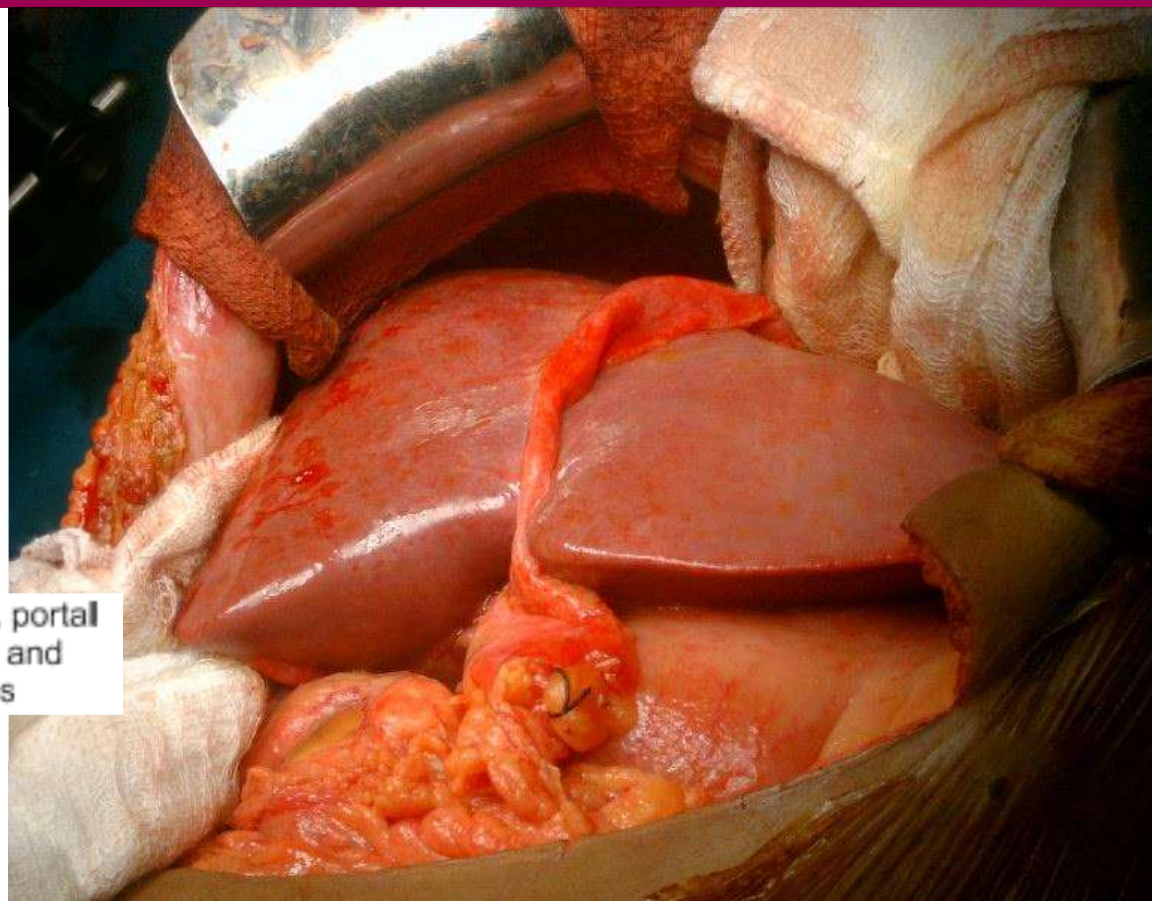
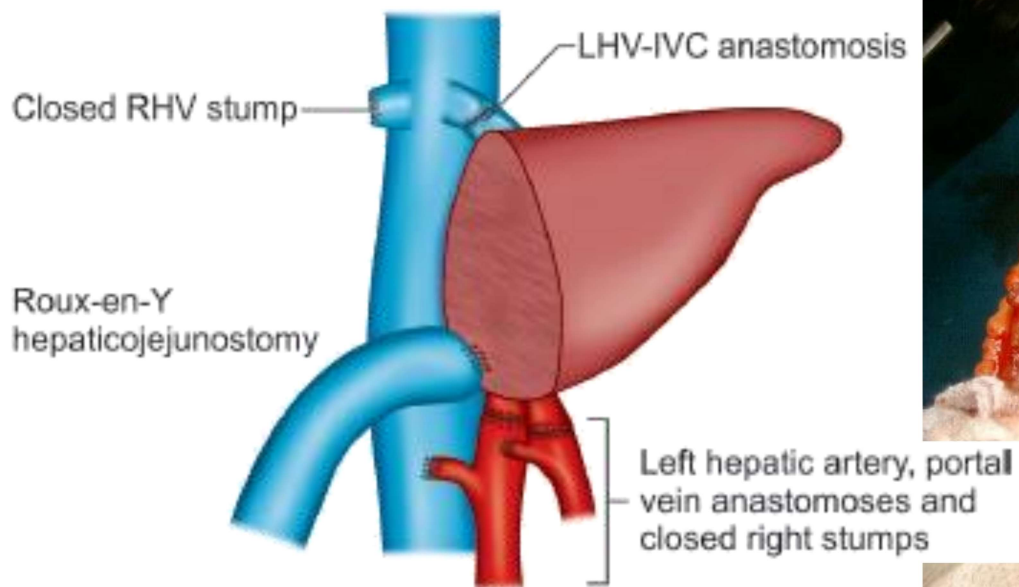


- ALF
- Severe PHT
- Long anhepatic time
- High lactates/acidosis

Graft implantation

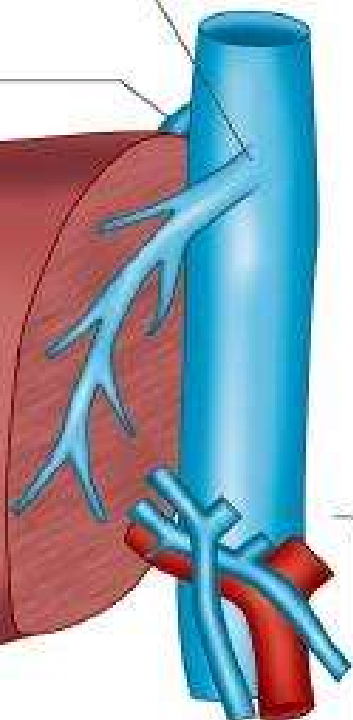


Graft implantation: Left lobe

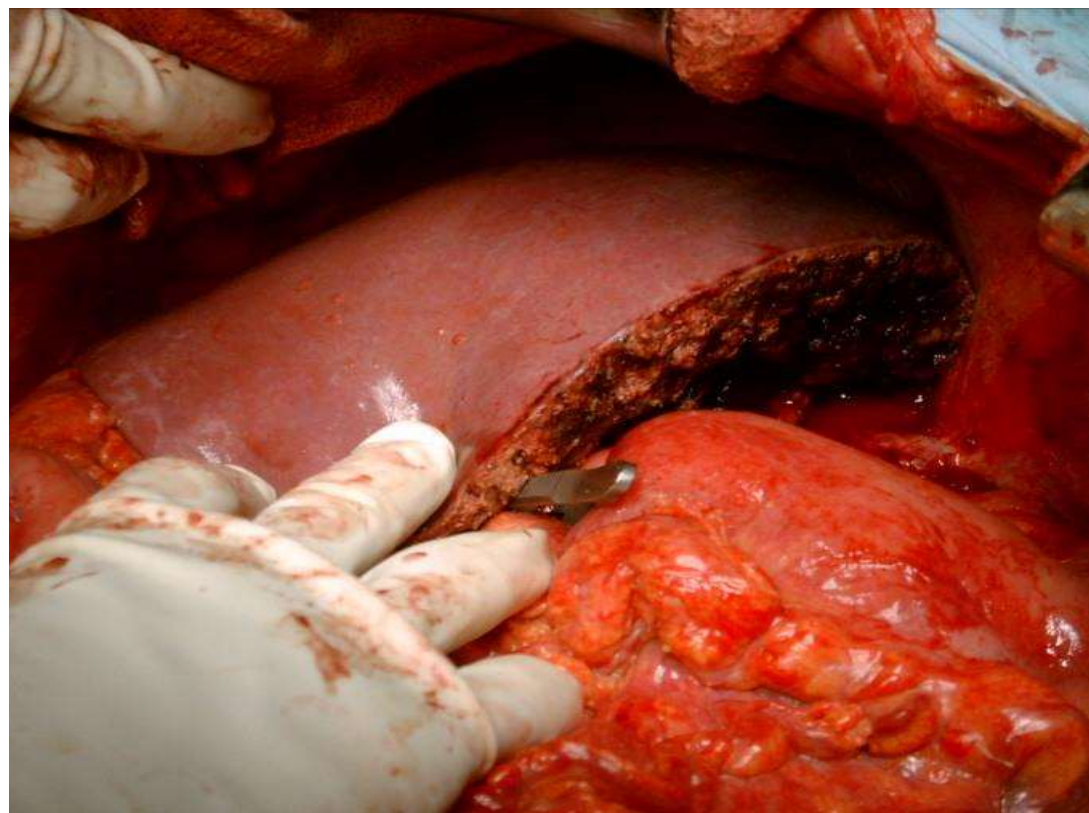


Graft implantation: Right lobe

RHV-IVC
anastomosis
MHV-IVC
anastomosis



Right hepatic
artery, portal
vein, hepatic
duct anastomoses
and closed
left stumps



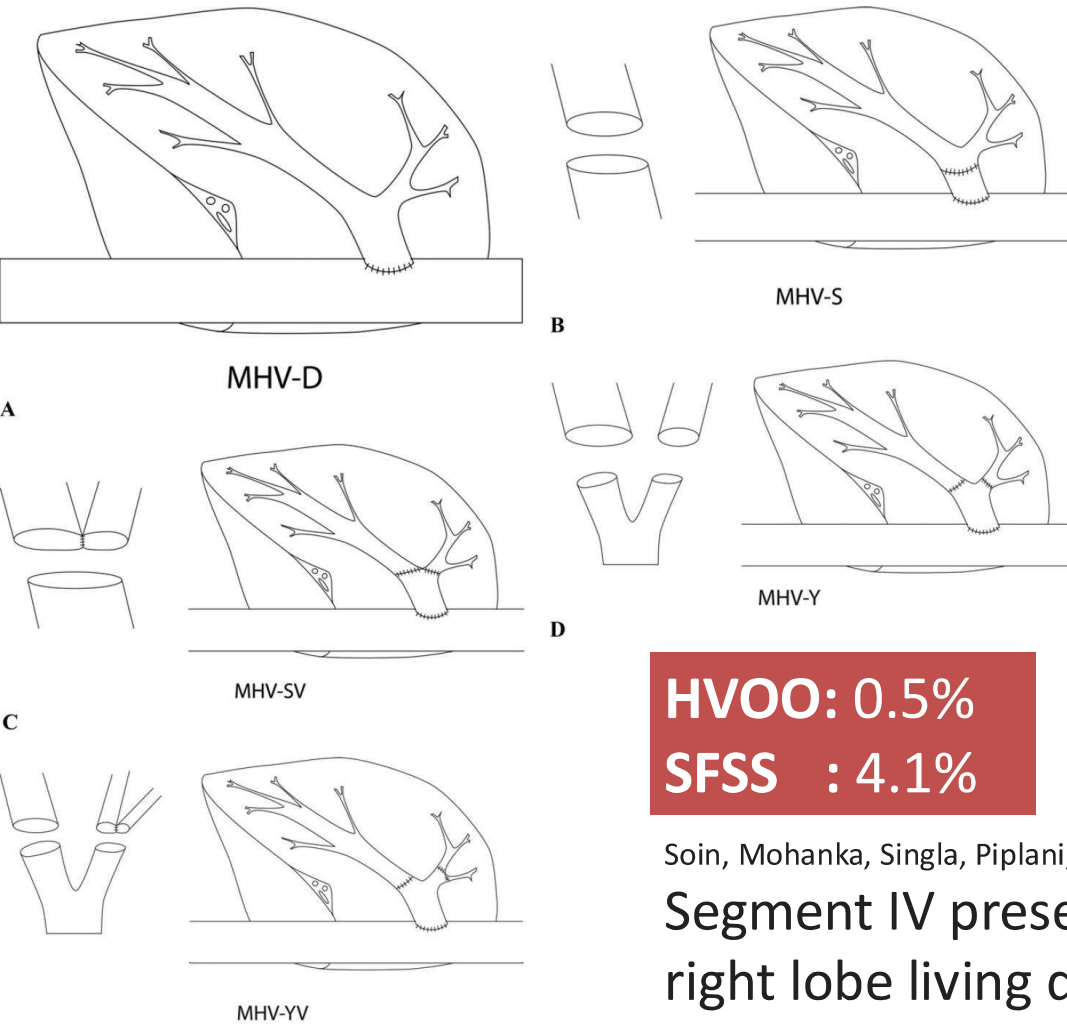
Classification

Group	Situation - Graft
MHV-D	No extension graft
MHV-S	Short straight extension graft on MHV
MHV-SV (MHV – near S8)	Venoplasty with short straight extension graft
MHV-Y (MHV – far S8)	Y graft
MHV-YV (MHV – 2 or more far S8)	Venoplasty, Y graft

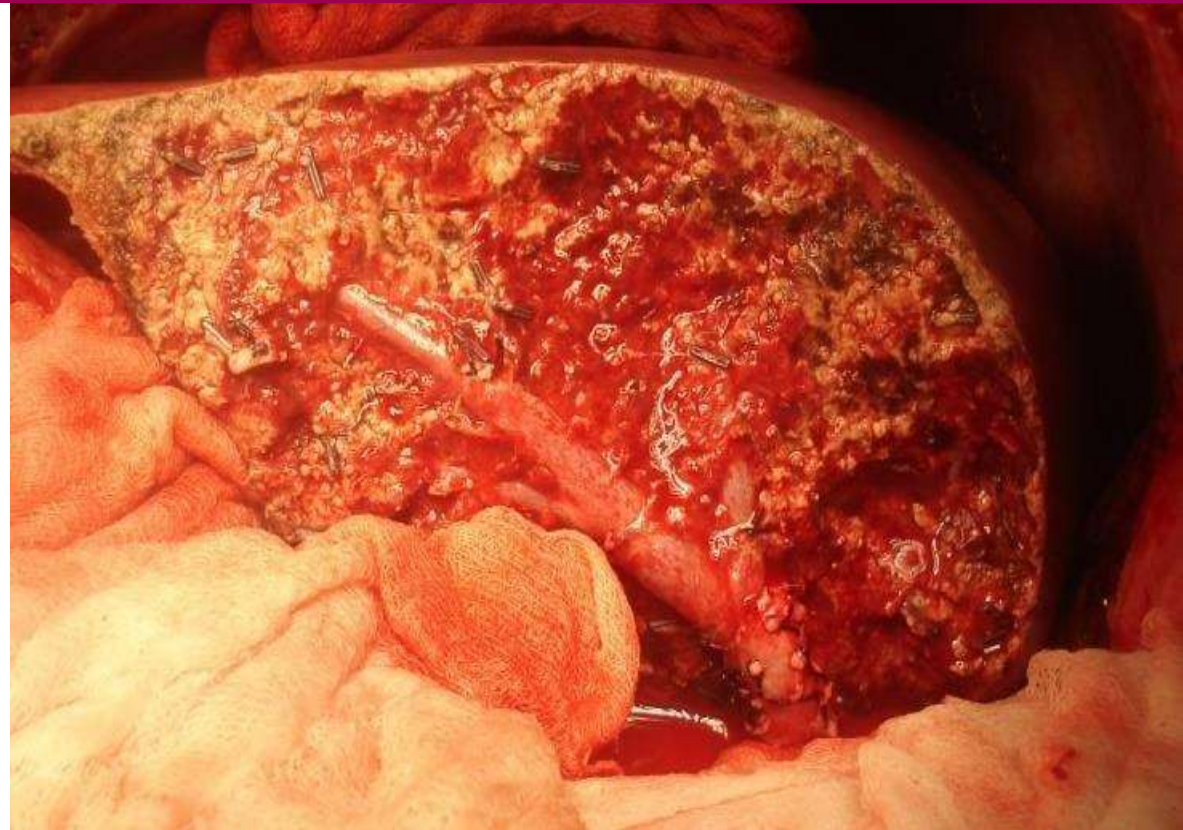
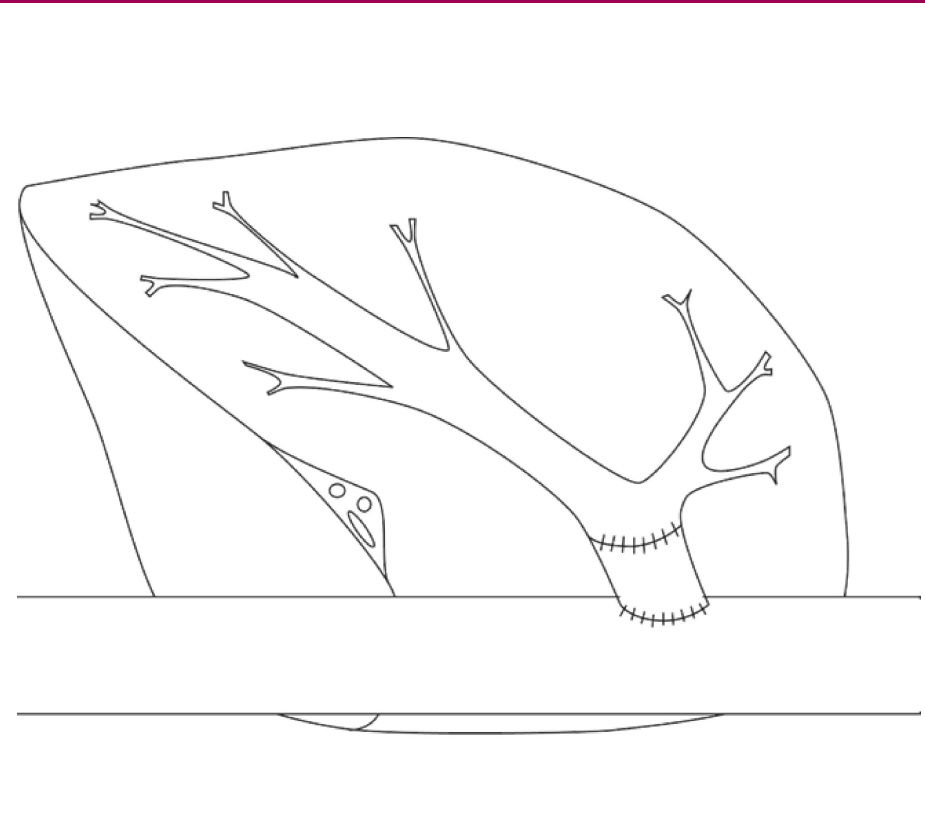
HVOO: 0.5%
SFSS : 4.1%

Soin, Mohanka, Singla, Piplani, Menon, Kakodkar, Rastogi, Goja, Kumaran, Nundy.

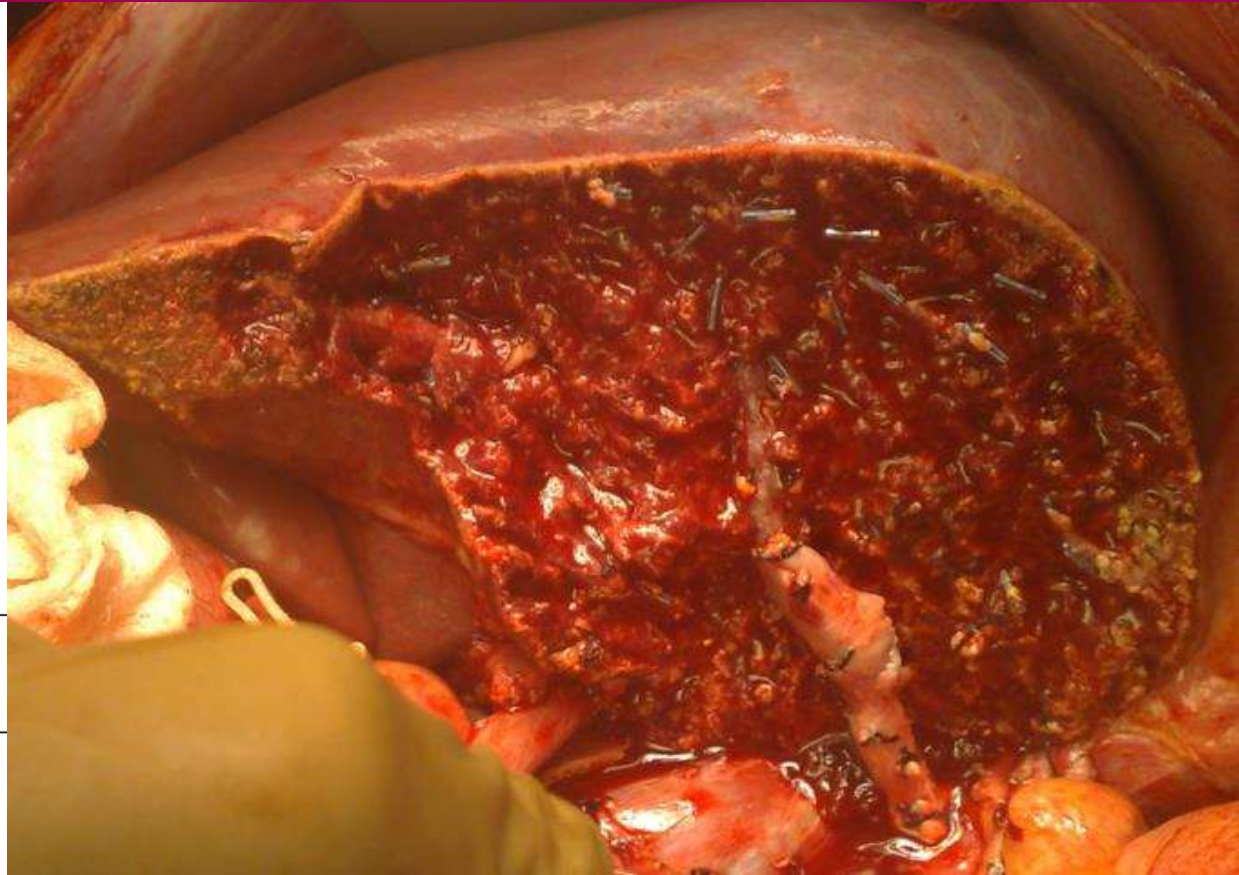
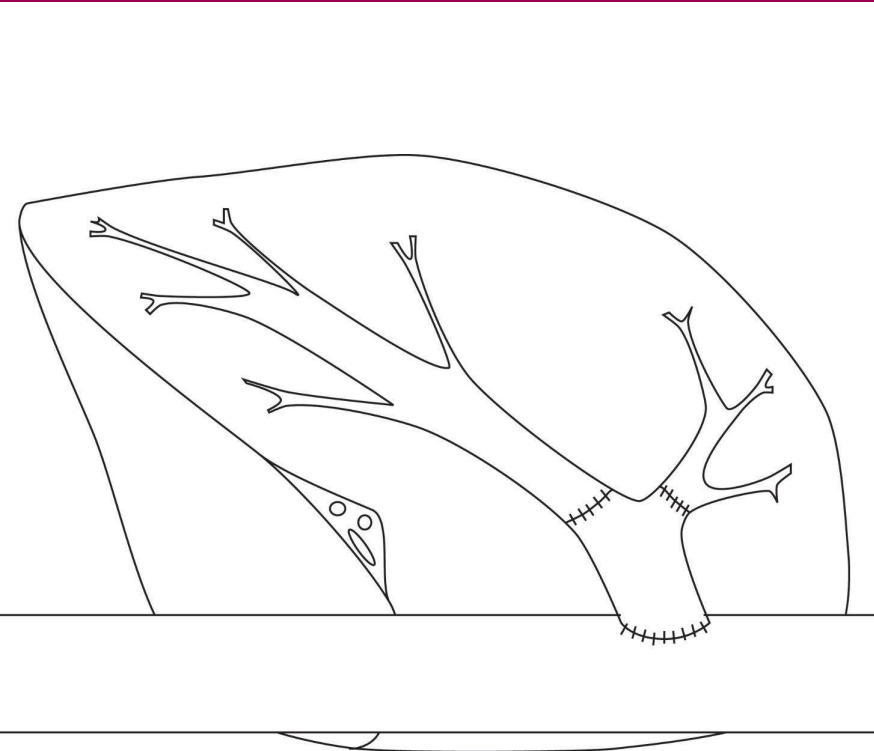
Segment IV preserving middle hepatic vein retrieval in right lobe living donor liver transplantation



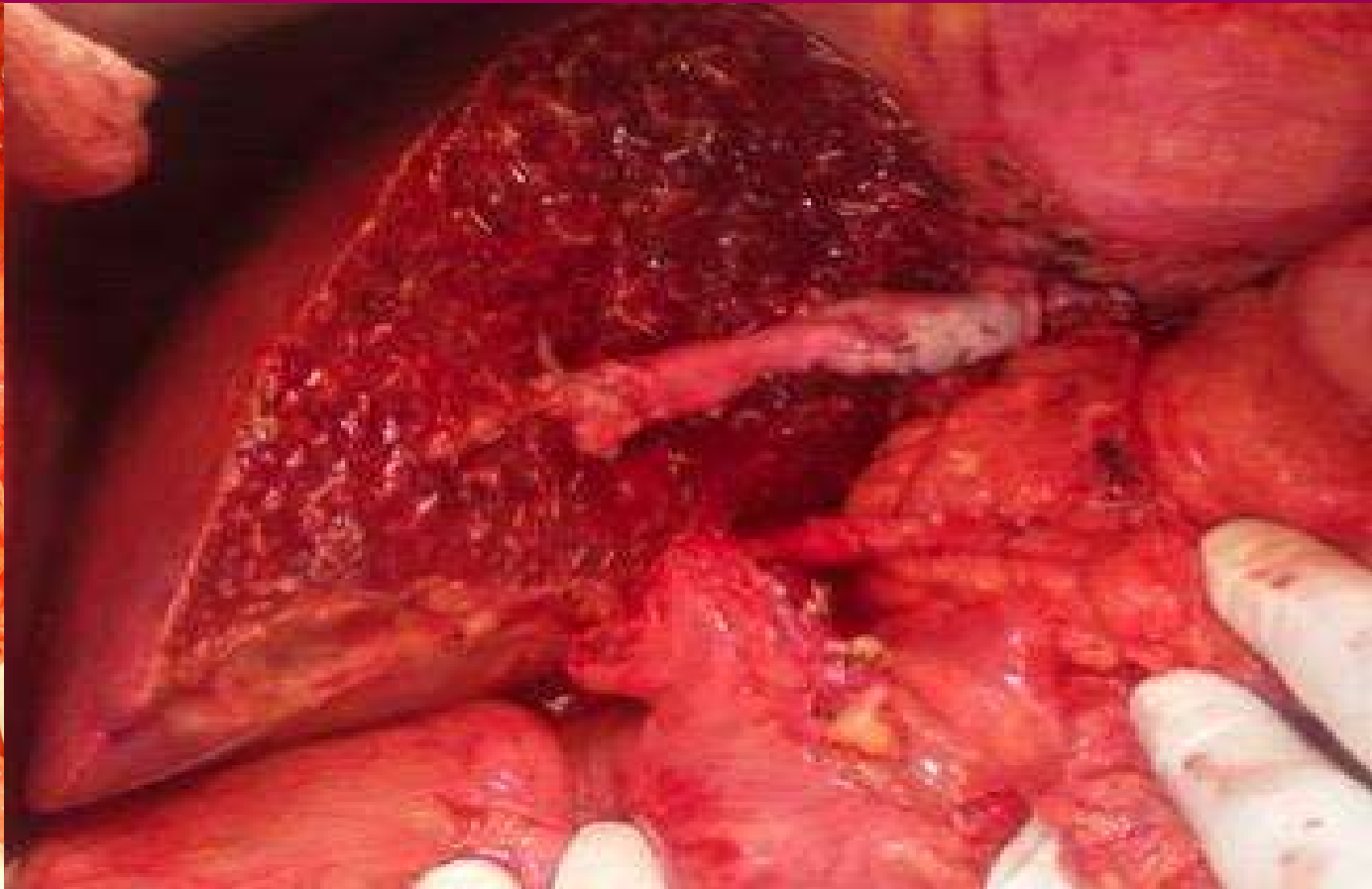
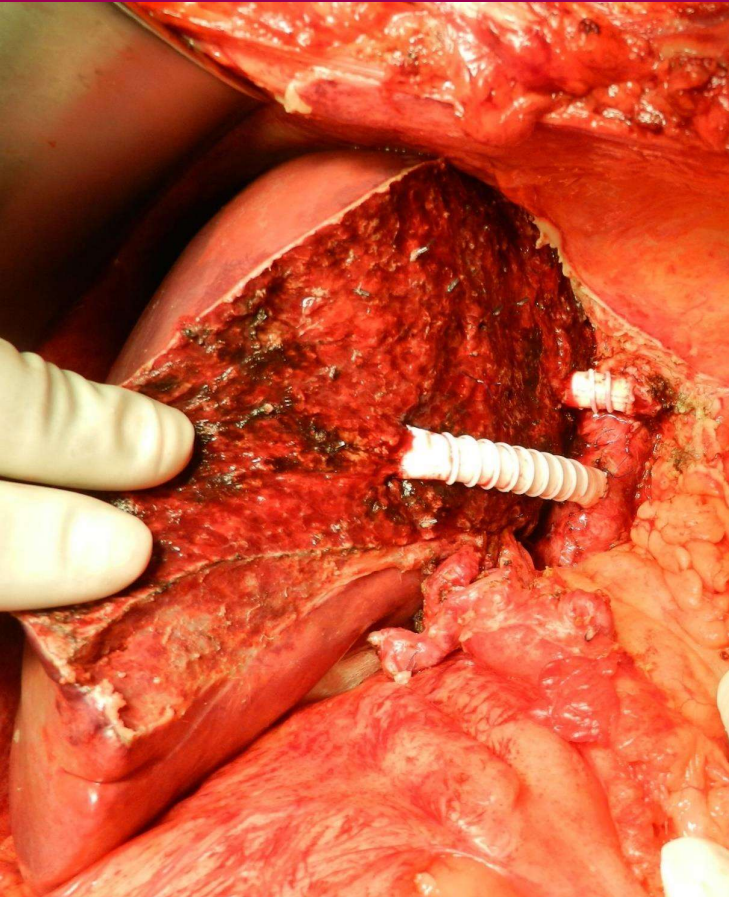
Graft implantation: MHV-S



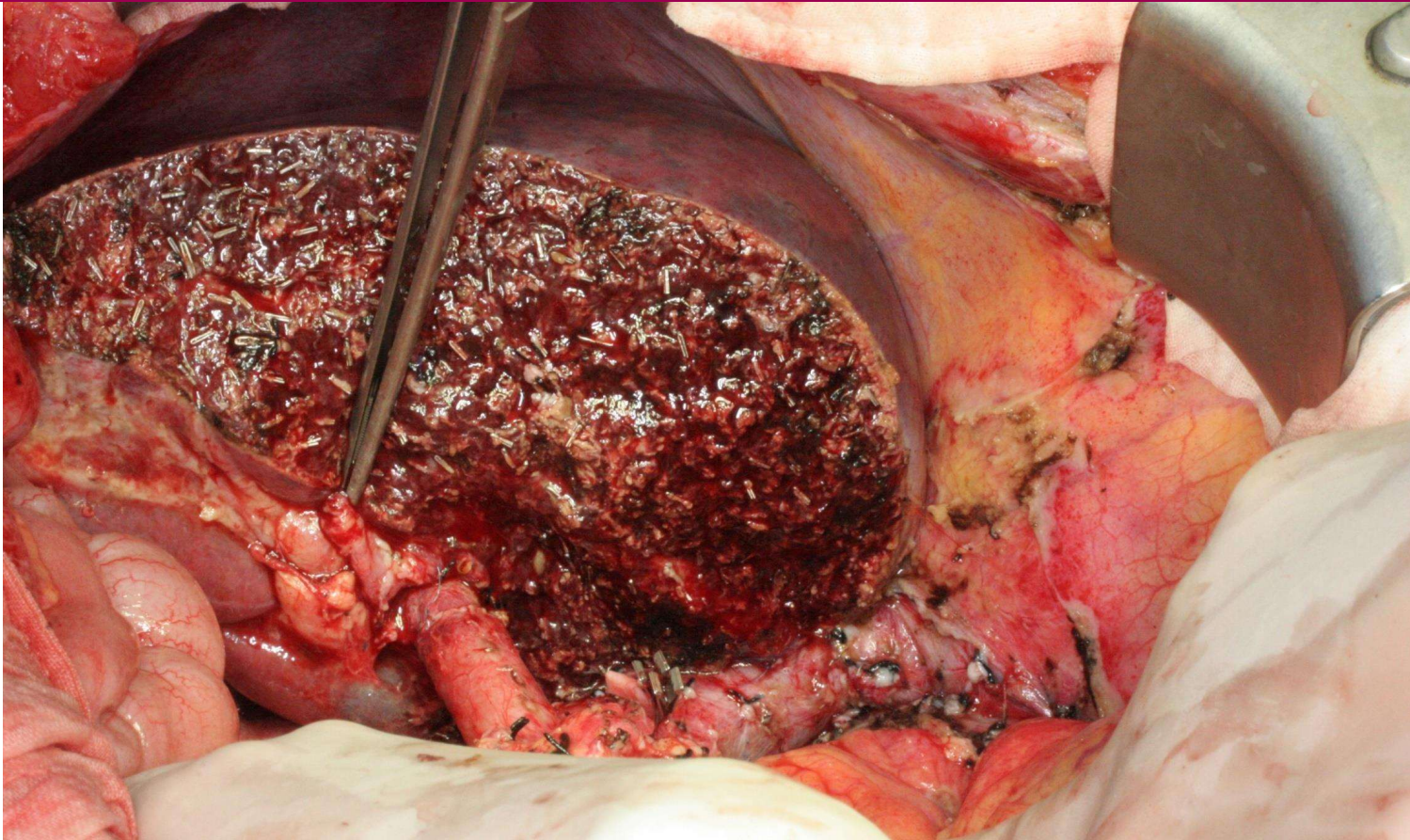
Graft implantation: MHV-Y

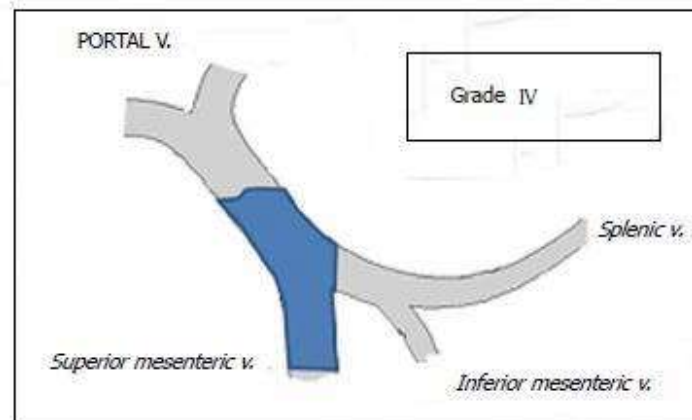
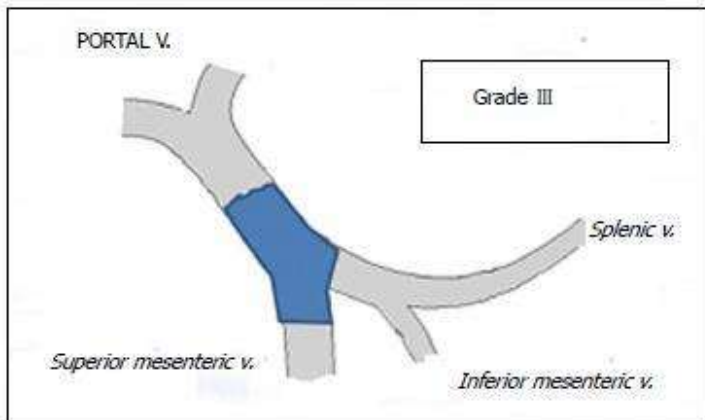
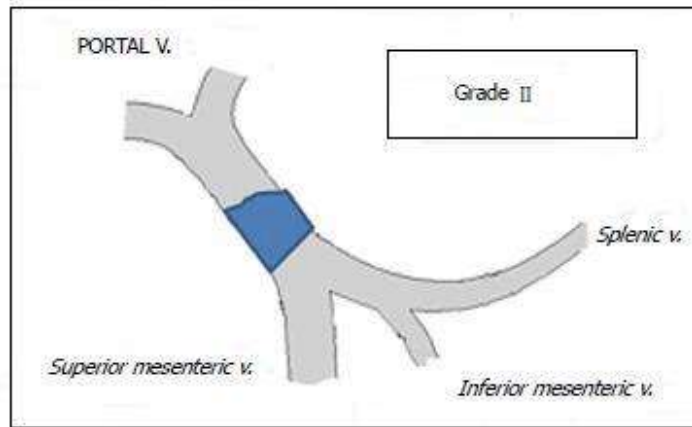
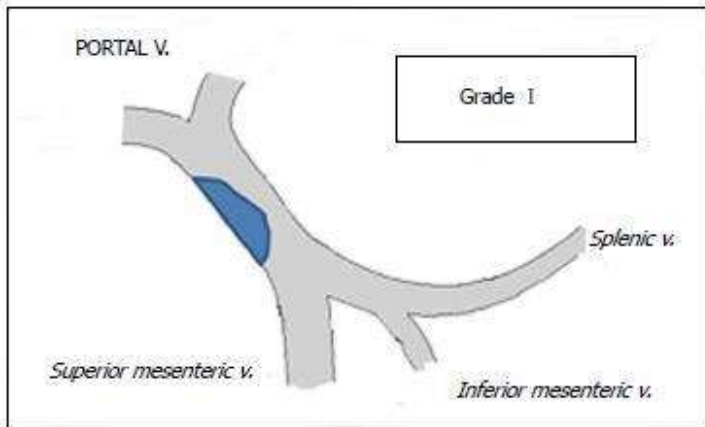


Graft implantation: MHV



Graft implantation: Portal vein



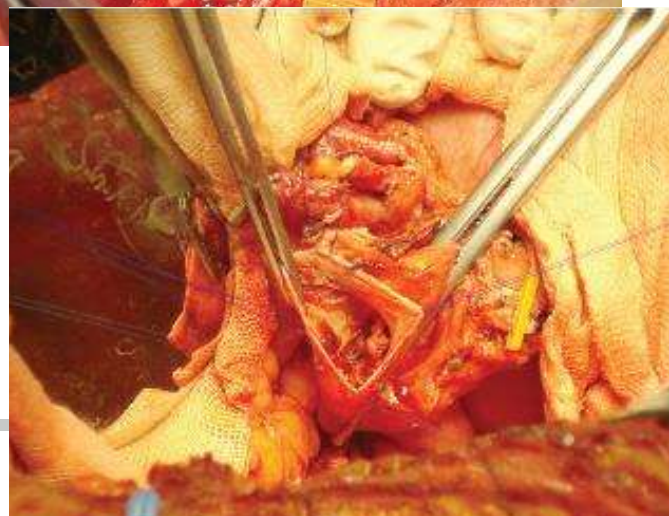
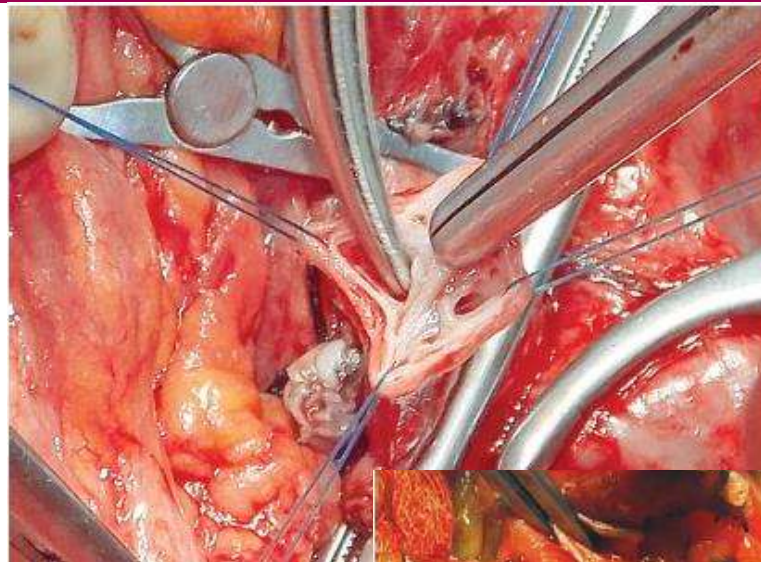
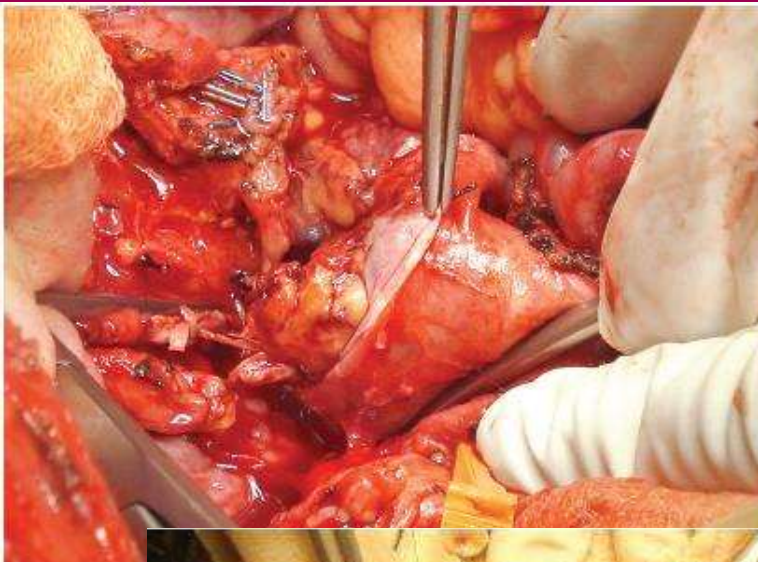


Venous involvement	Grade 1	Grade 2	Grade 3	Grade 4
PV	< 50%	> 50%	Complete	Complete
"Proximal" SMV	± Minimal	± Minimal	Complete	Complete
"Distal" SMV	None	None	None	Complete

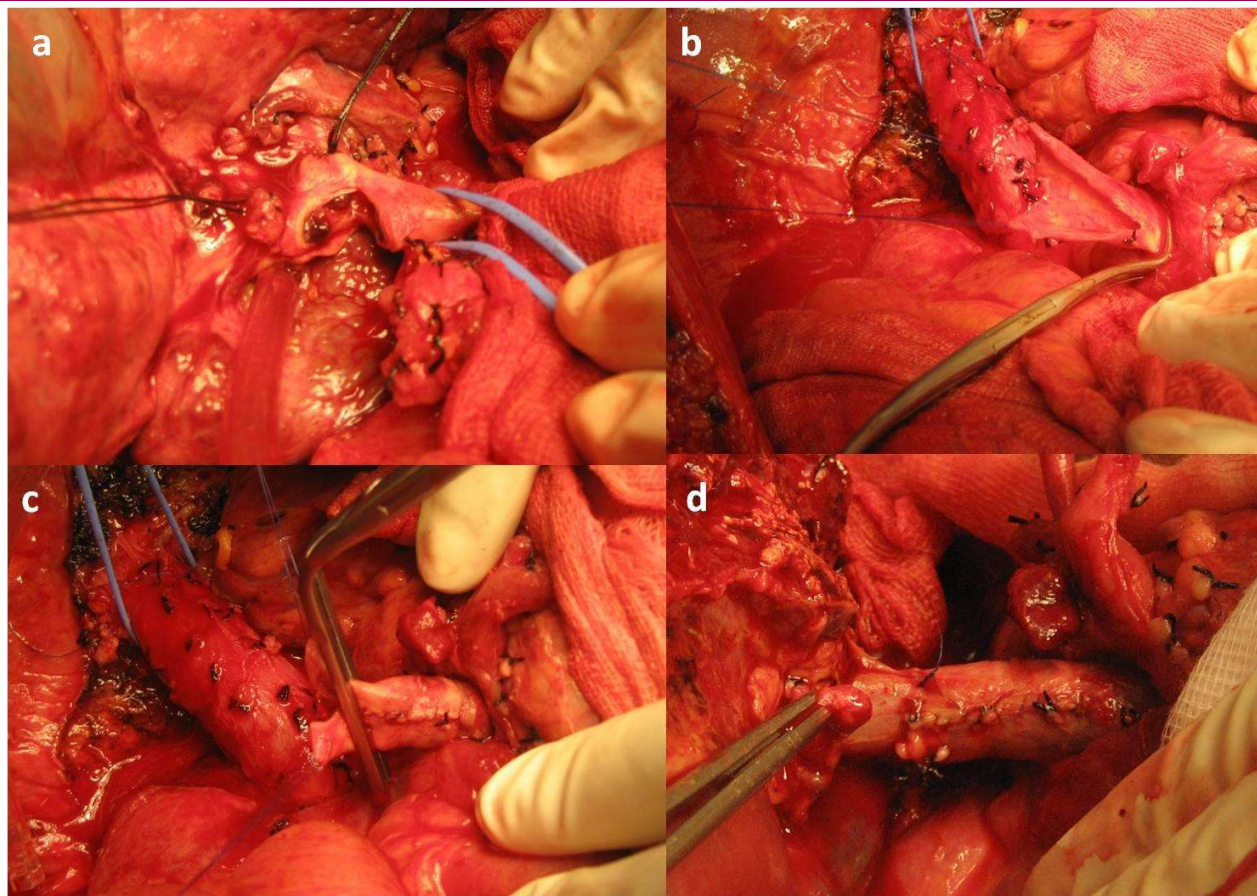
Portal vein Thrombosis (PVT)

- 10% of transplants
- Flow after thrombectomy
- Collaterals (lineo-renal, left gastric – coronary)

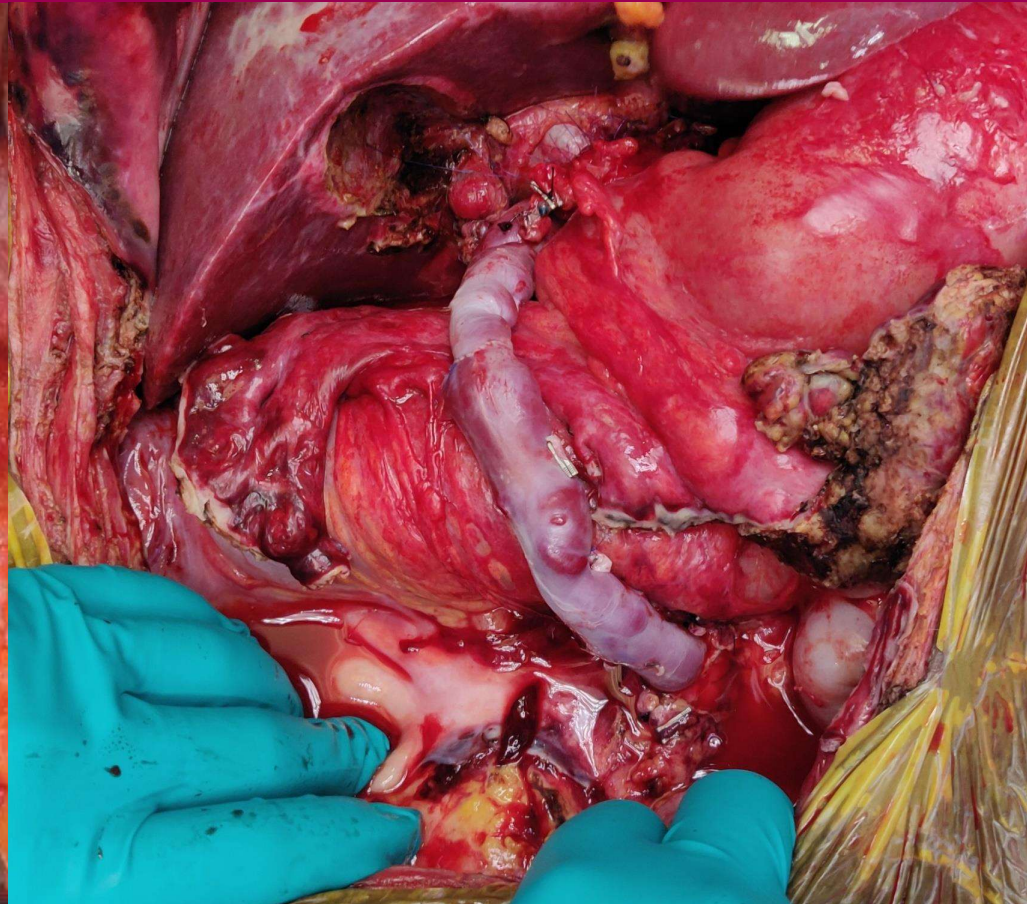
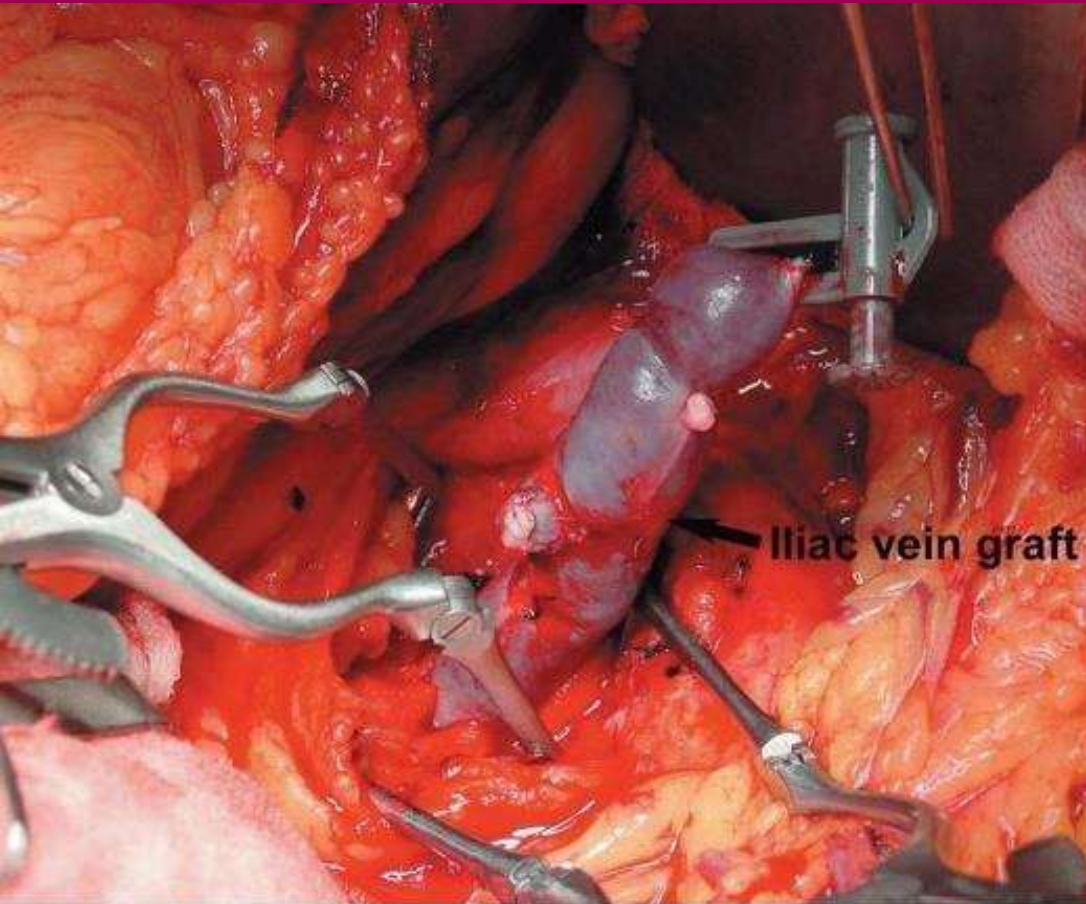
Portal thrombectomy



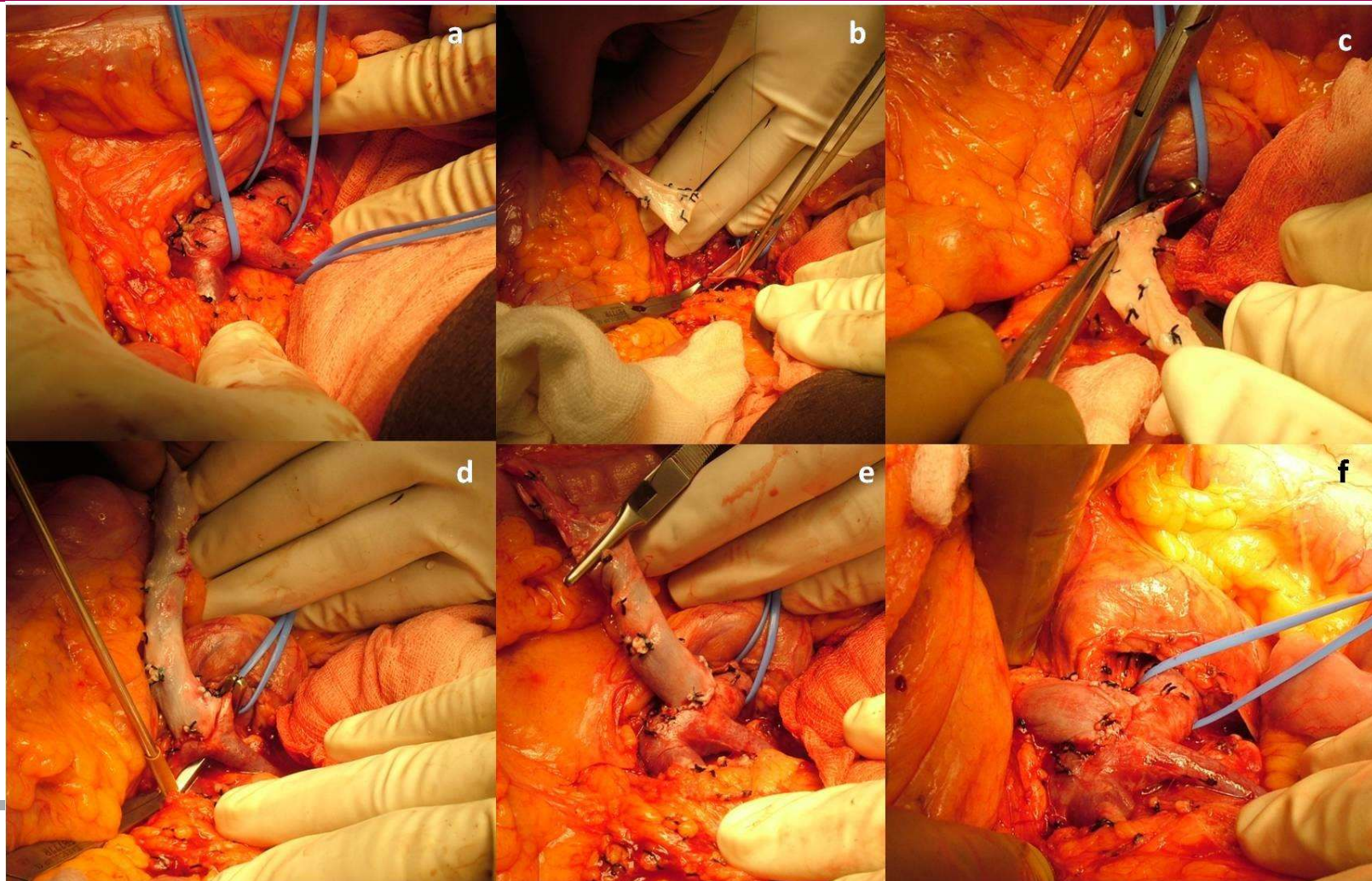
Portal thrombectomy & venoplasty



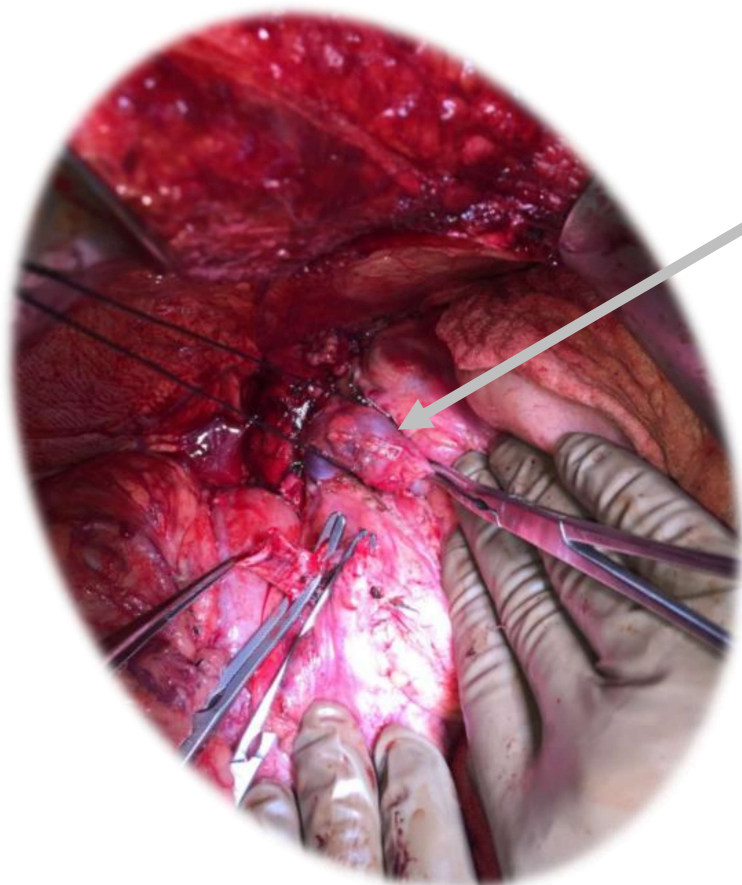
Alternative portal inflow: SMV



Alternative portal inflow: Splenic vein



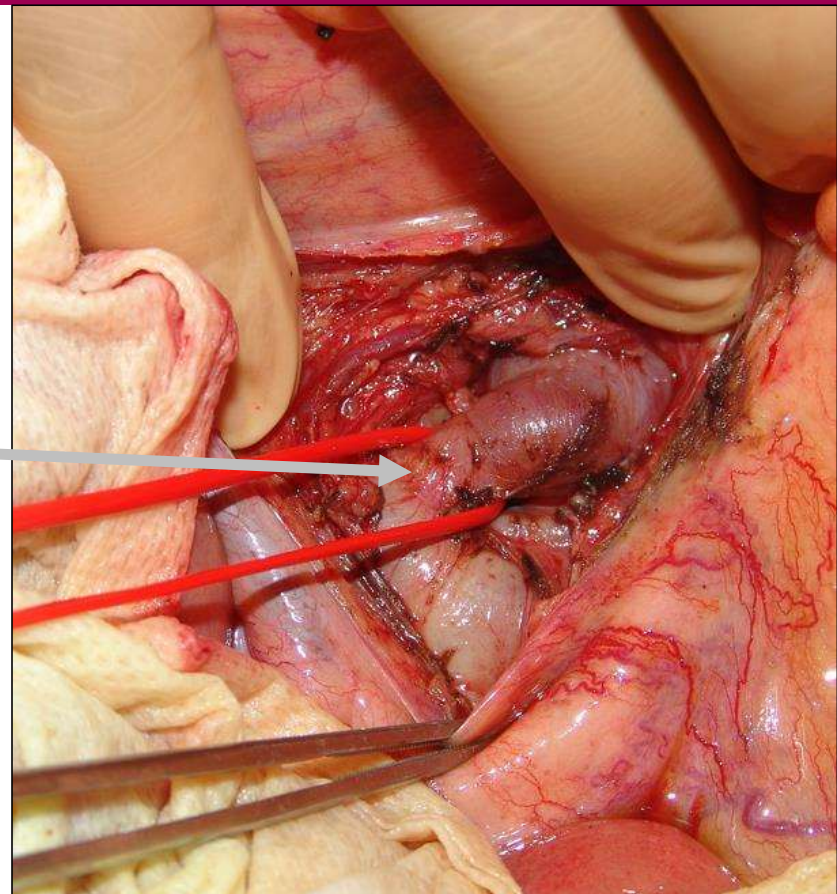
Low portal flow: Steal

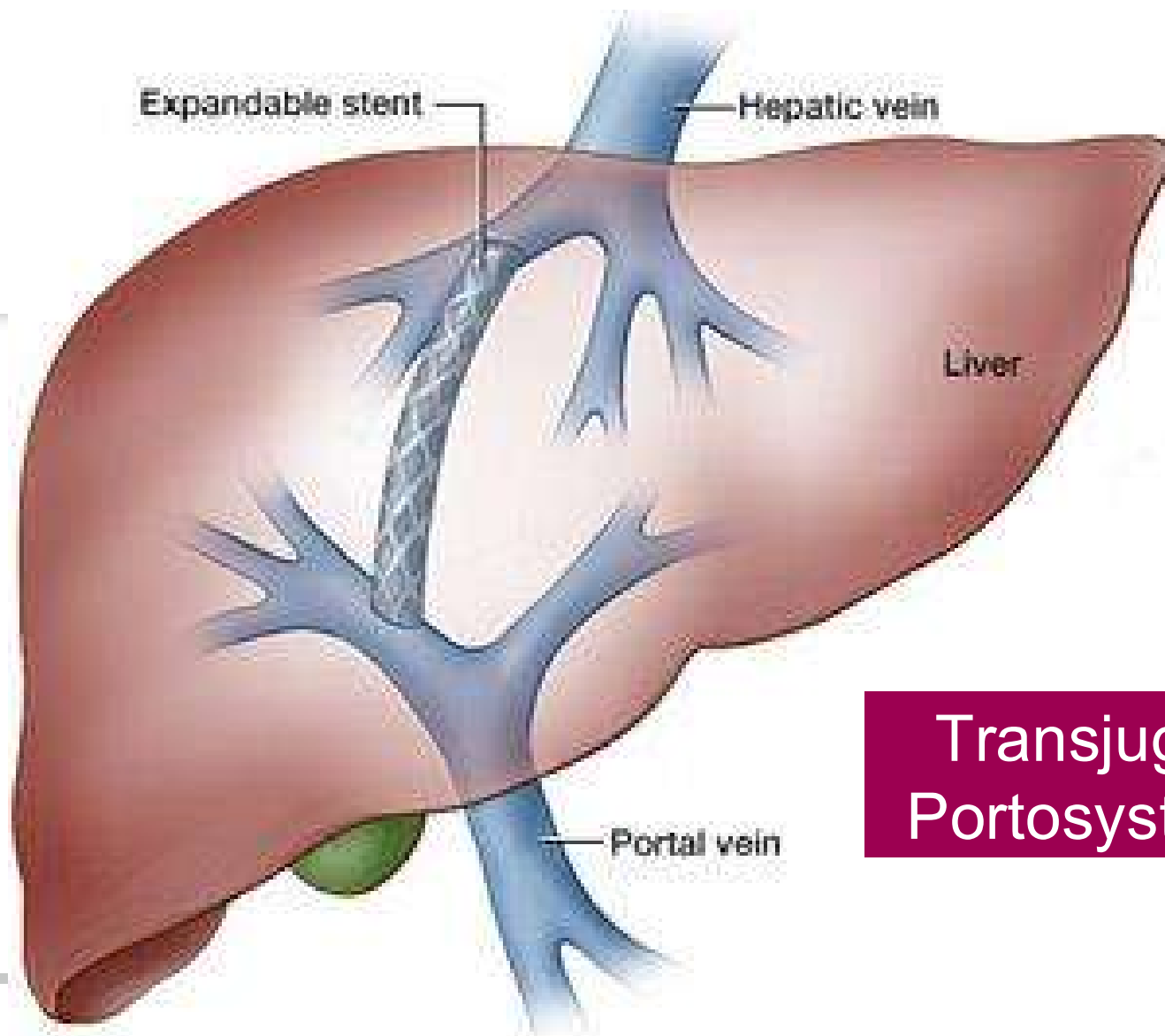


Left gastric vein ligation

Spleno-renal shunt ligation

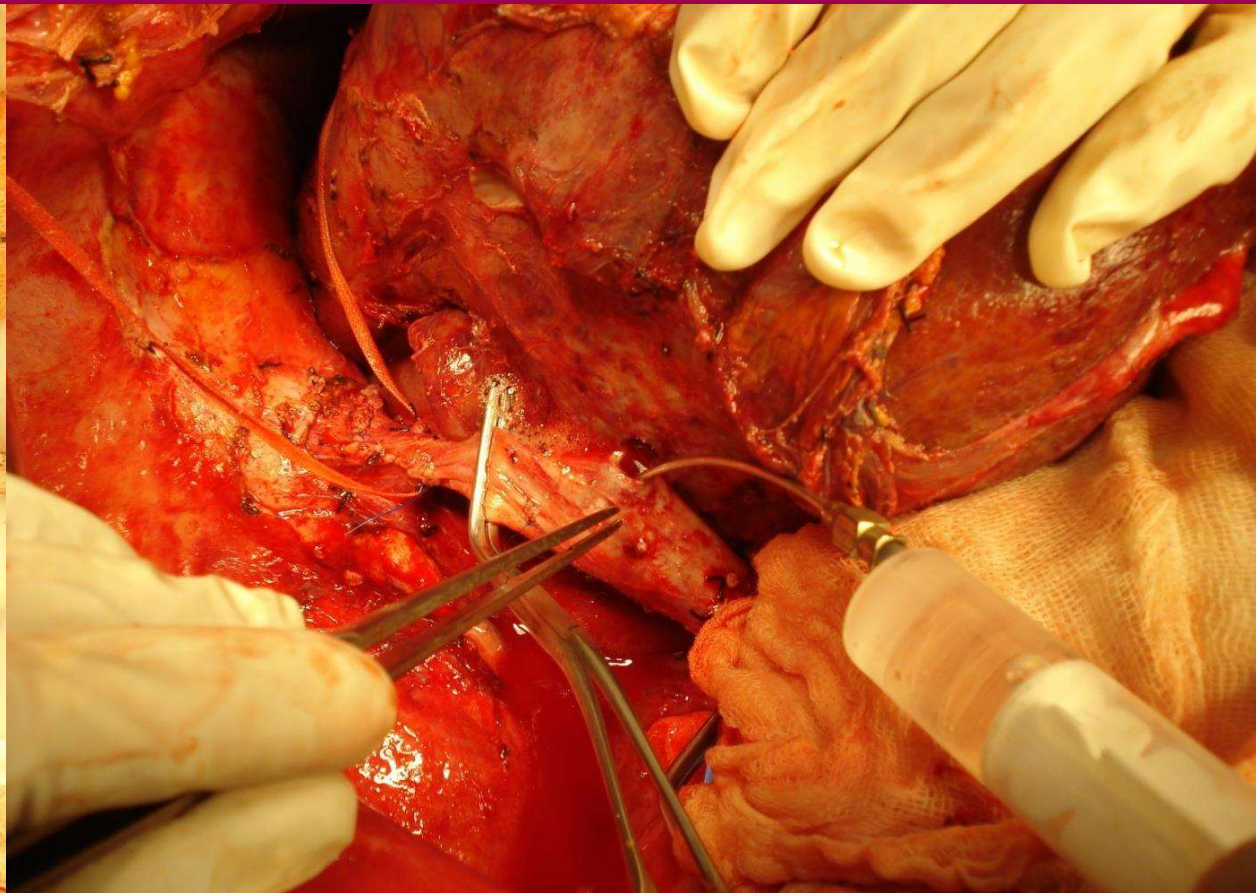
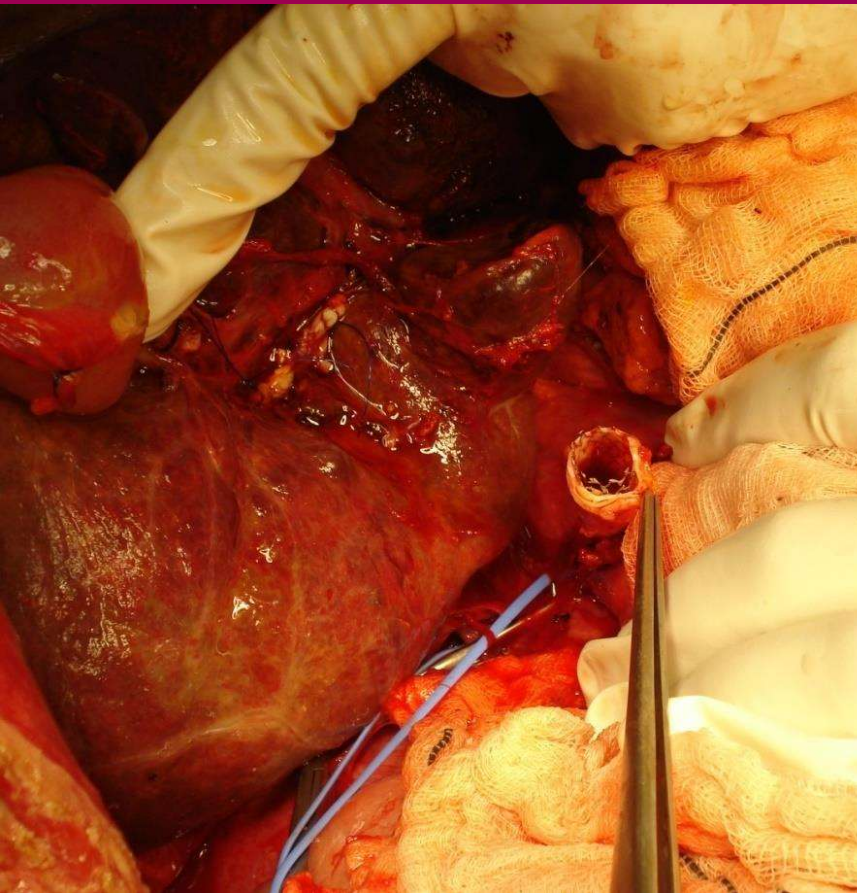
Portal flow: 100 – 300
ml/min / 100 g graft weight





Transjugular Intrahepatic Portosystemic Shunt: TIPS

TIPS



Hepatic artery reconstruction

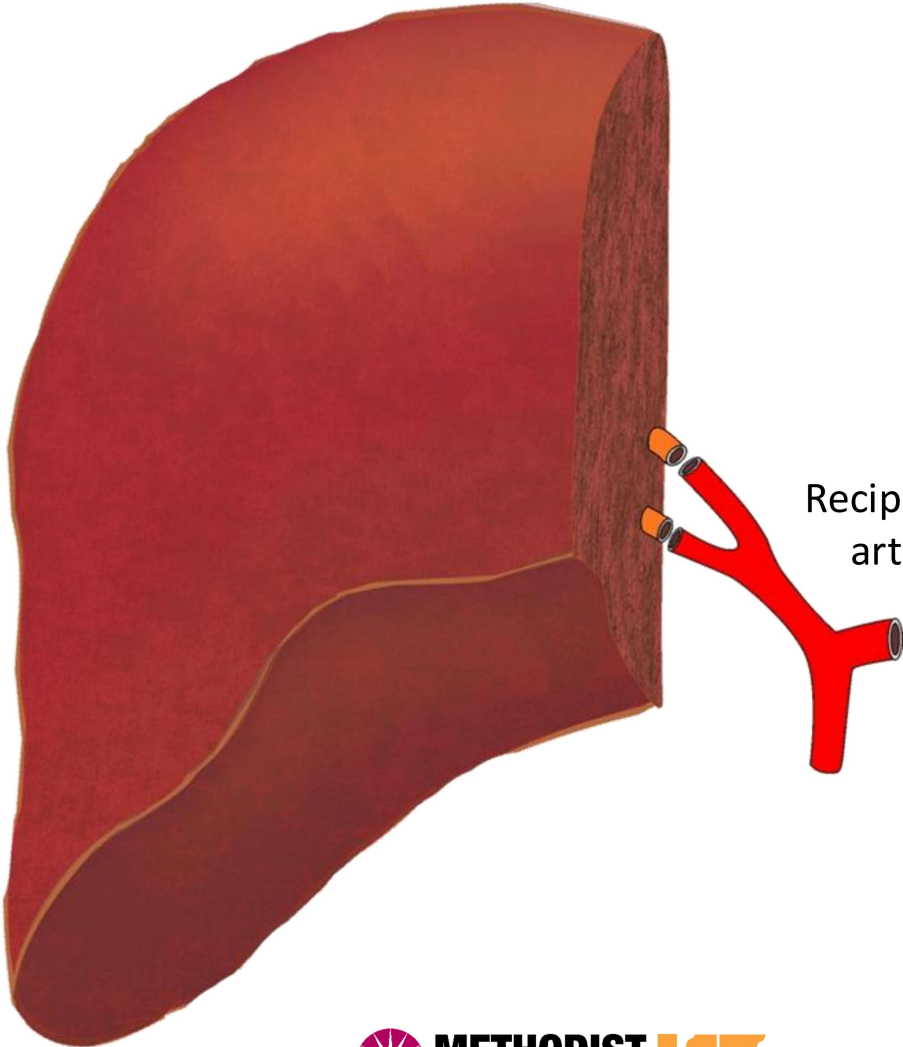
- 3x – 4.5x loupes
- Interrupted 7-0/8-0 Prolene®

Microvascular (about 2% cases):

- Short stump
- Small caliber
- Intimal dissection

Risk factors for HAT

- Handling
- Traction/tension
- Clips / ties
- Size mismatch > 2x
- Twist

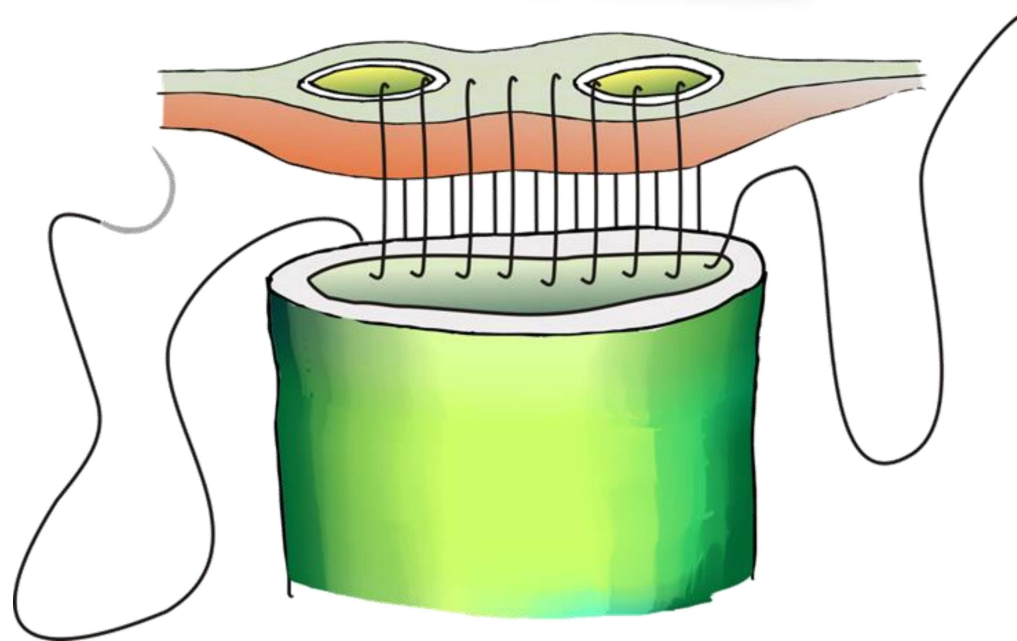
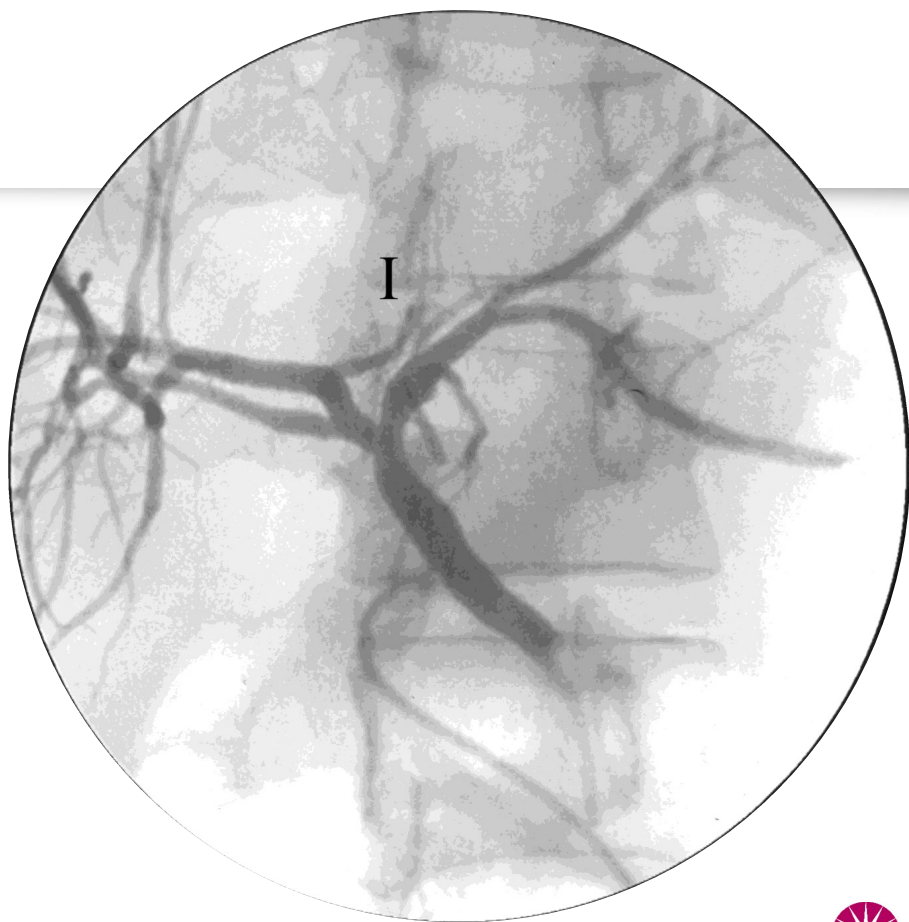


Recipient – 2 hepatic
artery branches

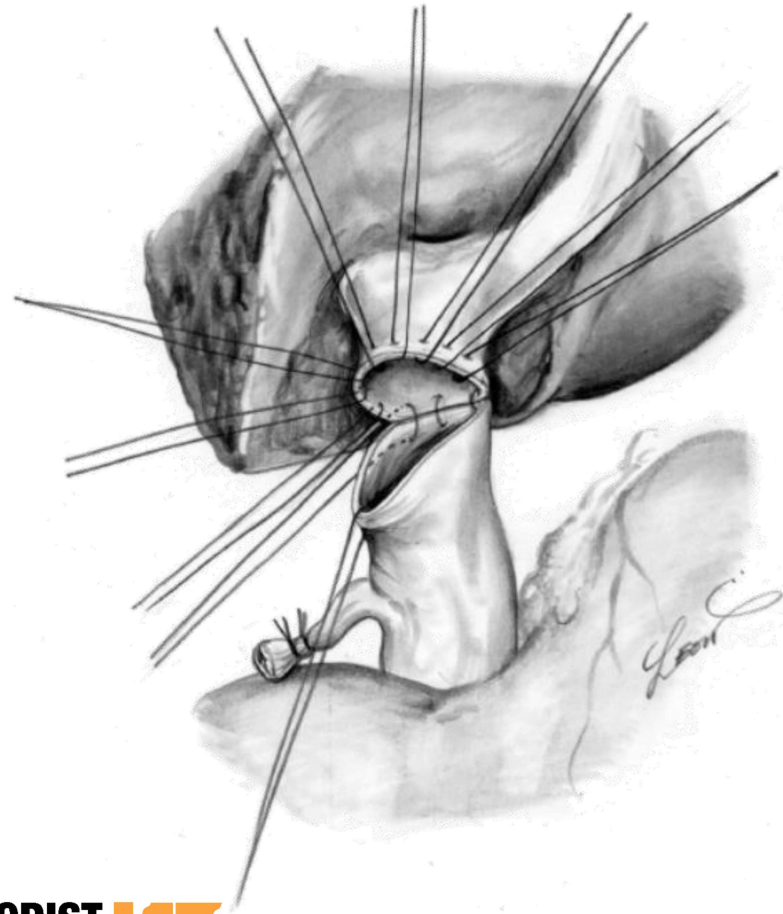
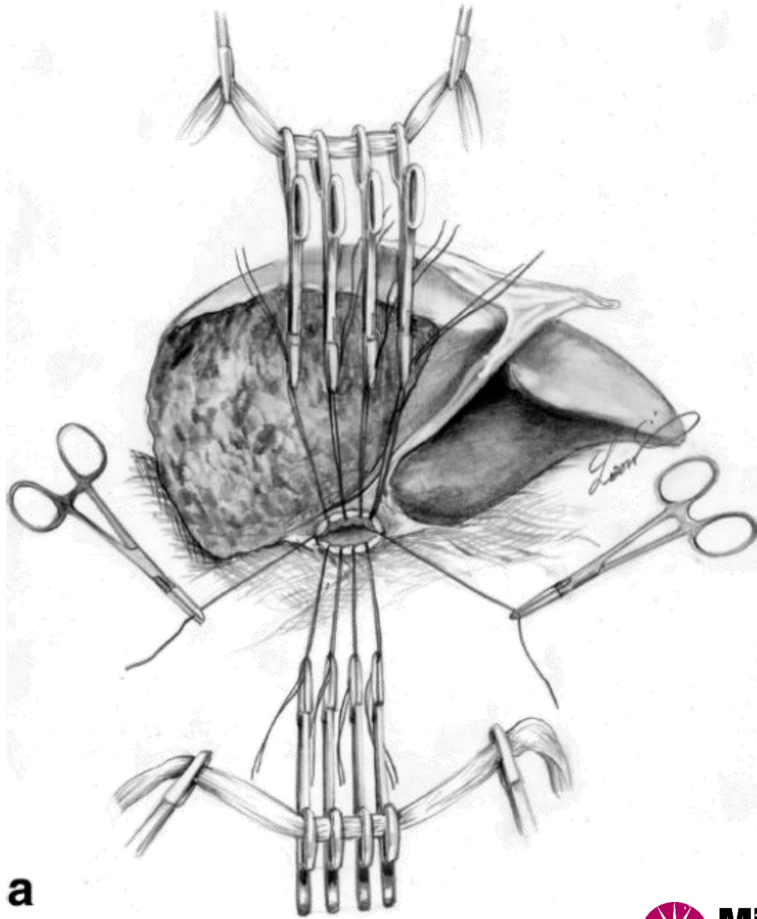
Single vs. Dual HA reconstruction

Author, Year	No. of Transplants	Liver Graft	Dual graft Artery, n (%)	Two Anastomoses, n (%)*	Biliary Complications	Remarks
Ikegami 1996 [29]	30	Left	16 (53.3)	3 (19)	-	No difference in biliary complications [†]
Suehiro 2002 [32]	37	Left	12 (32.4)	2 (17)	One anastomosis: 50% Two anastomosis: 15%	Significantly higher biliary complications with partial arterial reconstruction [†]
Uchiyama 2010 [33]	261	Right/left	Right: 6 (6.9) Left: 71 (39.9)	Right: 6 (100) Left: 24 (34)	One anastomosis: 44% Two anastomosis: 14%	Significantly higher biliary complications with partial arterial reconstruction [†]
Sugawara 2011 [30]	134	Left	64 (47.8)	5 (8)	One anastomosis: 24% Two anastomosis: 40%	No difference in HAT or biliary complications [‡]
Julka 2014 [19]	87 (pediatric)	Left	42 (48.3)	22 (52)	One anastomosis: 9% Two anastomosis: 10%	No difference in HAT or biliary complications [‡]
Lee 2016 [31]	136 (pediatric)	Left	62 (45.6)	23 (37)	-	No difference in biliary complications [†]
Cakir 2016 [34]	1036	Right	53 (5.1)	10 (18.9)	One anastomosis: 12.8% Two anastomosis: 0%	Biliary complications not evaluated
Present study	225	Right/left	23 (10.2)	12 (52)	One anastomosis: 36% Two anastomosis: 10%	Higher biliary complications with partial arterial reconstruction [‡]

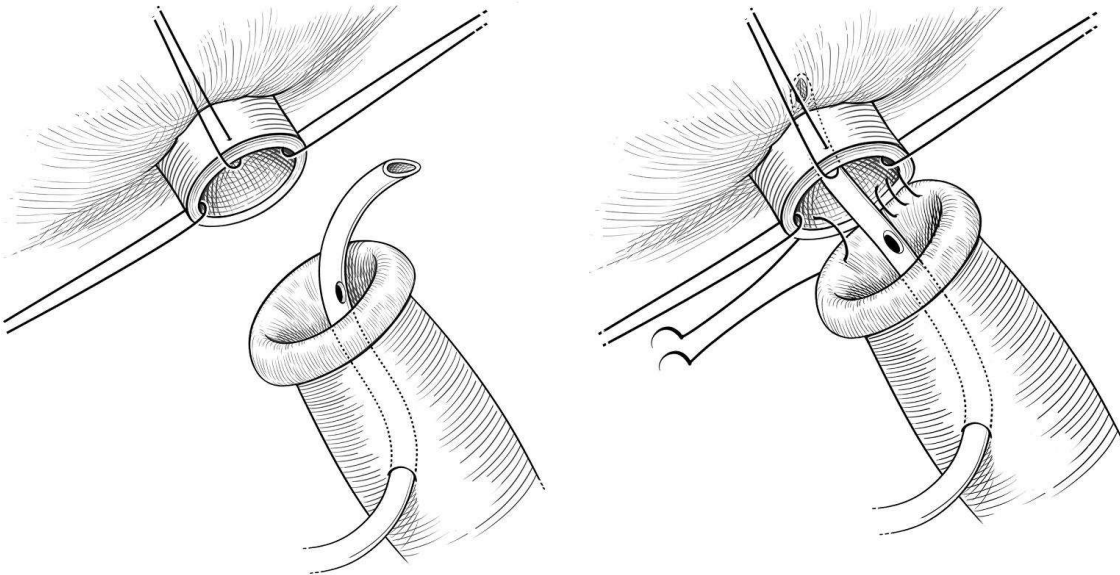
Biliary Reconstruction



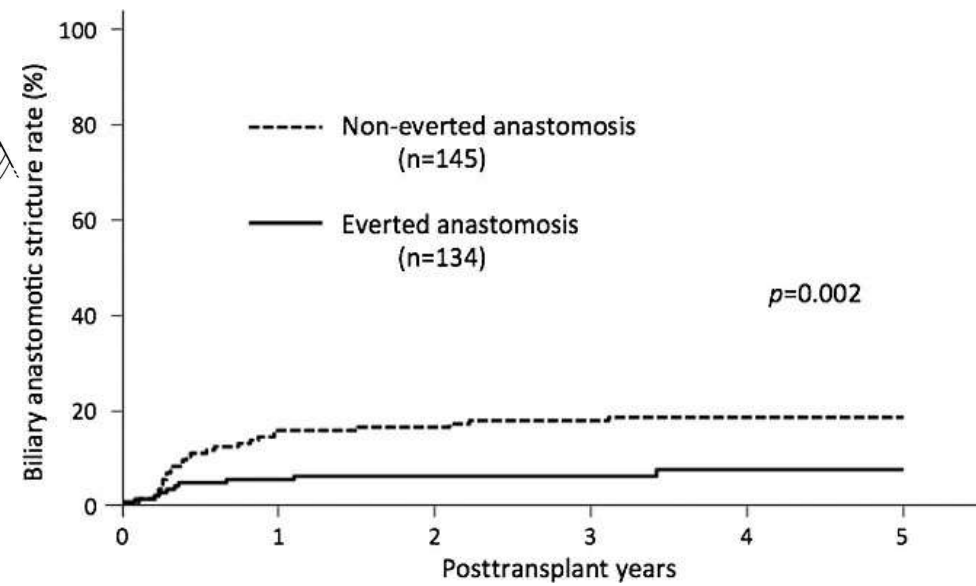
Open-up technique/Pre-placed sutures



Eversion technique



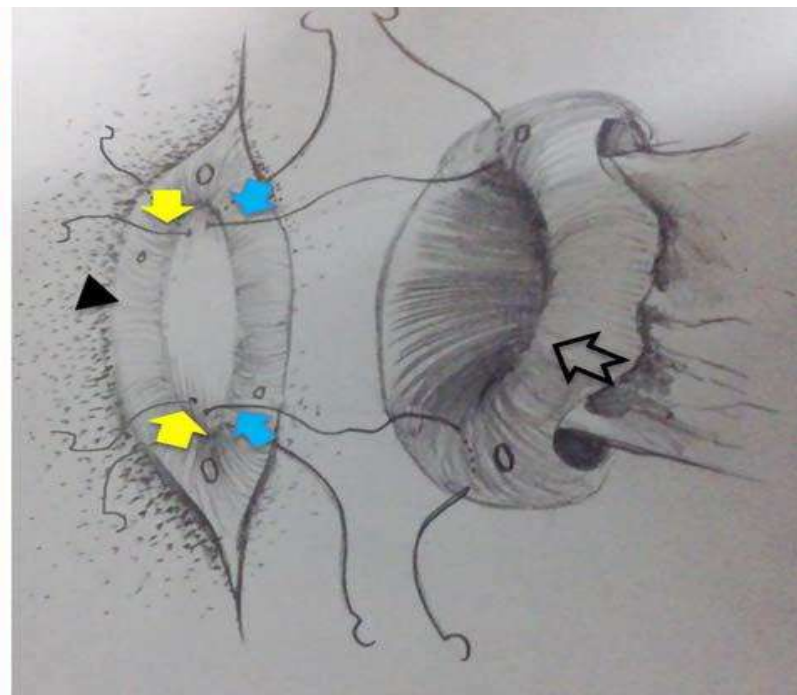
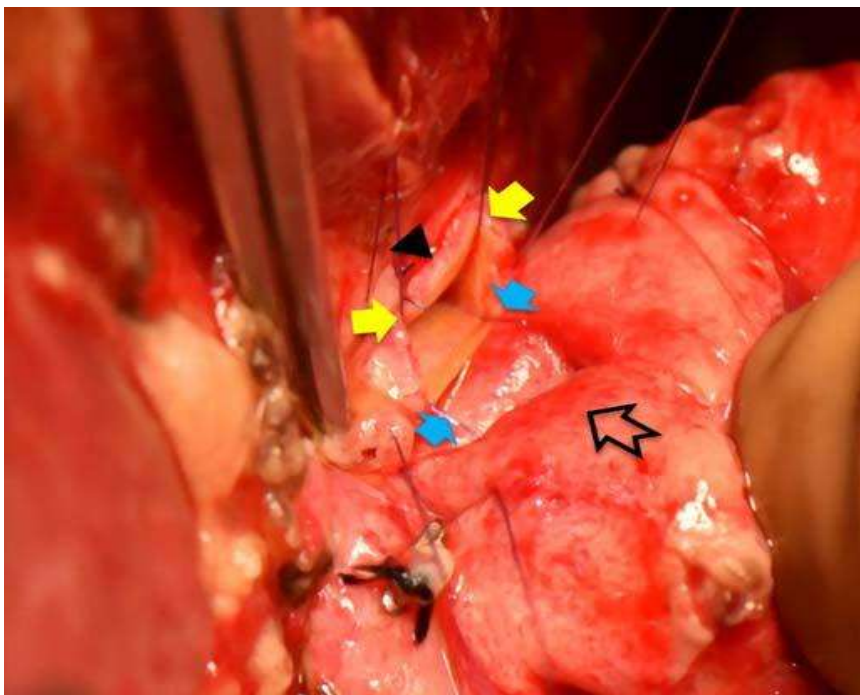
Ikegami, Transplantation 2017;101



Targeting the Achilles' Heel of Adult Living Donor Liver Transplant: Corner-Sparing Sutures With Mucosal Eversion Technique of Biliary Anastomosis

Liver transplantation 22:14–23, 2016

Vivek Vij, Kausar Makki, Vishal Kumar Chorasiya, Gaurav Sood, Ashish Singhal, and Puneet Dargan



Biliary T-tubes / Stents

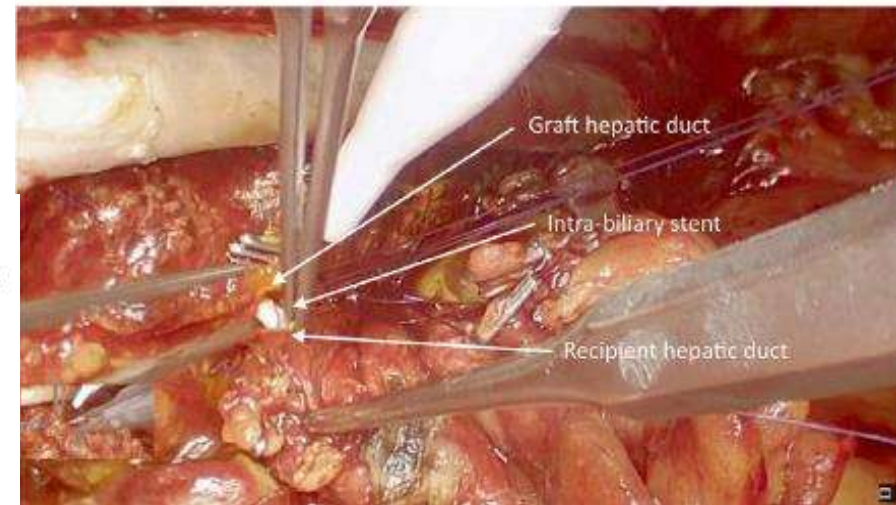
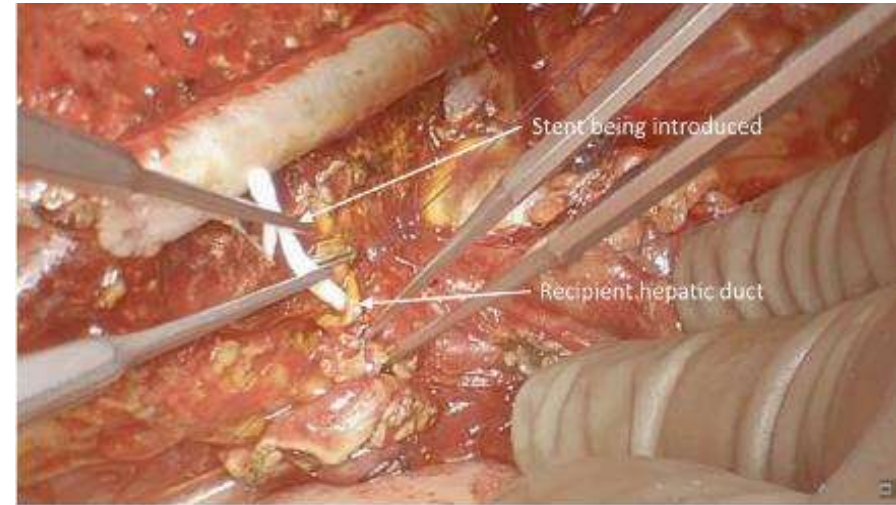
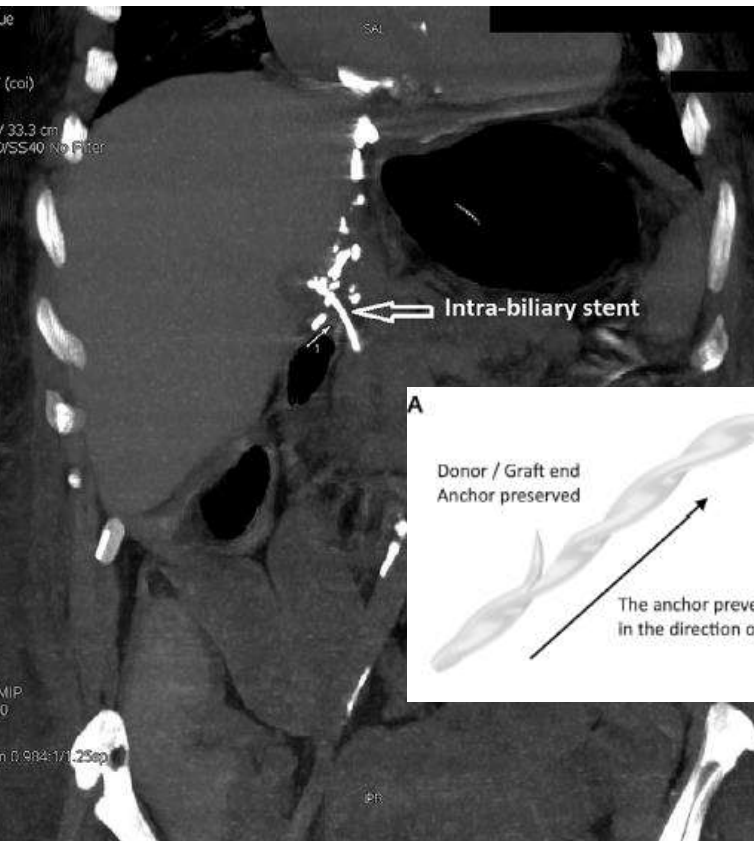
Type	Used	Exit site / Removal	Complications
T-tubes	More commonly DDLT	<ul style="list-style-type: none"> • Choledochotomy • Cystic duct stump 	<ul style="list-style-type: none"> • Peri-op bile leaks similar • T-tube exit site leaks higher • Modified placement: fewer exit site leaks
External (thinner than T-tubes)	Both DDLT / LDLT	<ul style="list-style-type: none"> • Choledochotomy • Cystic duct stump • Bowel loop (2-step technique) • Trans-hepatically 	<ul style="list-style-type: none"> • Fewer exit site leaks if removed at 4 to 6 months
Internal (trans-anastomotic / trans-sphincteric)	Both DDLT / LDLT	<ul style="list-style-type: none"> • Removed endoscopically at 3-6 months 	<ul style="list-style-type: none"> • Cholangitis, bile leaks, and proximal migration
Intraductal (trans-anastomotic)	Both DDLT / LDLT	<ul style="list-style-type: none"> • Difficult endoscopic extraction using complex maneuvers 	<ul style="list-style-type: none"> • Lesser incidence of cholangitis

Absorbable biliary stent

Archimedes Absorbable Internal Biliary Stent in Liver Transplants to Prevent Bile Leak

Transplantation Proceedings, 53, 2923–2928 (2021)

Ravi Mohanka*, Prashantha Rao, Ankush Golhar, Vinayak Nikam, Anurag Shrimal, Mitul Shah, Akash Shukla, Sudheer Pargewar, Rashmi Bhade, Parul Gadre, and Ritesh Dholu



Biliary T-tubes / Stents

# Patients	# Graft ducts	# Anastomosis	Biliary anastomosis (stent used)
DDLT			
9	1	1	dCHD to rCBD (10 Fr)
LDLT			
4	1	1	dRHD to rCHD (6 Fr)
3	2	1 (2:1)	dRAHD and dRPHD to rCHD (6 Fr)
2	2	2	dRAHD to rRHD (6 Fr), dRPHD to rLHD (6 Fr)
2	3	2	dRAHD to rRHD (6 Fr), Two dRPHD to rLHD (6 Fr)

- No bile leak, bilioma or bile duct stricture
- 1 distal migration into duodenum → ascending cholangitis → settled after stent removal
- 2 patients died, 1 PNF & other MDR lung infection



Preparation

Preparing a live donor

Phase 1

- Blood type
- Viral markers
- Liver and Renal profile
- UPT (for females)

Phase 2

- CT Liver Attenuation Index
- MRE

Phase 3

- Triphasic CT Liver
- Volumetry
- Anatomy

Phase 4

- MRCP

Phase 5

- Virology
- Endocrine
- Hematology
- Pulmonary
- Cardiology
- Gynecology

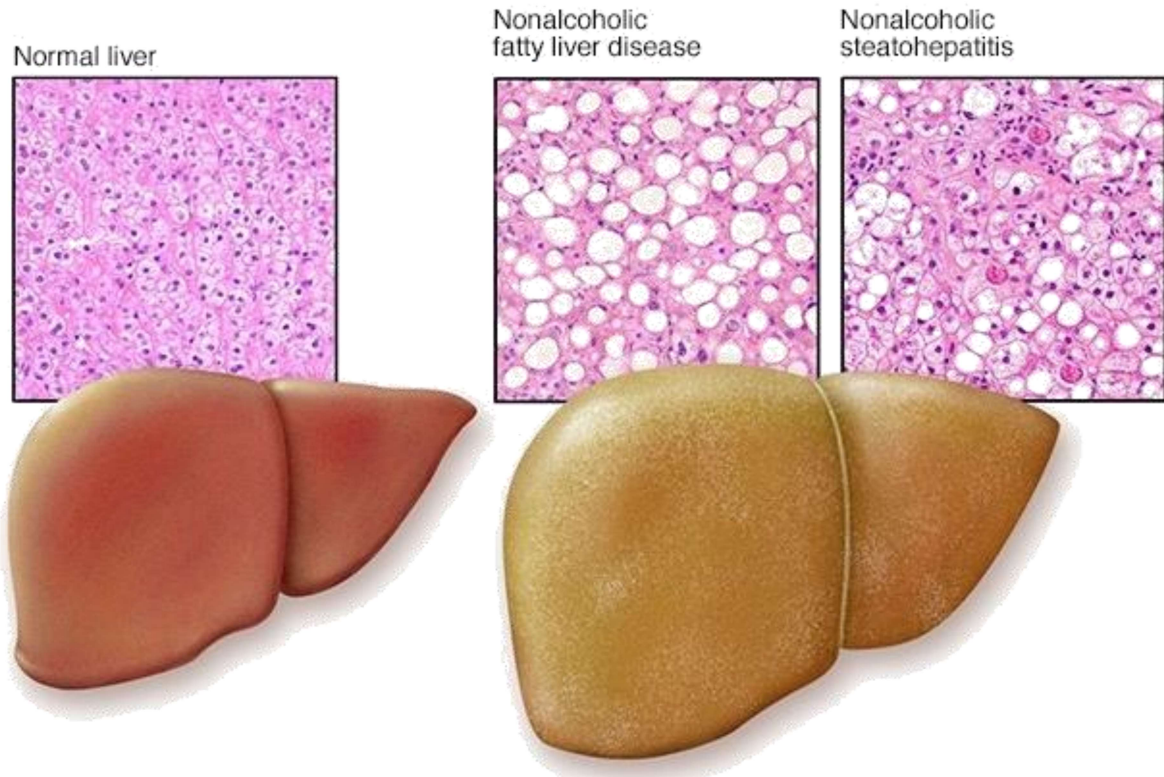
Phase 6

- Cardiology
- Pulmonary
- Anesthesia
- Gynecology
- Psychiatry
- Psychologist
- Hepatology

- Quality of liver
- Quantity: GRWR and FLR
- Extra & intra-hepatic anatomy
- Fitness for major surgery

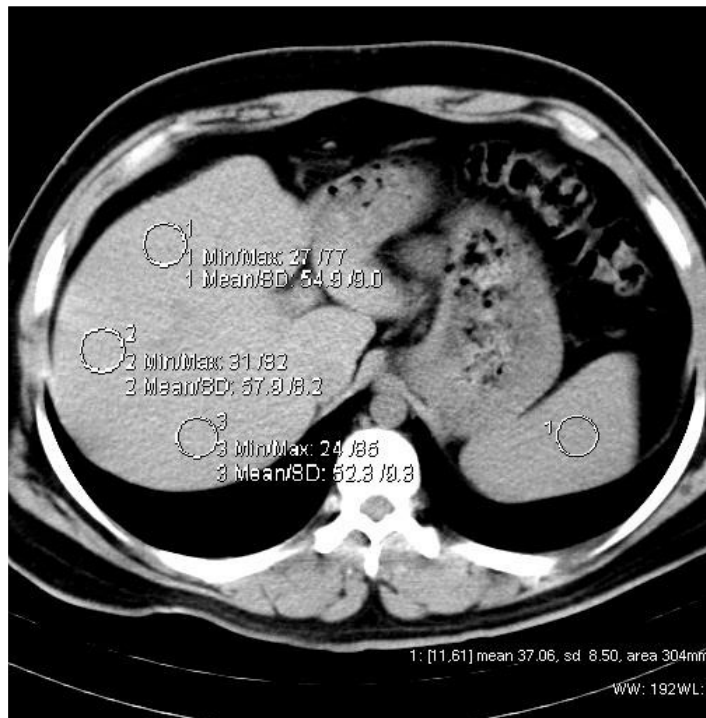
Who can be a live donor

- 18 – 55 years, BMI < 30
- HCV, HIV, HBsAg –ve (HBcAb+ ok)
- Triphasic CT: volumetry, vascular
- MRE/Fibroscan: Steatosis/Fibrosis
- MRCP: biliary tree map



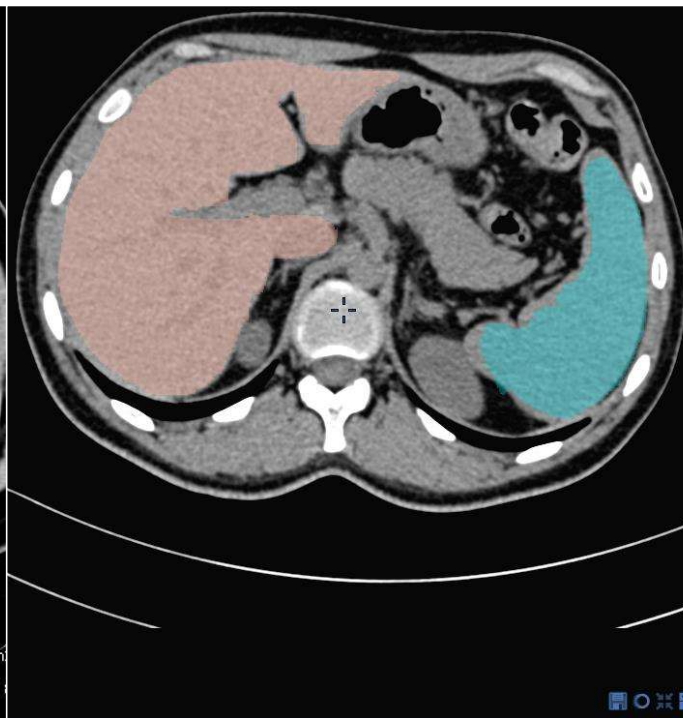
Recipient	Blood donor			
	O	A	B	AB
O	✓	✗	✗	✗
A	✓	✓	✗	✗
B	✓	✗	✓	✗
AB	✓	✓	✓	✓

Assessment of liver steatosis: CT LAI



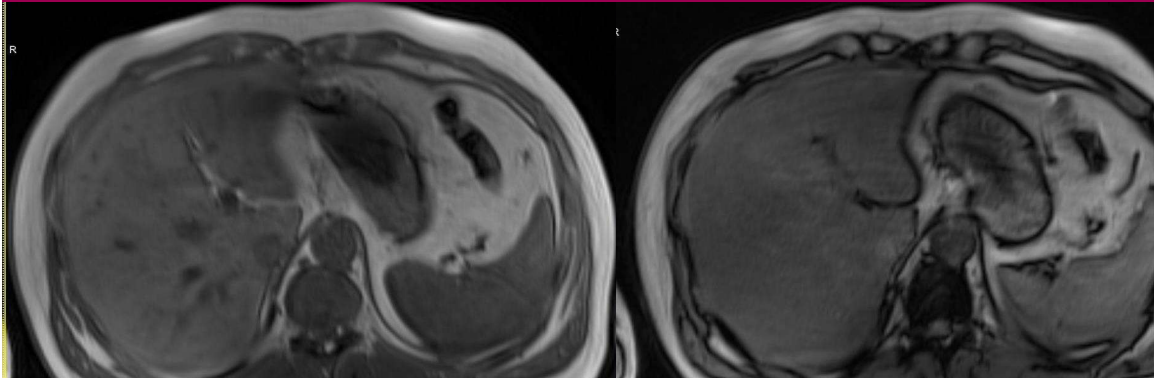
Manual

25 ROIs in Liver & 5 ROIs in Spleen, LAI = (L-S)



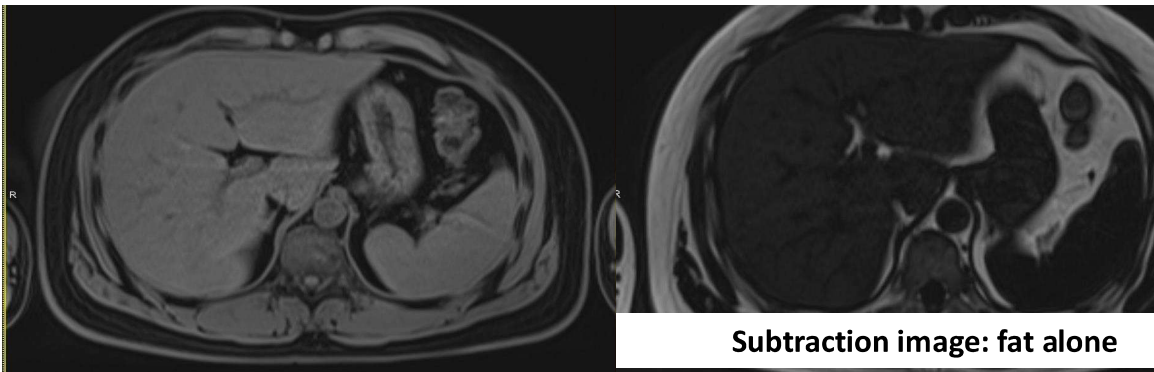
Automated

Assessment of liver steatosis: MRI



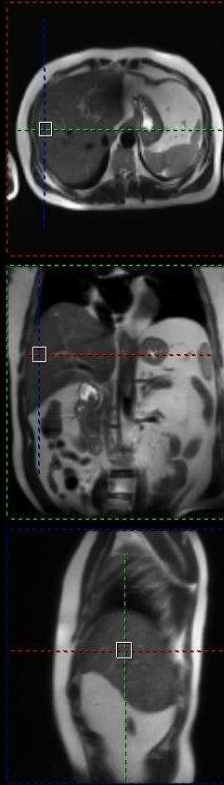
In-phase: Fat + water

Out-phase: water alone



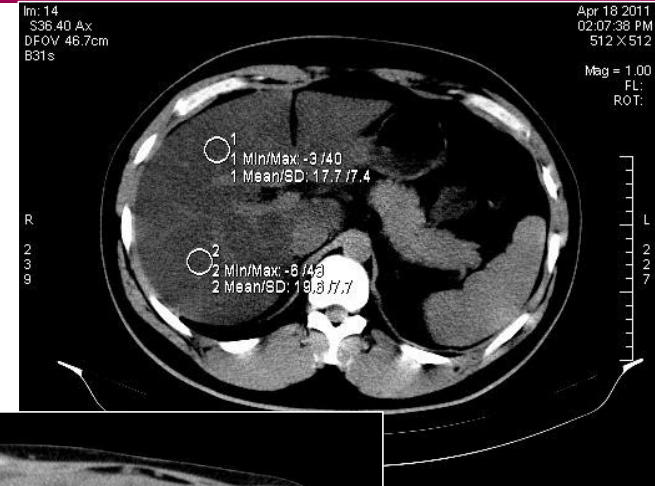
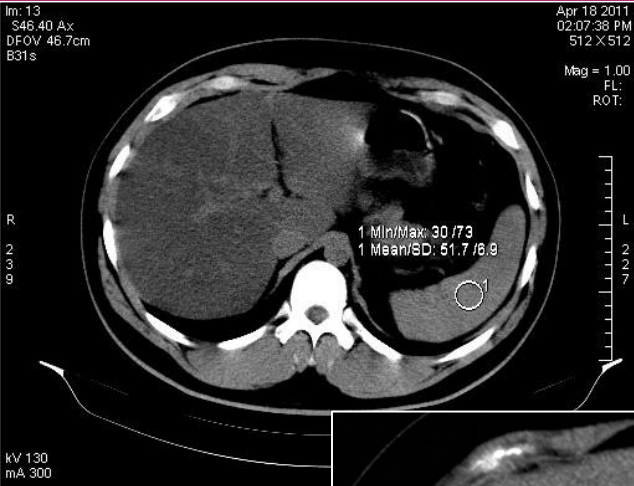
Subtraction image: fat alone

2-point Dixon

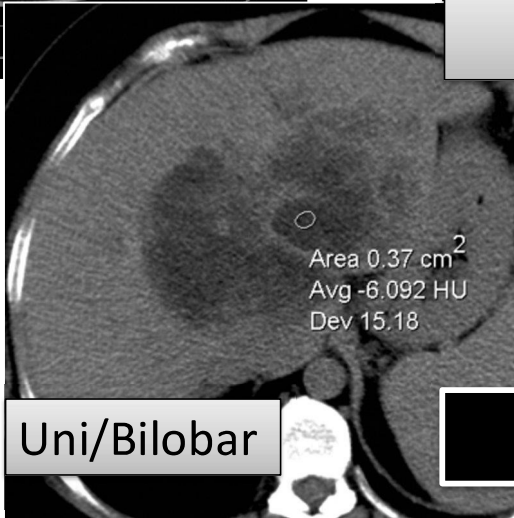


MR spectroscopy

Fatty liver

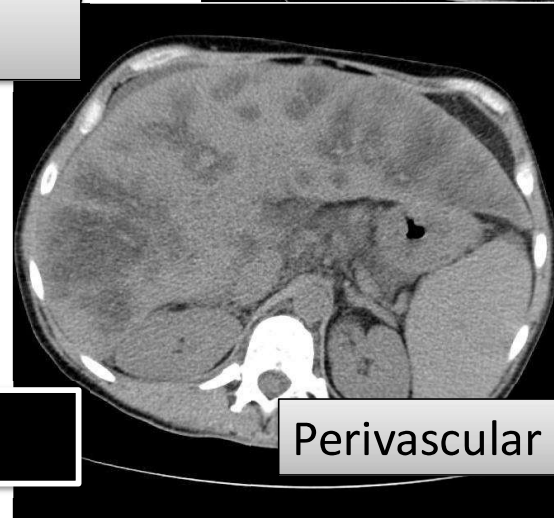


Diffuse



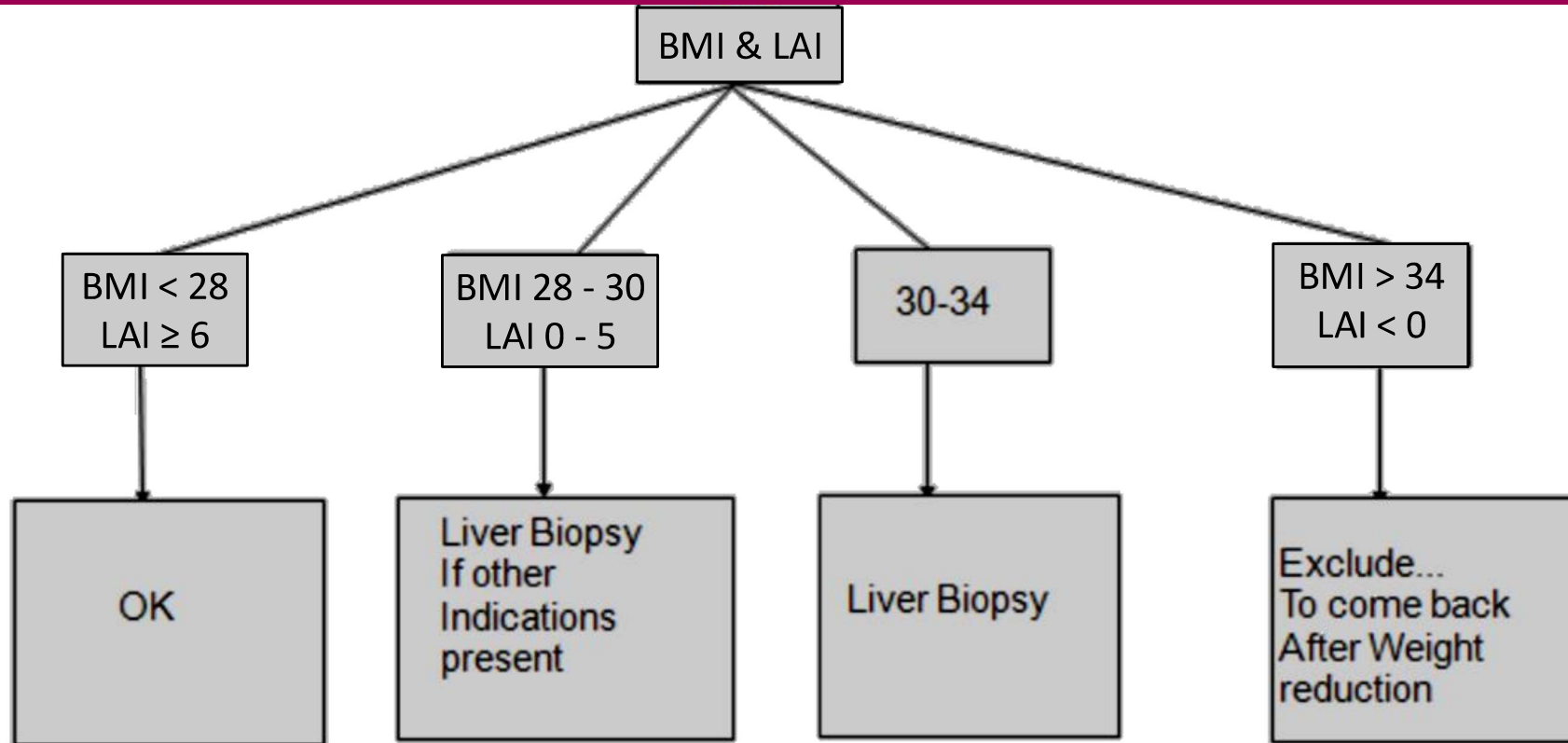
Uni/Bilobar

Focal



Perivascular

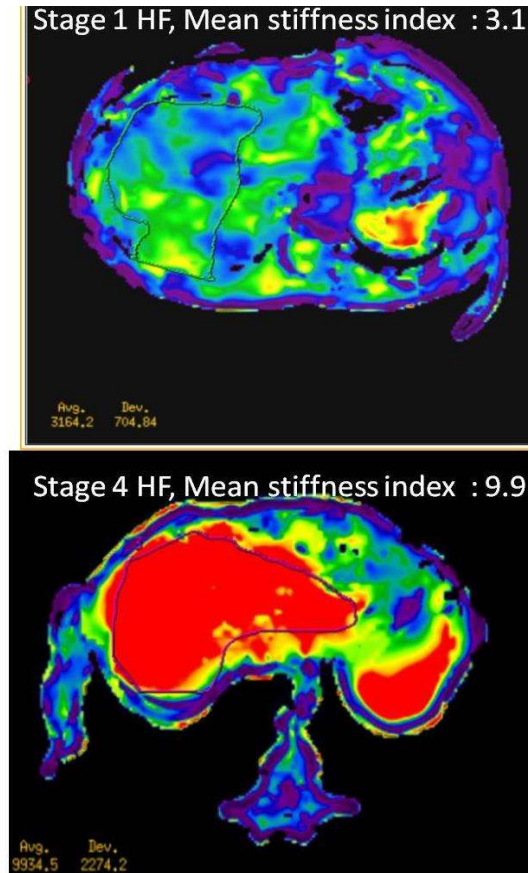
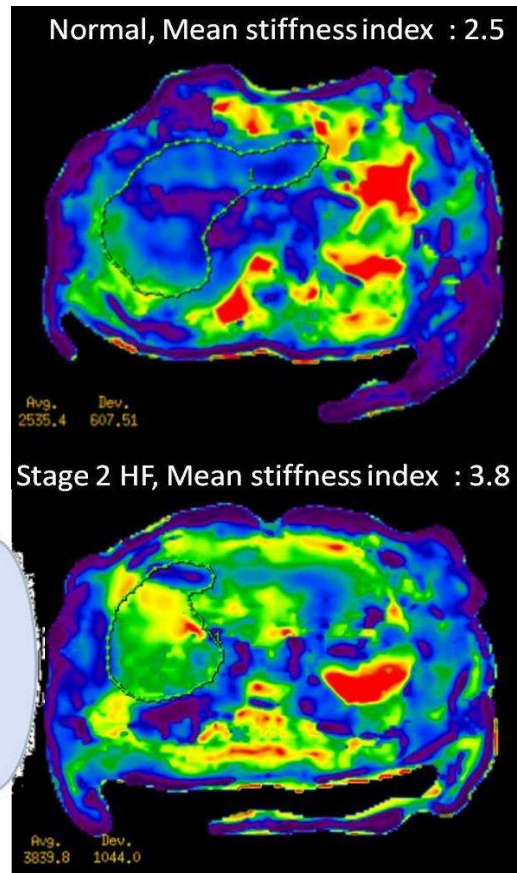
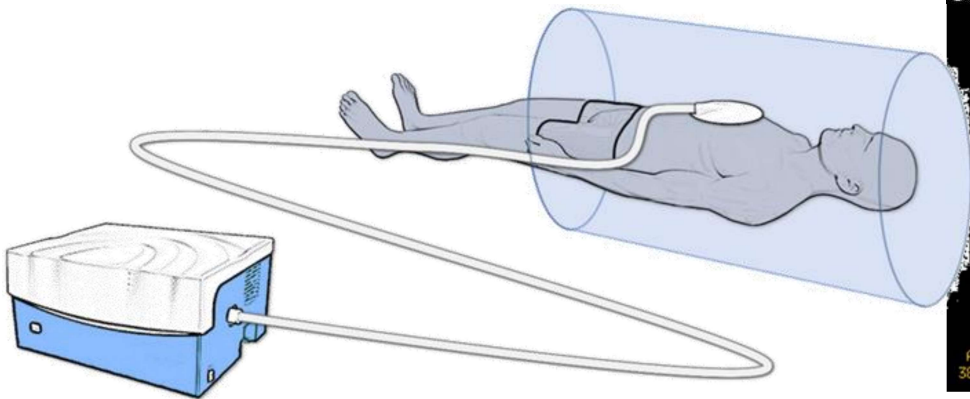
Assessment of liver steatosis: CT



Acceptable macrosteatosis: Right lobe graft < 20%, Left lobe graft 30%

Assessment of liver fibrosis

- Fibroscan®: Inaccurate with Ascites / right lobe tumors, cholestasis, hepatitis
- ARFI: Assessment of a focused area
- MR Elastography (MRE)

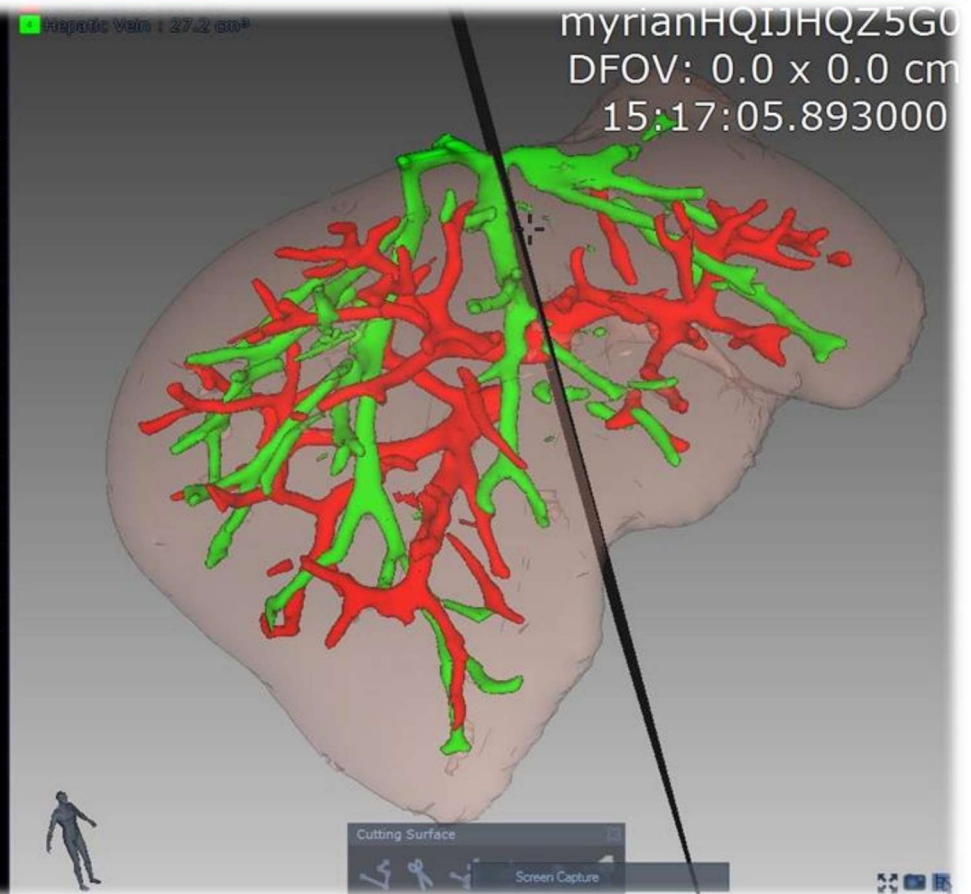
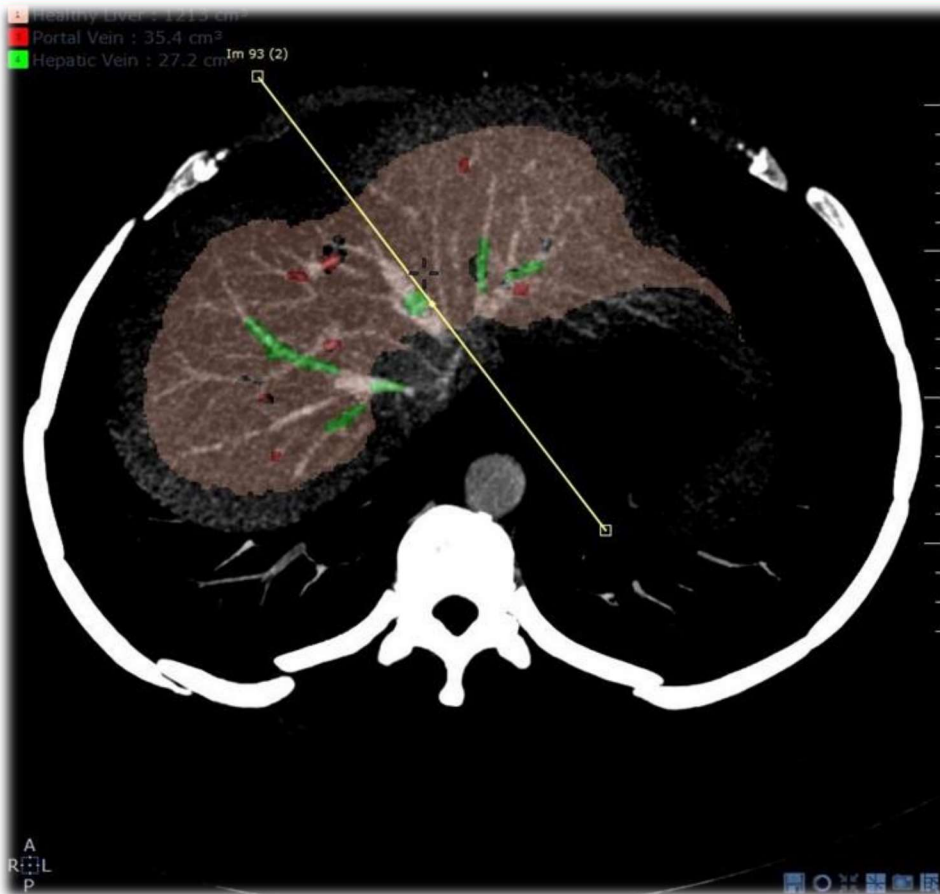


Liver biopsy

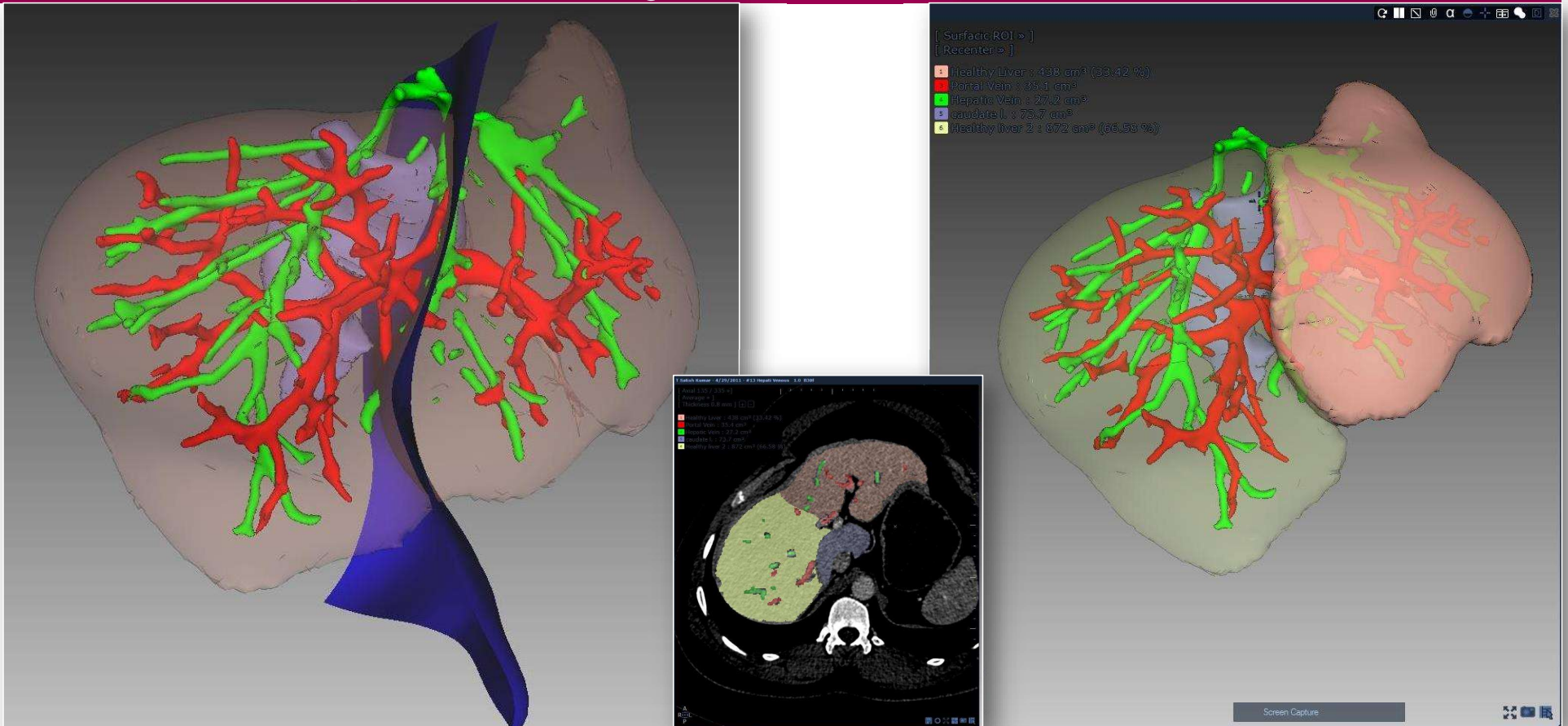
	F0	F1	F2	F3	F4
MRE elasticity (kPa)	2.1 ± 0.2	2.3 ± 0.1	2.6 ± 0.2	3.4 ± 0.4	5.4 ± 0.6
MRE viscosity (Pa.s)	1.8 ± 0.4	1.8 ± 0.5	1.9 ± 0.7	2.9 ± 0.7	4.8 ± 1.3
FibroScan Elasticity (kPa)	5.1 ± 1.3	6.6 ± 3.2	5.4 ± 1.4	14.2 ± 9.4	31.0 ± 21.9

% Fat	Biopsy	MRI (Chemical Shift + MR Spectroscopy)
< 5%	25	26
5 - 10%	5	4
10 - 20%	1	2
> 20%	1	*

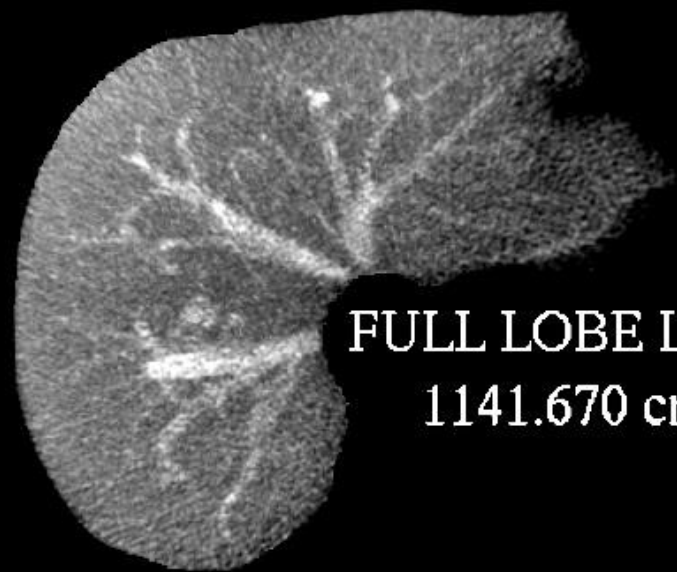
Virtual hepatectomy



Virtual hepatectomy



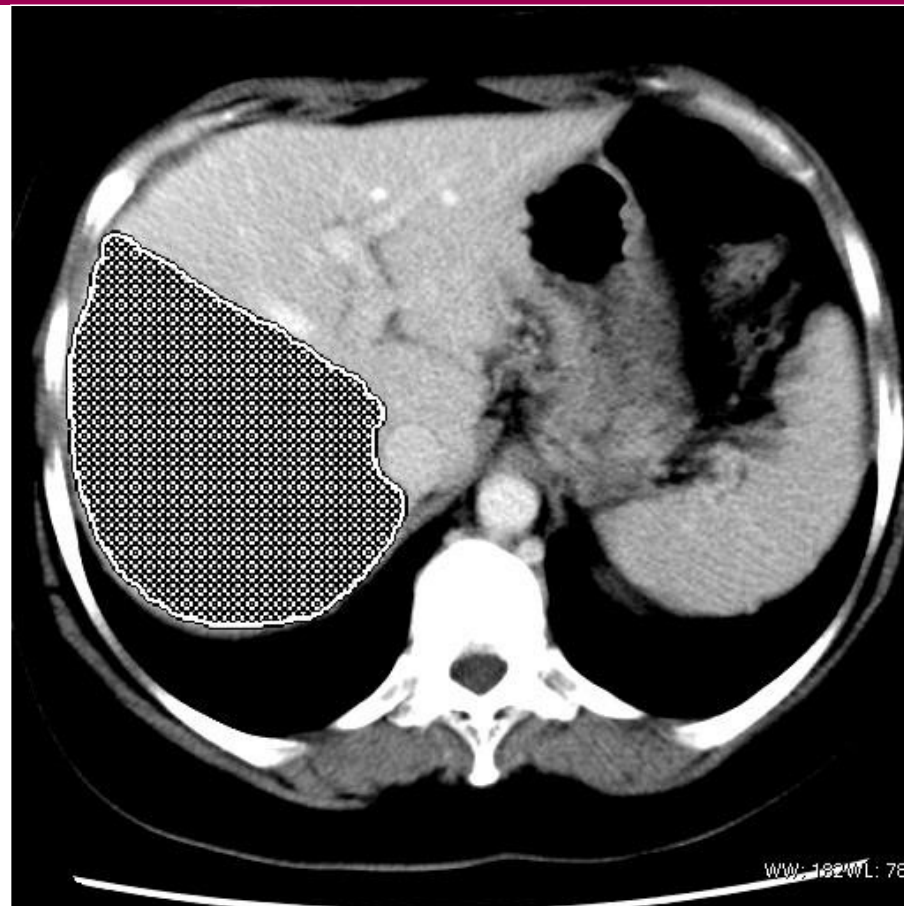
Volumetry: Manual



FULL LOBE LIVER
1141.670 cm³

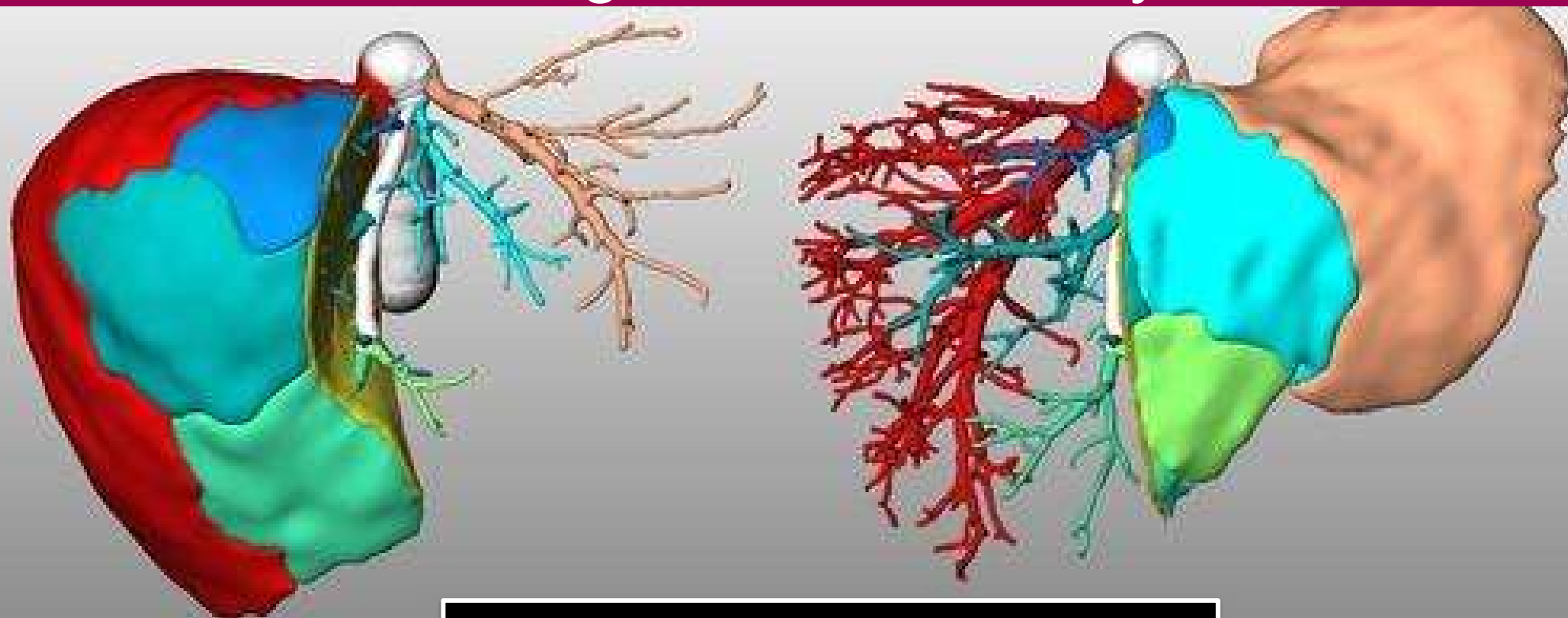
Processing time: 32.8 ± 6.9 minutes

WW: 69WL: 137



WW: 102WL: 78

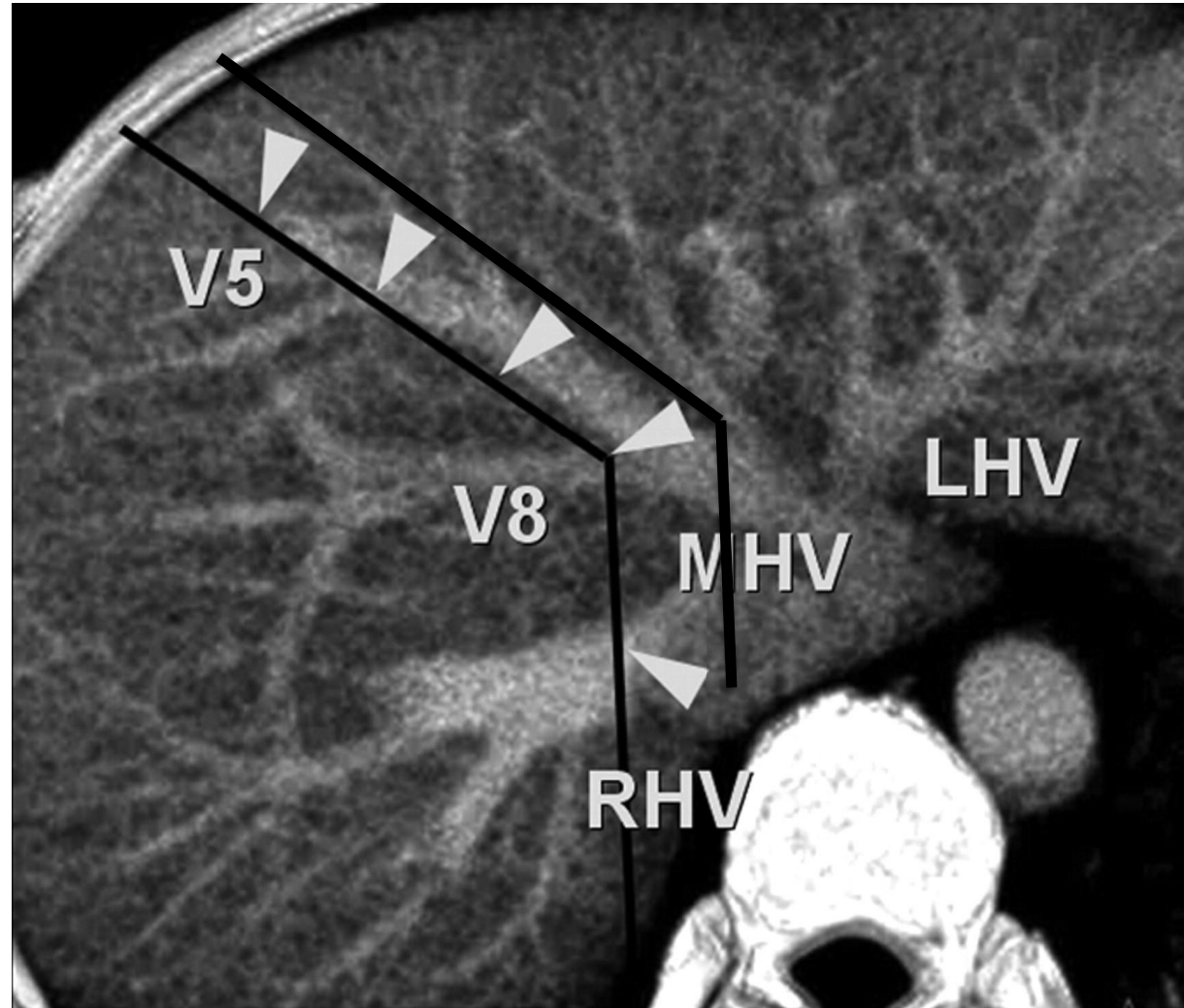
Automated with Segmental Volumetry



Processing time: 4.4 ± 1.9 minutes

Volumetry

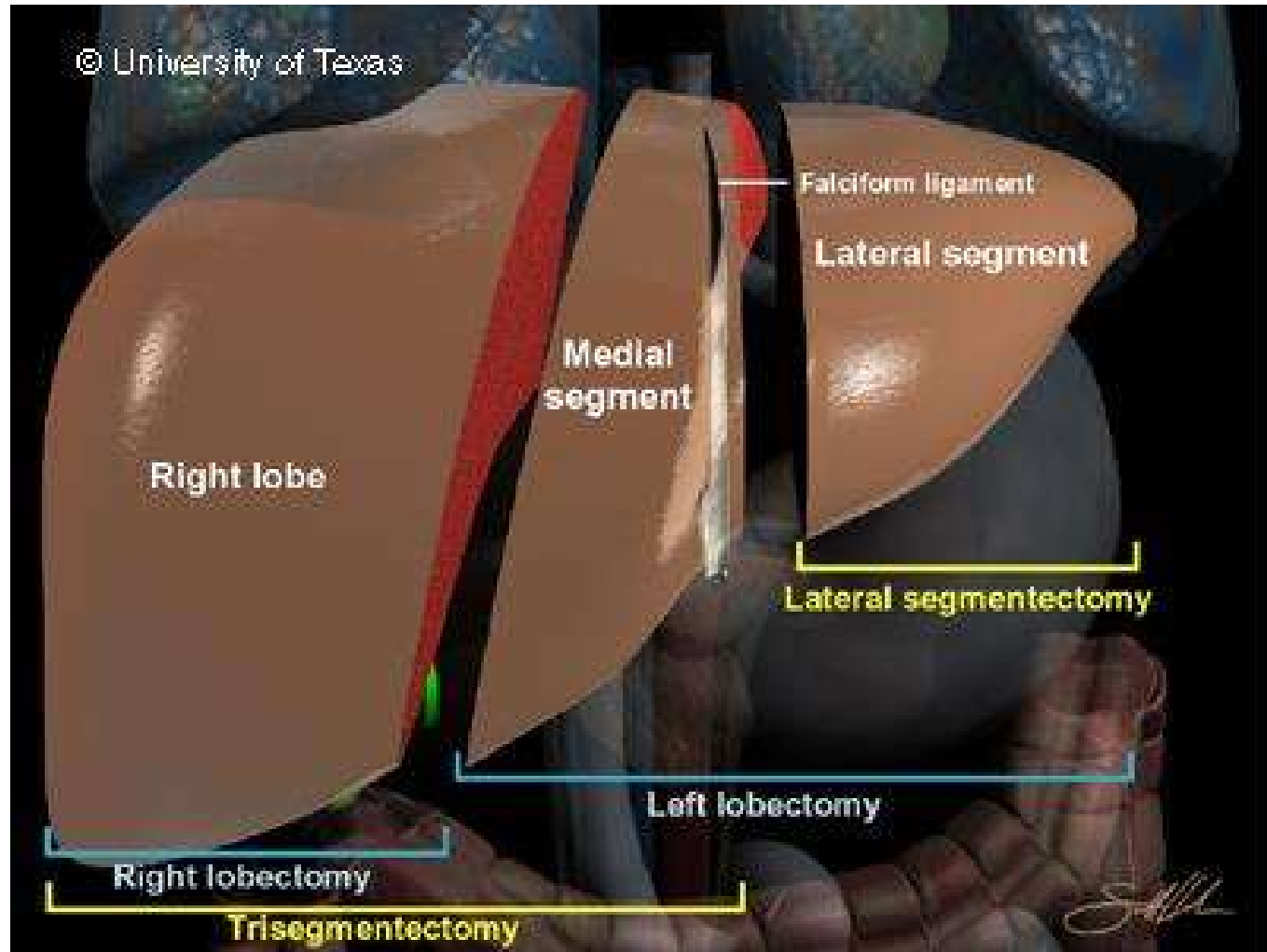
TLV: 1455 cc	Right lobe	Left lobe
Right of MHV	983 cc GRWR 1.3	471 cc FLR 32%
Left of MHV	1083 cc GRWR 1.4	372 cc FLR 25%



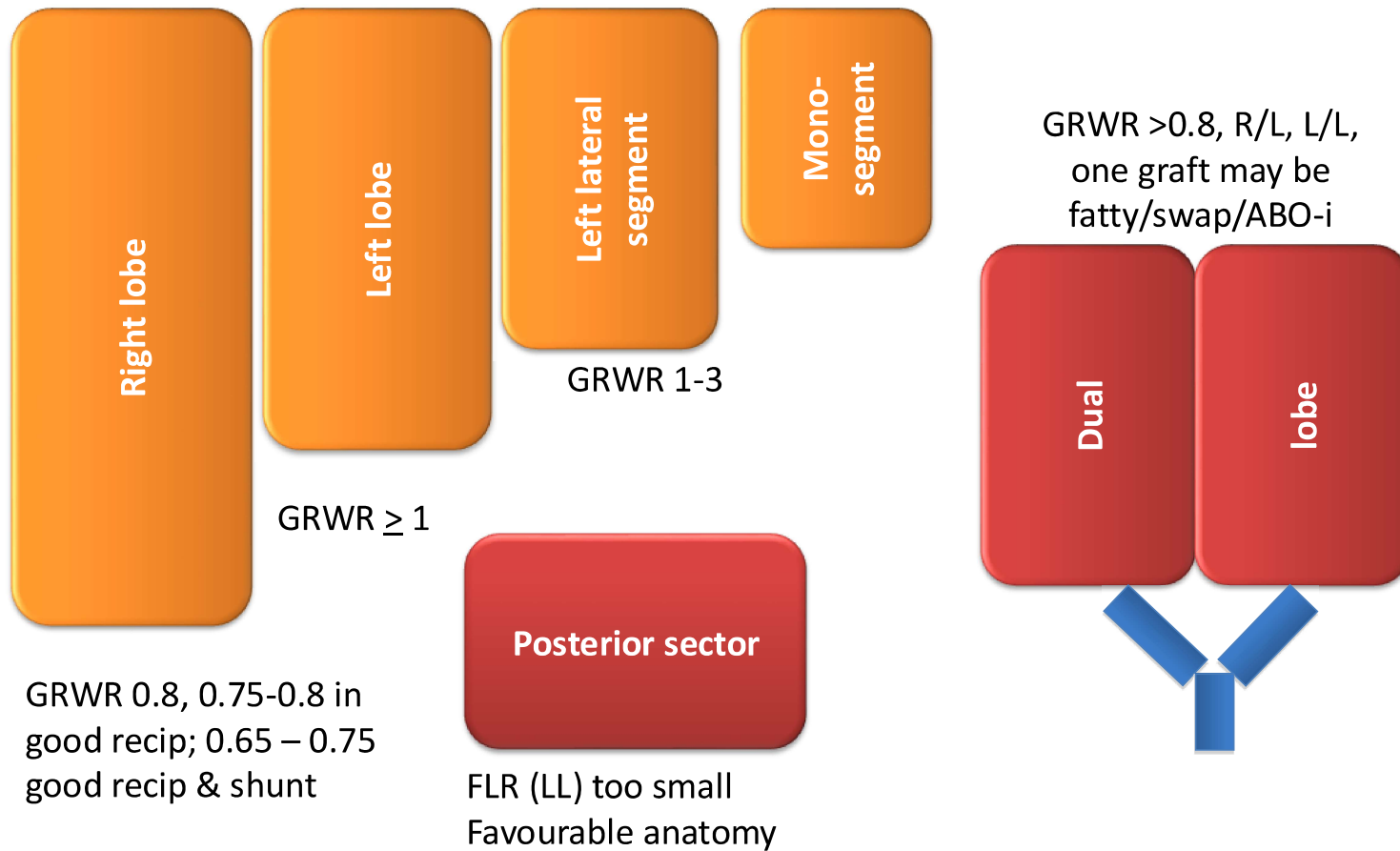
- **Total Liver Volume:** 1000 – 1500 grams
- **Right lobe (2/3rd):** 650 – 1000 gms
- **Left lobe (1/3rd):** 350 – 500 gms

- **Adult:** 50 – 100 kgs needs about 400 – 800 grams of liver
- **Child:** Volumes always adequate/large

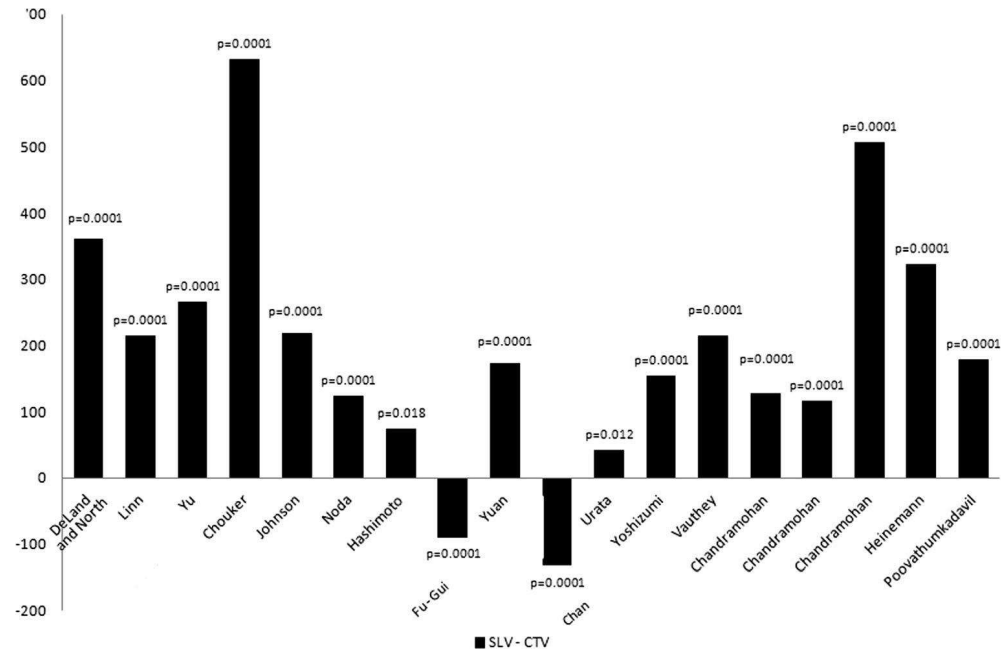
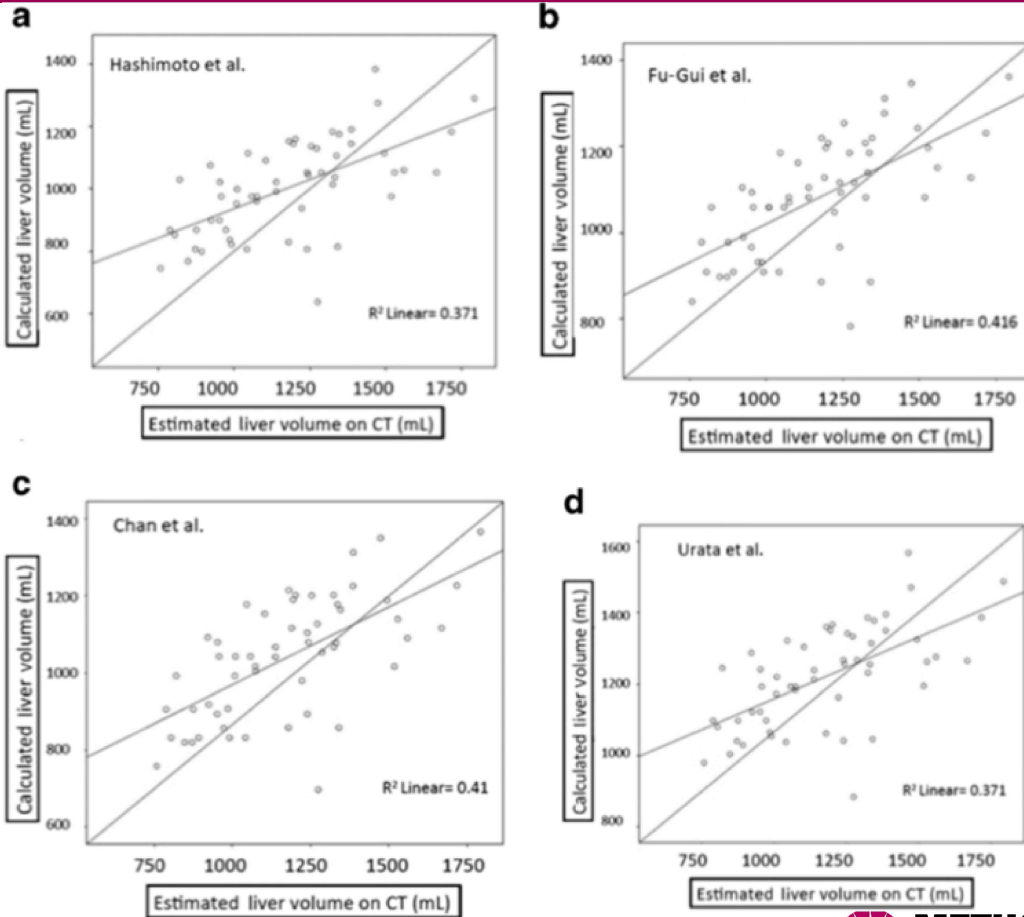
Lobe	Patient
Right lobe	Adult
Left lobe	Small adult or adolescent child
Left lateral segment (LLS)	Child
Monosegment / reduced (LLS)	Small child (< 10 kg)



Graft selection



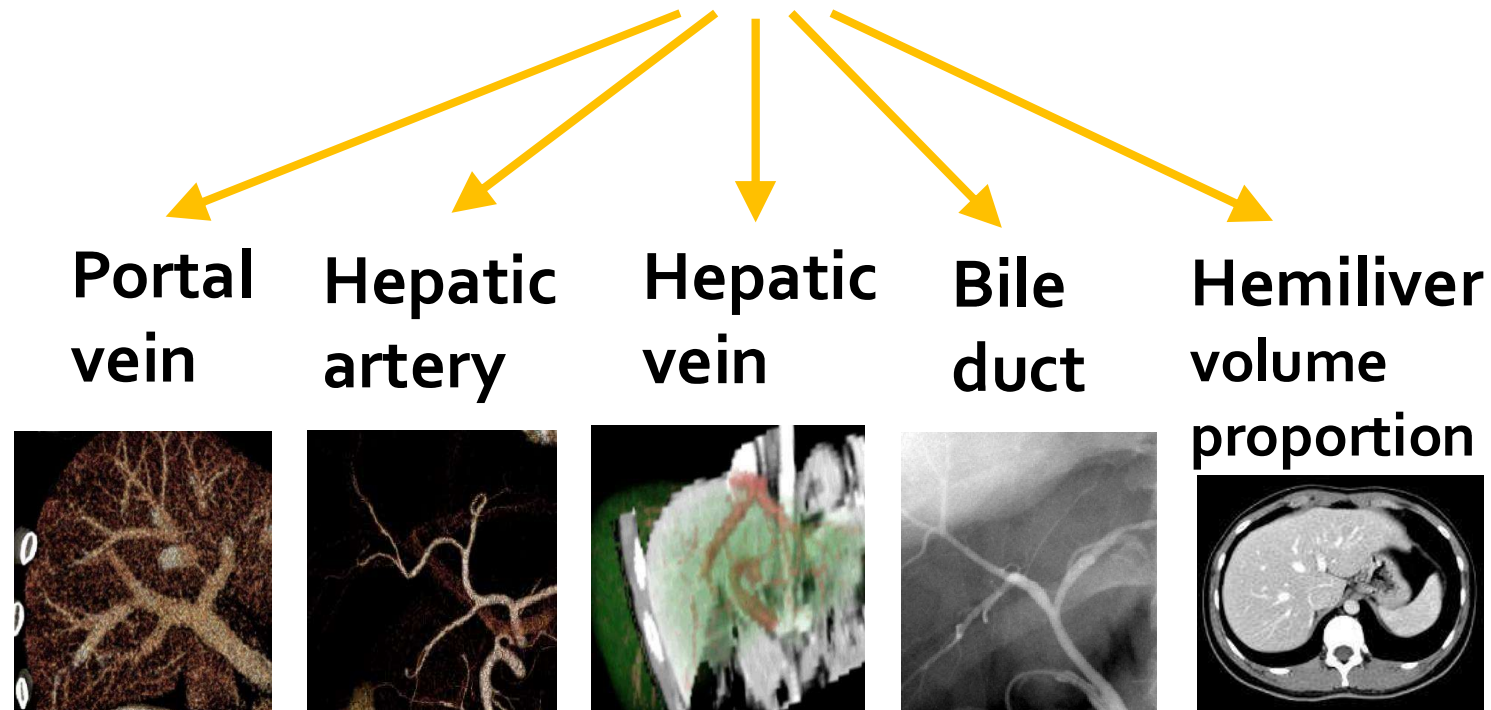
Standard Liver Volume (SLV) for Indian Population



Chaubal, Mohanka, et al. Estimation of liver volume in the western Indian population. Indian J Gastroenterol. 2016 Jul;35(4):274-9

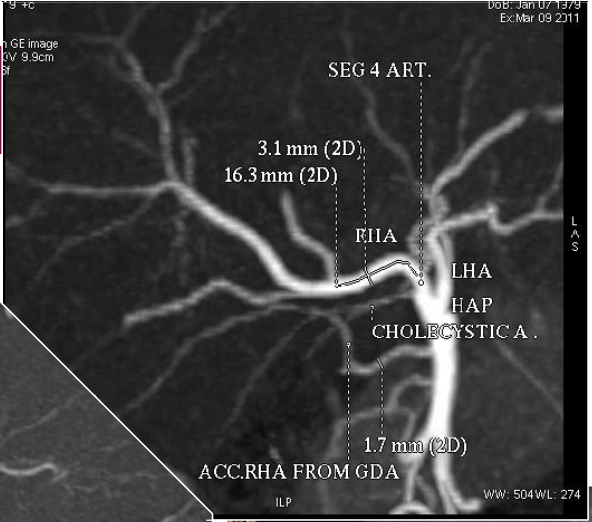
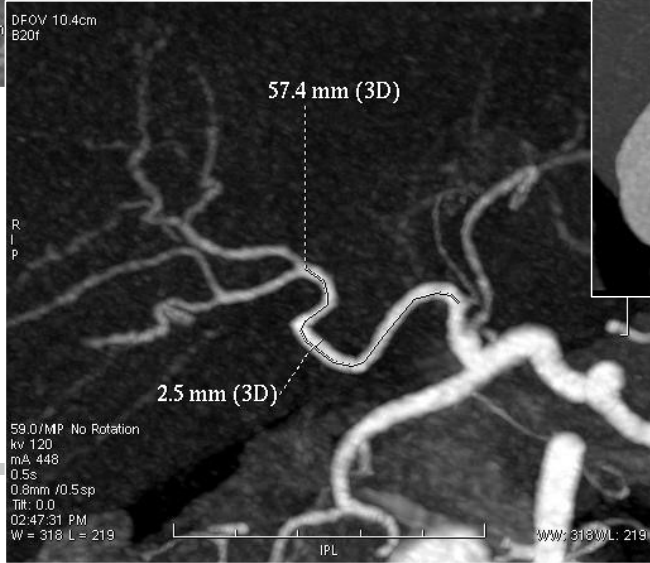
Extra-hepatic anatomy: The Roadmap

Normal/variations



Grossly normal in only $\frac{1}{3}$ \Rightarrow $\frac{2}{3}$ with at least 1 significant variation

Arterial anatomy



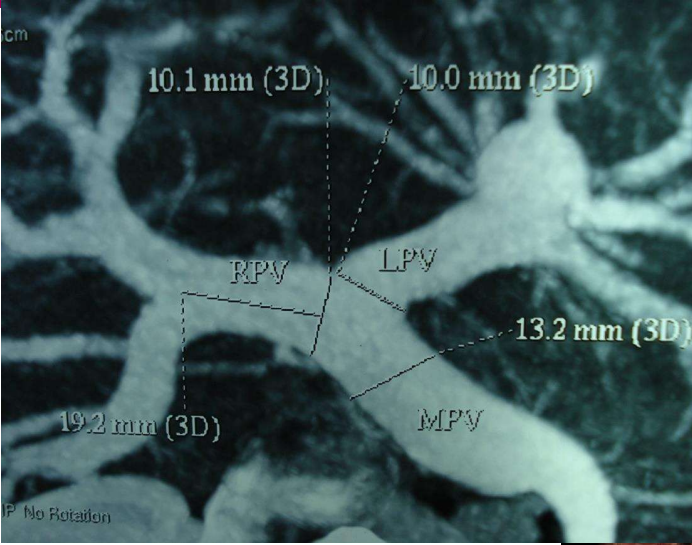
Arterial anatomy



Celiac axis stenosis, GDA supplies the liver

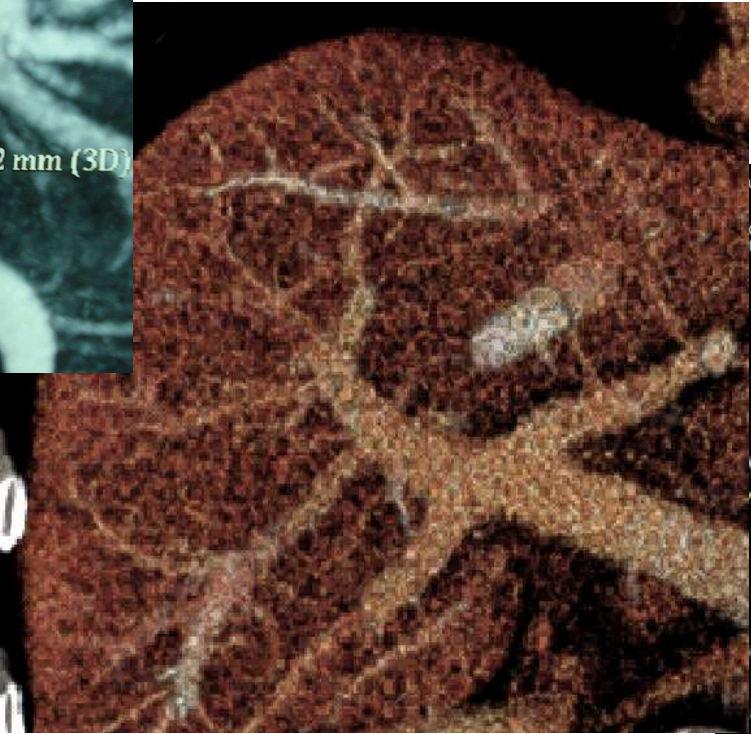
2 arteries to each lobe

Portal vein anatomy

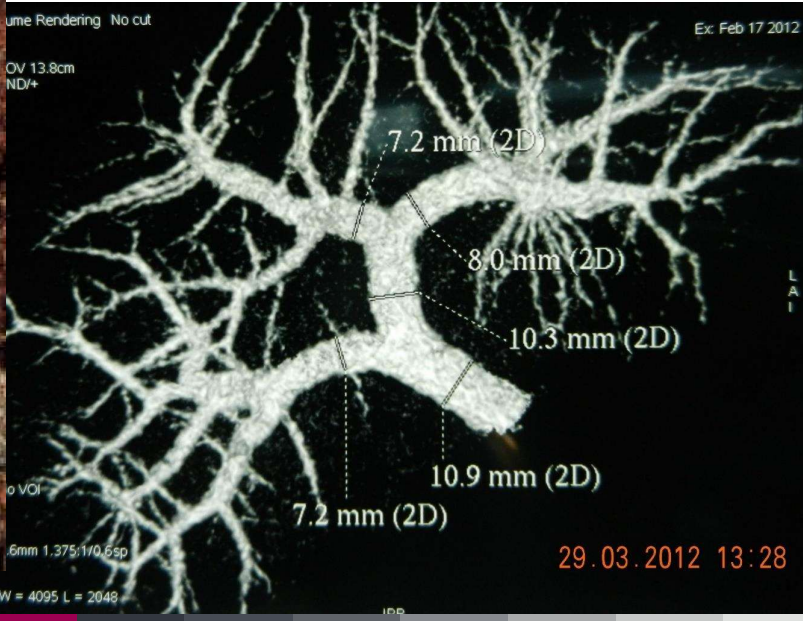


Type A (80%)

Type B (12%)



Type C (8%)

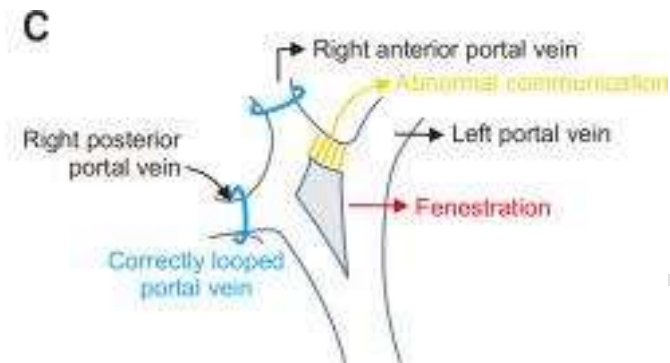
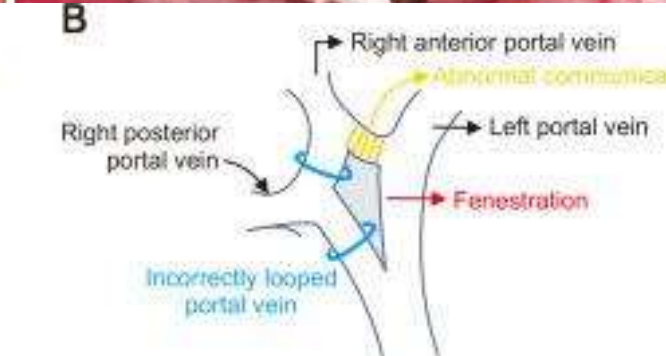
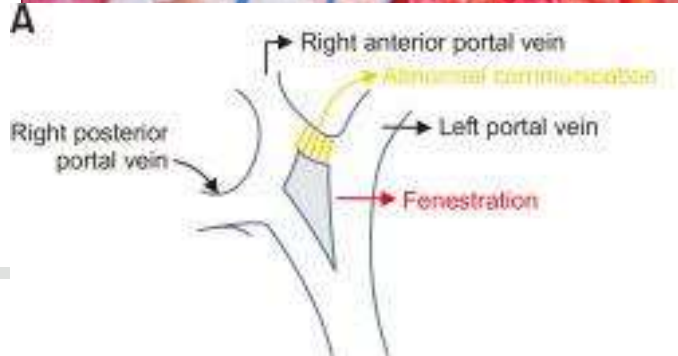
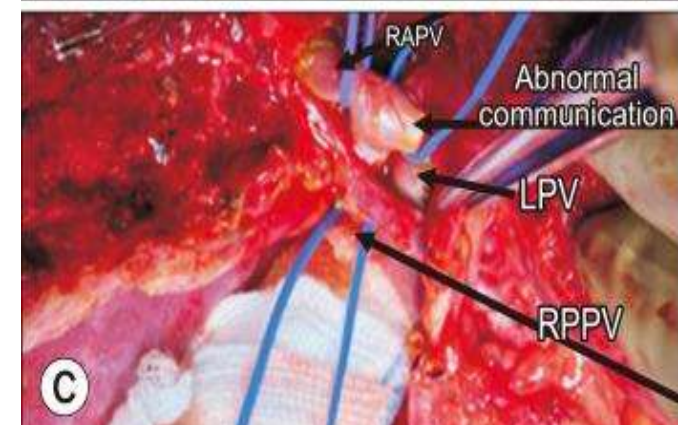
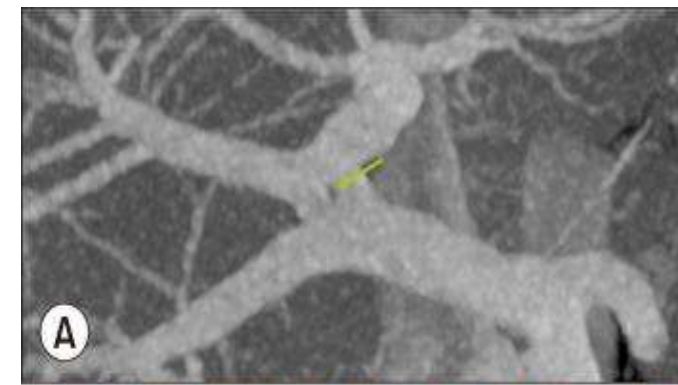


Fenestrated PV

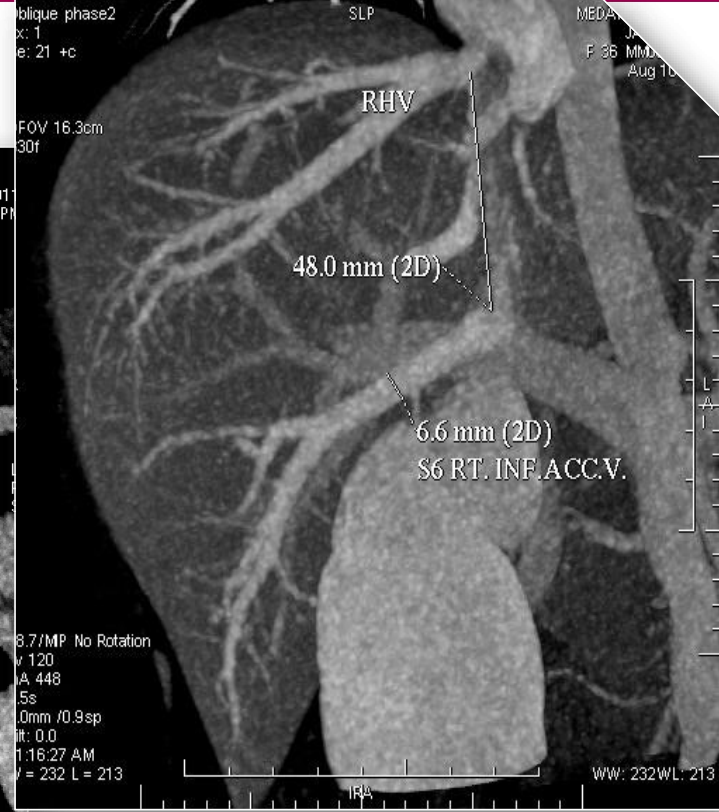
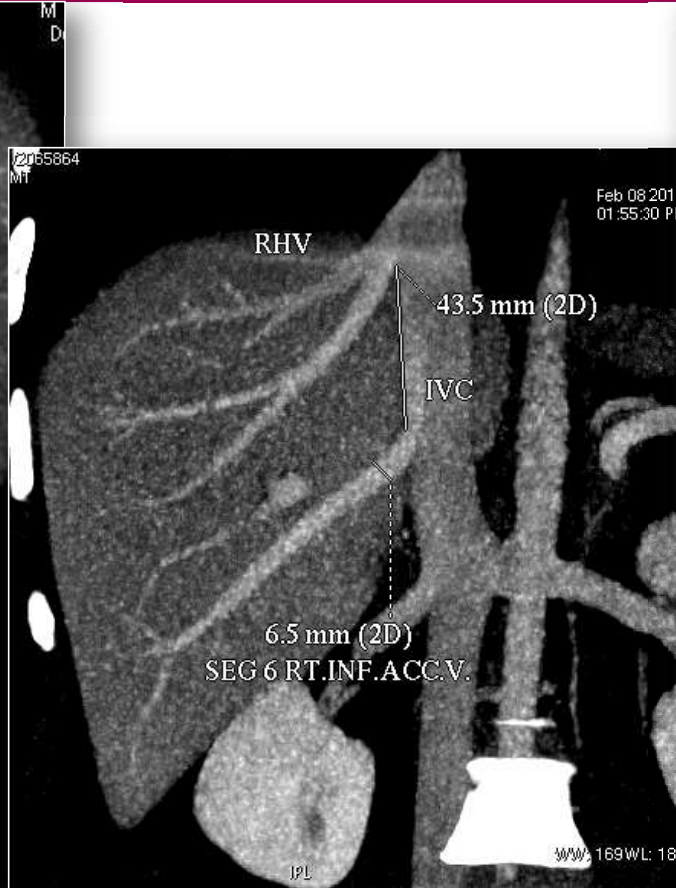
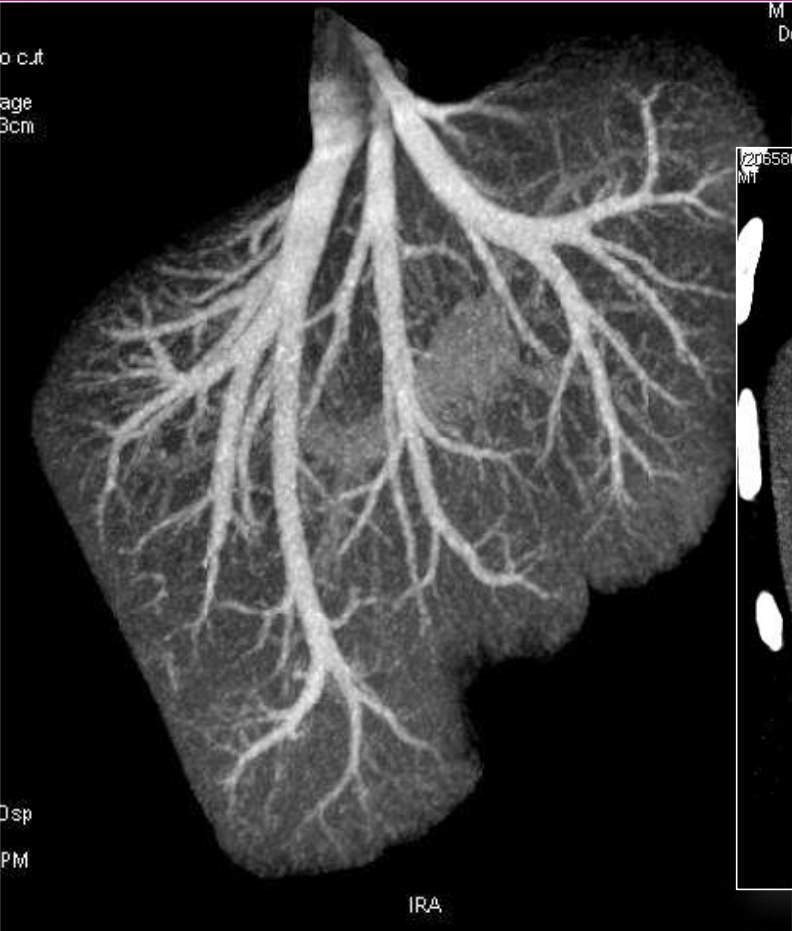
Banker A, Rao P, Ganesan K, Mohanka R

Korean J Transplant

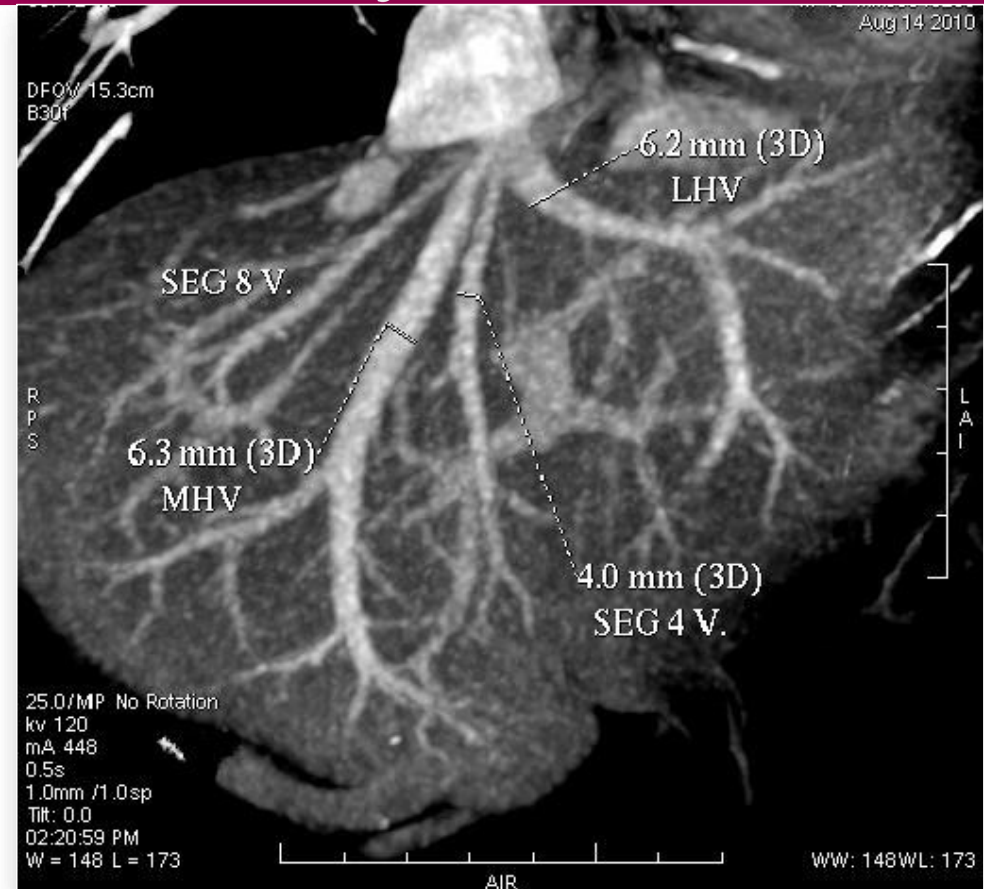
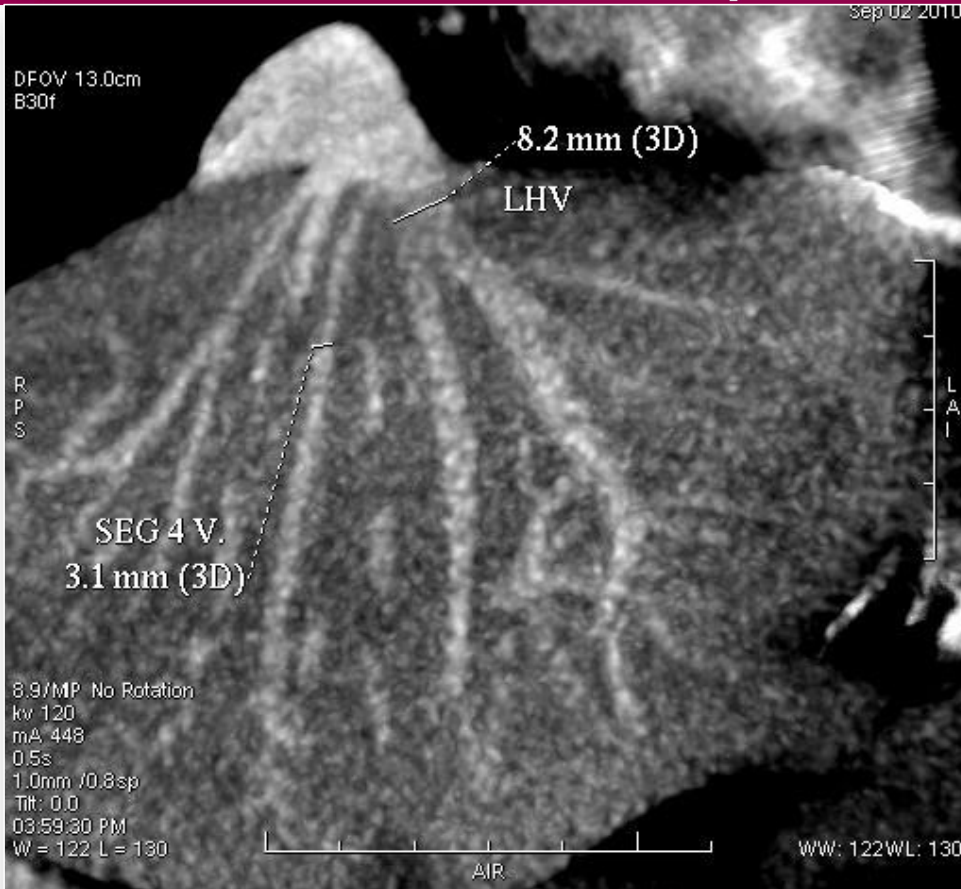
2023 Jun 30;37(2):141-143



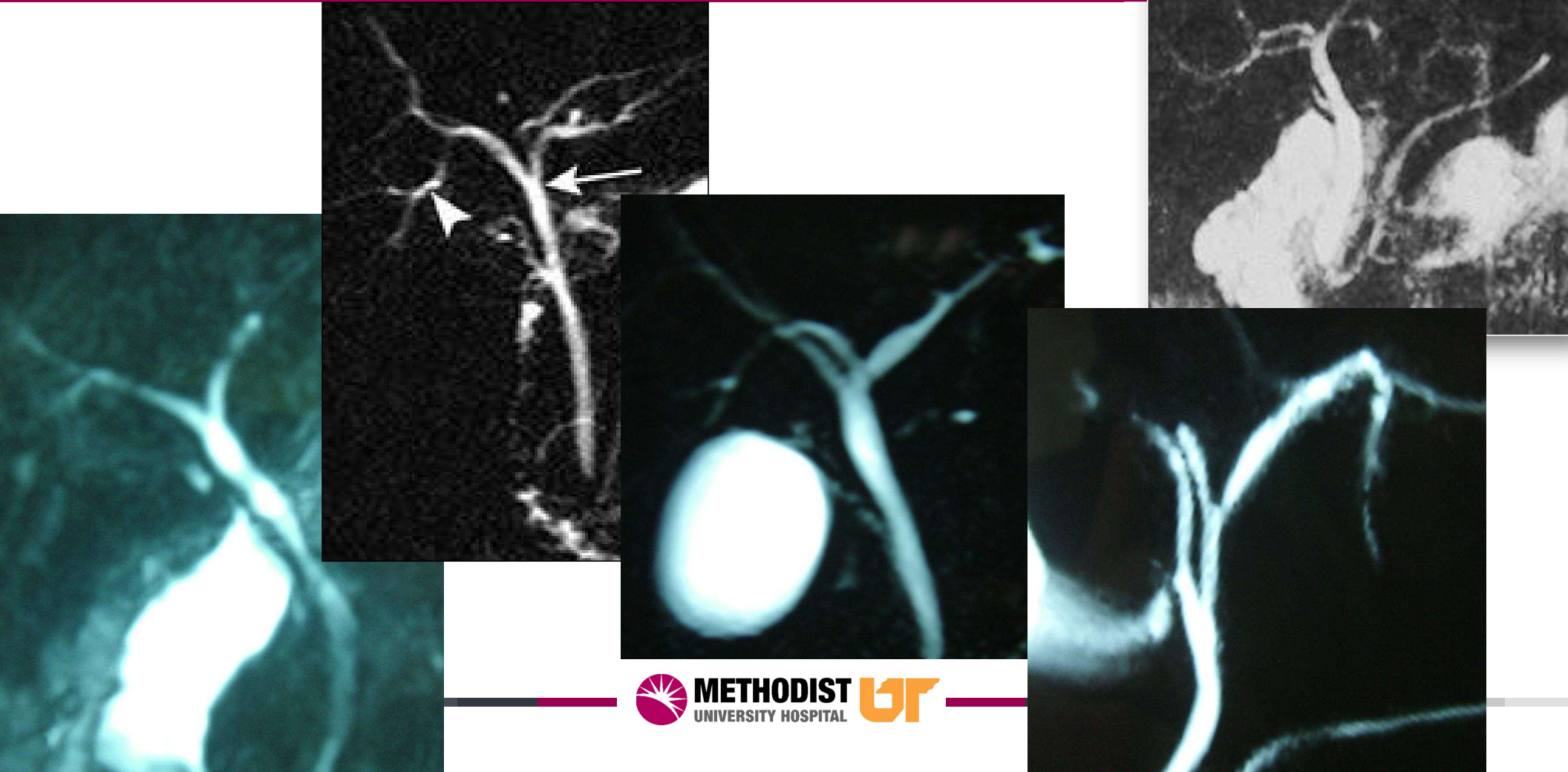
Hepatic vein anatomy



Hepatic vein anatomy



Biliary anatomy



Biliary anatomy

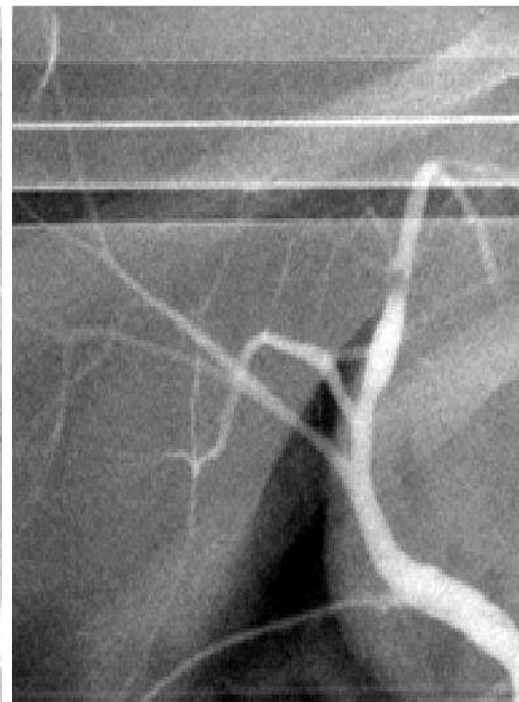
63%



12%



13%



12%

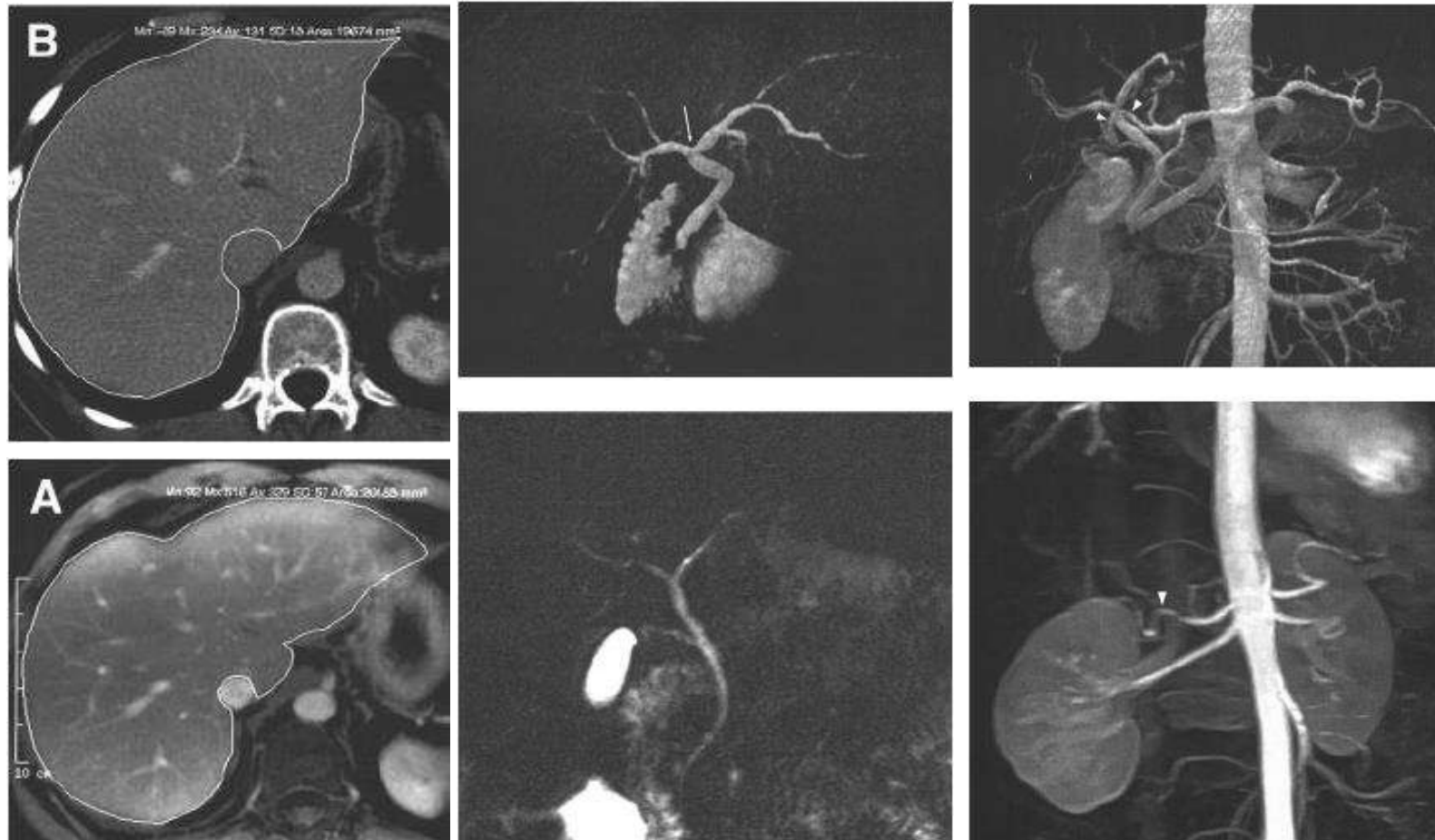


“All-In-One” Imaging Protocols for the Evaluation of Potential Living Liver Donors: Comparison of Magnetic Resonance Imaging and Multidetector Computed Tomography

*Tobias Schroeder,¹ Massimo Malagó,² Jörg F. Debatin,³ Mathias Goyen,³
Silvio Nadalin,² and Stefan G. Ruehm⁴*

Triple phase CT	MRI
<ul style="list-style-type: none">• Better display of intra-hepatic arteries, portal vein• Easy accessibility• Shorter scan time• Preferred by most surgeons	<ul style="list-style-type: none">• No radiation• Less contrast toxicity

All-in-one Imaging



Recipient evaluation

Phase 1

Laboratory Investigation
Microbiology/Infection profile
Virology
Tumor markers
Endocrine profile
Haemolytic profile
Cardiology Evaluation
Pulmonary Evaluation
Gynecology Evaluation

Phase 2

CT abdomen and pelvis
OR
CT Contrast Non-ionic
OR
MRI Abdomen
OR
MRI Contrast

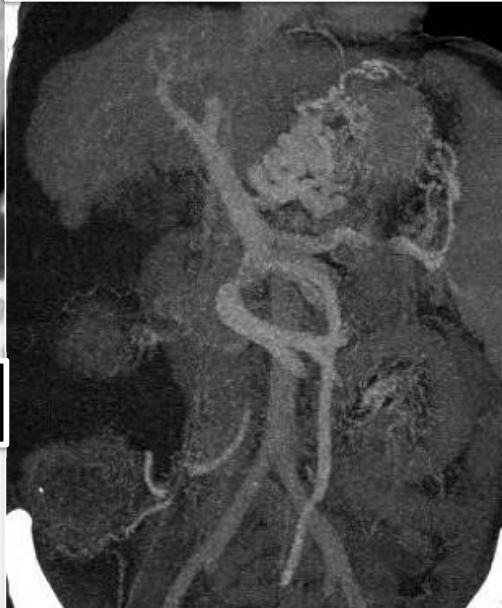
Phase 3

Doctor's Consultations
Cardiology
Pulmonology
Endocrinology
Anesthesia
Gynecology
Nutrition
Physiotherapy
Psychiatry
Hepatology
Transplant surgery

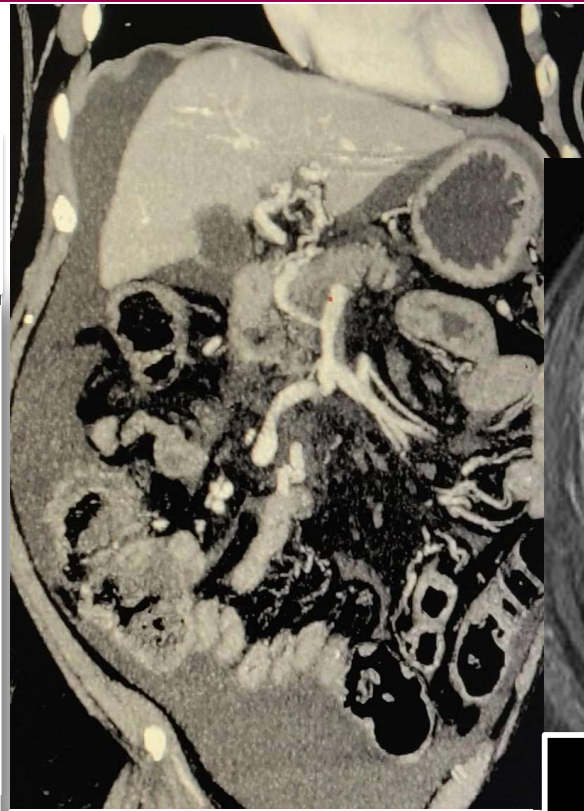
Recipient evaluation



Mesenteric collaterals



Celiac stenosis



Portal Vein Thrombosis



HCC



Outcomes

Donor outcomes

IS THE SAFETY OF LIVE LIVER DONORS BEING ASSURED?

An area of major concern in the evolution of LDLT has been donor safety which also includes donor mortality. Firstly, there is no reliable information on the extent of the problem as currently there is no mechanism for mandatory reporting of donor death. To our knowledge, apart from a single published case from Chennai,¹² none of the donor deaths have been formally reported in literature. The print and electronic media have highlighted some of the deaths.³⁶ Although the precise number will never be known, based on a study of media reports as well as personal communications (after assuring anonymity), we estimate the figure to be currently between 18 and 20, thus with roughly 6000 LDLTs being performed that would make a figure of 0.3%. It is difficult to define an 'acceptable' threshold figure for donor deaths but the worldwide figures reported range from 0.2% to 0.5%.¹² Of course,

at very small centers large centers in India any individual dying in ing but what is also urency and disclosure media speculation and is to learn the right

Liver Transplant Forum

JOURNAL OF CLINICAL AND EXPERIMENTAL HEPATOLOGY

Liver Transplantation in India: At the Crossroads

Sanjay Nagral[†], Aditya Nanavati[†], Aabha Nagral[‡]

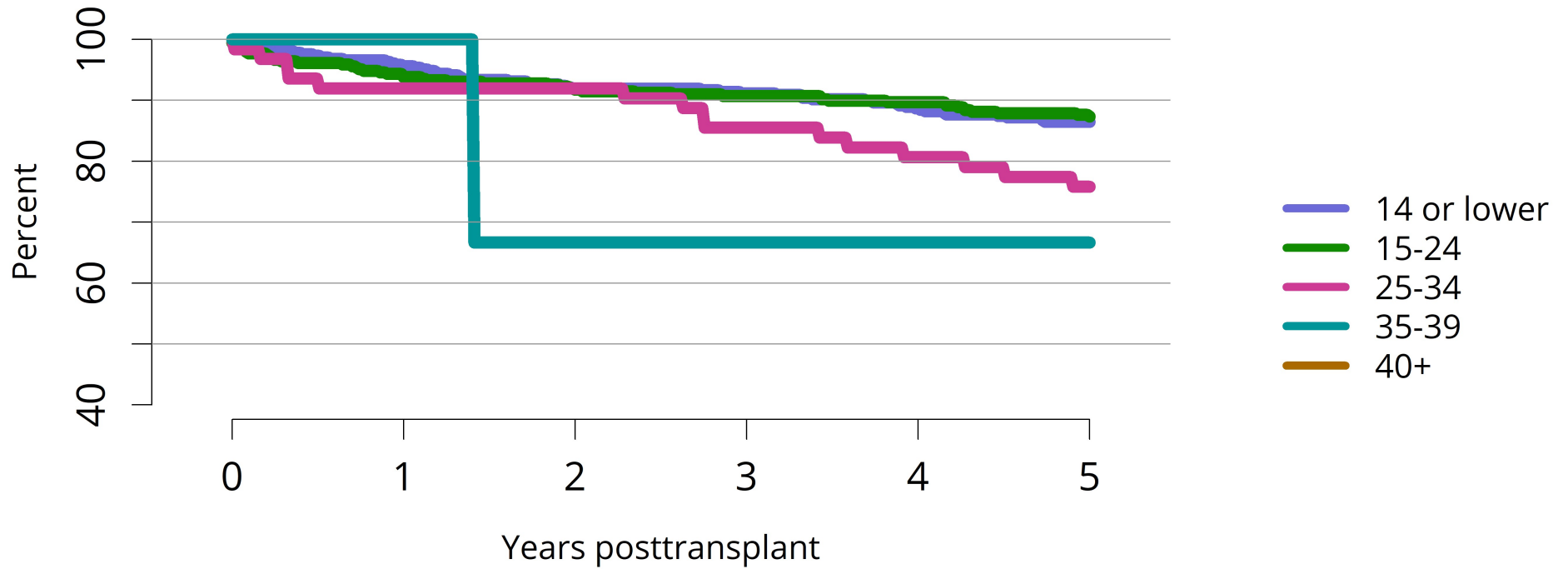
Donor outcome in live-related liver transplantation

Col P.P. Rao^{a,*}, Lt Col D. Routh^b, Surg Capt C.S. Naidu, *vsm*^a,
Col Sanjay Sharma^a, Col A.K. Sharma, *vsm*^a, Lt Col Priyaranjan^b,
Wg Cdr V. Trehan^b, Wg Cdr Amit Gaur^b

Table 4 – Grades of postoperative complications.

Clavien's grade	Total (%)	Left lateral segmentectomy	Left hepatectomy	Right hepatectomy with MHV	Right hepatectomy without MHV
I	7 (20.6)	0	1	1	5
II	2 (6.0)	0	0	0	2
III	0	0	0	0	0
IV	0	0	0	0	0
V	0	0	0	0	0

Recipient outcomes



OPTN/SRTR 2022 Annual Data Report

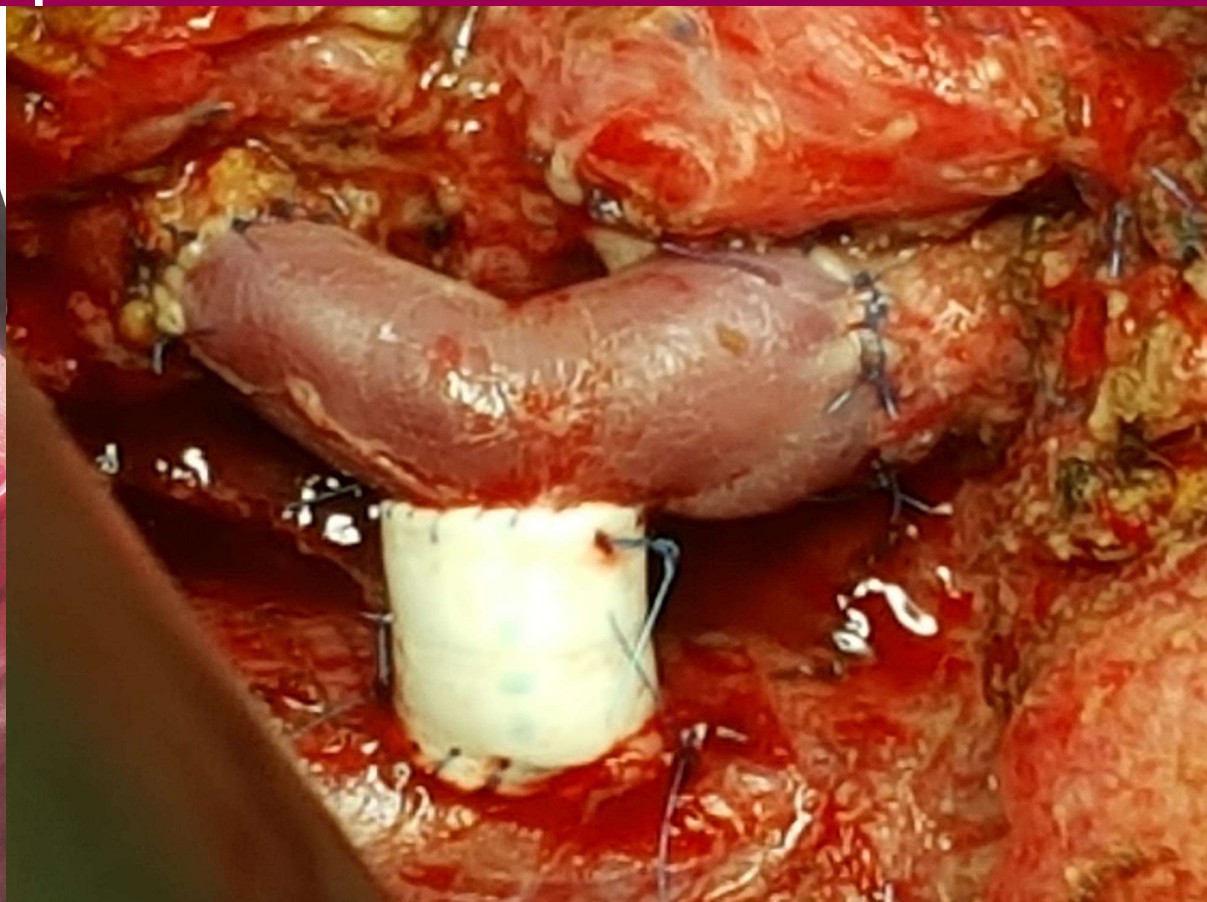
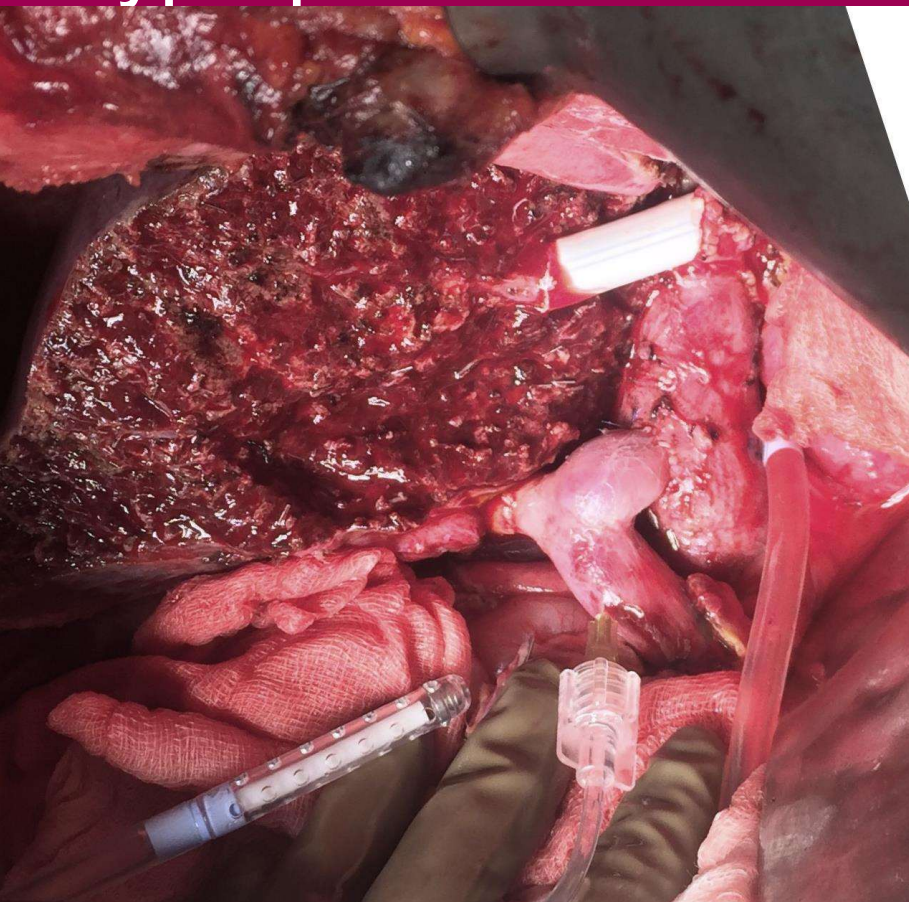
Recipient outcomes

- Small for size syndrome (SFSS)
- Biliary complications
- Hepatic arterial complications
- Portal vein thrombosis
- Hepatic vein outflow obstruction

Risk factors

- Low GRWR
- Steatotic graft
- High MELD
- Recent SBP
- Chest infection
- Renal dysfunction

Hyperperfusion: Hemi-porto-caval shunt

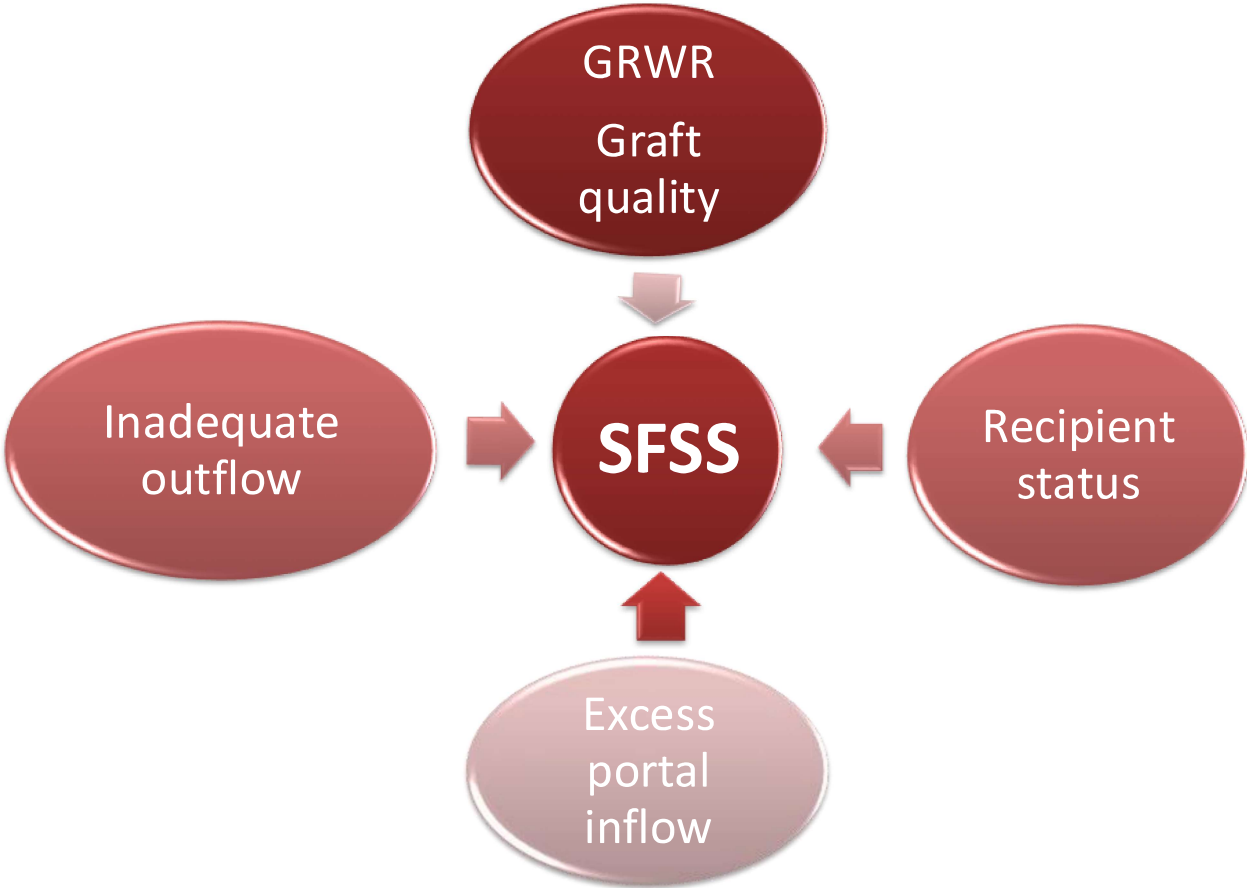


Ultra Low GRWR

- 92 adult LDLT, 12 centers
- Final GRWR \leq 0.6, follow-up 3-years
- 32 (36.7%) SFSS \rightarrow higher 30-day, 90-day and 1-year mortality
- Pre-operative MELD and inpatient status \rightarrow predictors for SFSS
- Pre-LT renal dysfunction \rightarrow predictor of survival (HR 3.1 (1.1 - 8.9))
- Portal flow hemodynamics (PFH) and portal flow modulation (PFM) were not predictive of SFSS or survival

Reddy, Mohanka, et al. International Multicenter Study of Ultra-Low GRWR Grafts in Adult Living Donor Liver Transplantation. Am J Transplant. 2024 Jun 22:S1600-6135(24)00386-1

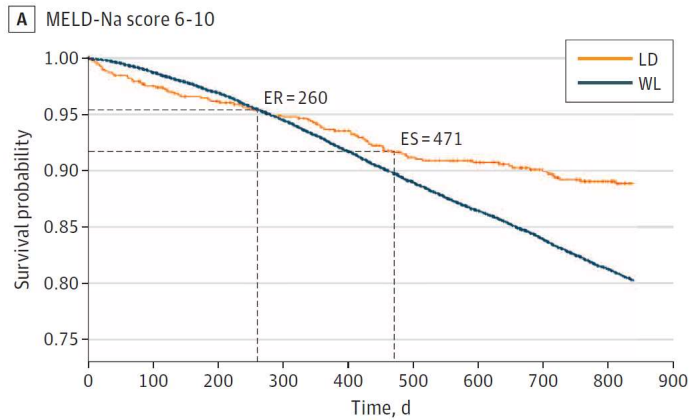
SFSS



SFSS: Definition and management

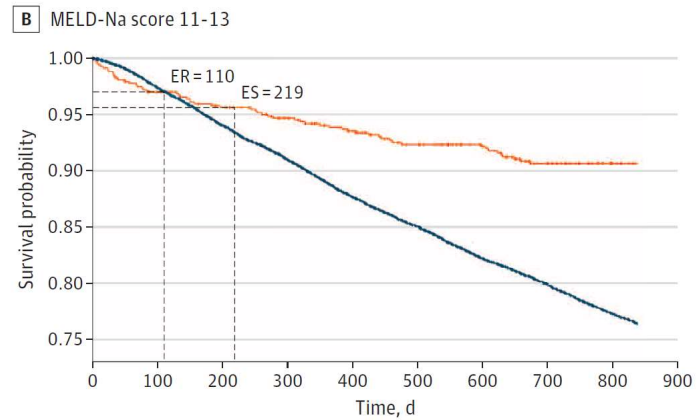
Severity grading	POD 7	POD 14	Graft loss (%)	Recommended treatment
Grade A (pre-SFSS)	T. Bil >5 mg/dL	T. Bil >5 mg/dL or ascites 1 L/d	<9%	Medical care <ul style="list-style-type: none"> • SST (octreotide) • Beta-blockers • Vasopressin (terlipressin) • PGE1 PGI2 (iloprost)
Grade B (portal hypertensive phase)	T. Bil >10 mg/dL or INR >1.6	T. Bil >10 mg/dL and ascites 1 L/d	9%–26%	Medical care, Inflow modulation IR/surgery
Grade C (liver failure phase)	T. Bil >10 mg/dL and INR >1.6	T. Bil >20 mg/dL	59%–77%	IR/surgery Possible liver re-LT

Kirchner, Mohanka, et al. Management of Established Small-for-size Syndrome in Post Living Donor Liver Transplantation: Medical, Radiological, and Surgical Interventions: Guidelines From the ILTS-iLDLT-LTSL Consensus Conference. *Transplantation*. 2023 Oct 1;107(10):2238-2246



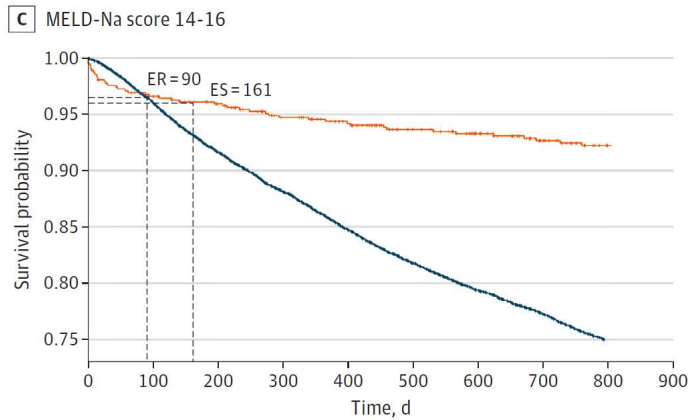
No. at risk

LD	11038	10347	9944	9509	9119	8680	8286	7891	7443
WL	23312	22530	21639	20751	19909	19119	18349	17623	16935



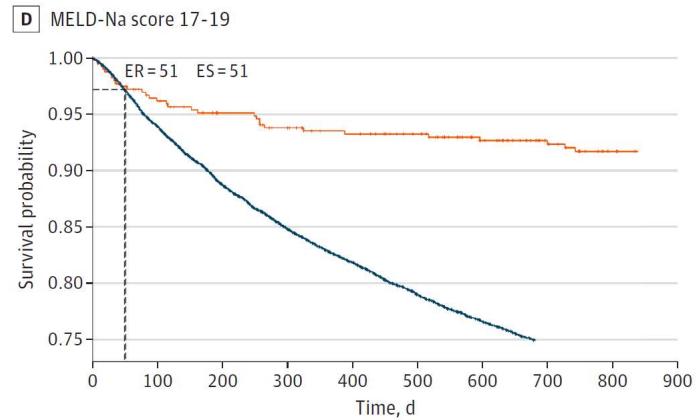
No. at risk

LD	7129	6584	6263	5941	5640	5353	5068	4777	4500
WL	16588	15806	14930	14219	13495	12923	12308	11803	11332



No. at risk

LD	8434	7848	7460	7130	6730	6376	6084	5733	5392
WL	17369	16331	15299	14512	13810	13197	12679	12222	11775



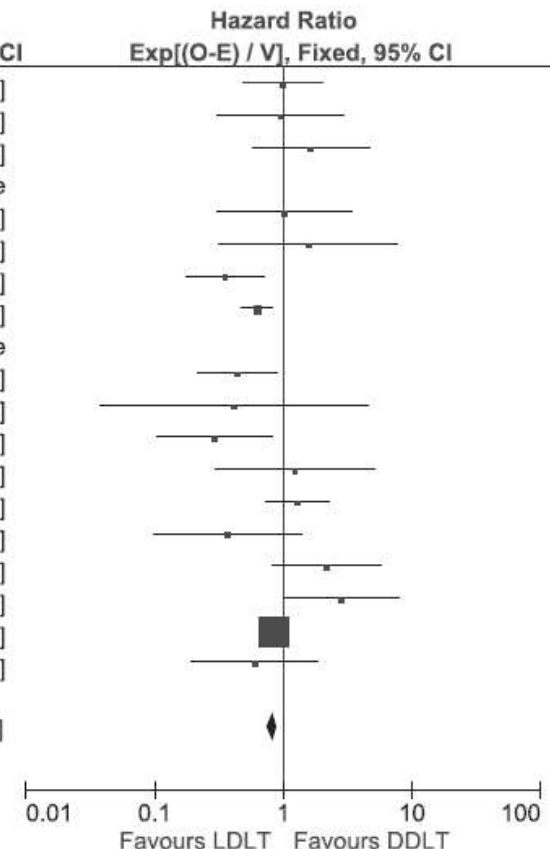
No. at risk

LD	6999	6484	6160	5878	5584	5269	5002	4717	4433
WL	12597	11633	10836	10249	9796	9388	9043	8735	8471



(A) 1 Year Patient Survival

Study or Subgroup	LDLT		DDLT		O-E	Variance	Weight	Hazard Ratio	
	Events	Total	Events	Total				Exp[(O-E) / V], Fixed, 95% CI	Exp[(O-E) / V], Fixed, 95% CI
Al Sebayel, 2015	14	222	16	269	0	7.46	1.4%	1.00 [0.49, 2.05]	
Barbas, 2017	4	48	12	128	-0.139	3	0.6%	0.95 [0.31, 2.96]	
Bhangui, 2011	5	36	12	120	1.73	3.53	0.7%	1.63 [0.58, 4.63]	
Chen, 2014	0	0	0	0	0	0		Not estimable	
Chen, 2015	4	34	8	72	0.049	2.67	0.5%	1.02 [0.31, 3.38]	
Chok, 2017	6	54	2	40	0.68	1.5	0.3%	1.57 [0.32, 7.80]	
E. Kim, 2017	12	109	21	76	-7.96	7.64	1.4%	0.35 [0.17, 0.72]	
Hu, 2016	51	389	1670	6470	-23	49.49	9.2%	0.63 [0.48, 0.83]	
Jiang, 2013	0	0	0	0	0	0		Not estimable	
Kim JM, 2017	20	146	12	35	-6.18	7.5	1.4%	0.44 [0.21, 0.90]	
Kim, 2014	1	21	2	29	-0.589	0.67	0.1%	0.42 [0.04, 4.55]	
Lee, 2012	6	48	9	23	-4.42	3.6	0.7%	0.29 [0.10, 0.82]	
Lei, 2013	3	31	5	52	0.397	1.875	0.3%	1.24 [0.30, 5.17]	
Li, 2011	20	128	29	221	2.92	11.84	2.2%	1.28 [0.72, 2.26]	
Liu, 2006	4	124	5	56	-2.22	2.22	0.4%	0.37 [0.10, 1.37]	
Reichman, 2013	10	145	7	145	3.17	4.12	0.8%	2.16 [0.82, 5.67]	
Schmeding, 2007	4	17	38	269	3.73	3.62	0.7%	2.80 [1.00, 7.85]	
SRTR 2005-2017	440	2750	13368	58120	-67.49	426	78.9%	0.85 [0.78, 0.94]	
Wan, 2014	4	40	12	80	-1.52	3	0.6%	0.60 [0.19, 1.87]	
Total (95% CI)		4342		66205			100.0%	0.83 [0.76, 0.90]	
Total events	608		15228						
Heterogeneity: $\text{Chi}^2 = 33.11, \text{df} = 16 (P = 0.007); I^2 = 52\%$									
Test for overall effect: $Z = 4.34 (P < 0.0001)$									



Survival benefit sustained at 3 and 5 years, higher biliary complications



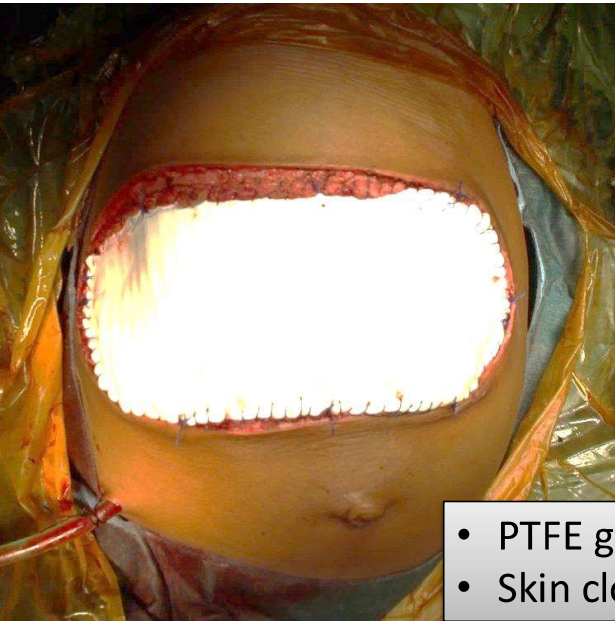
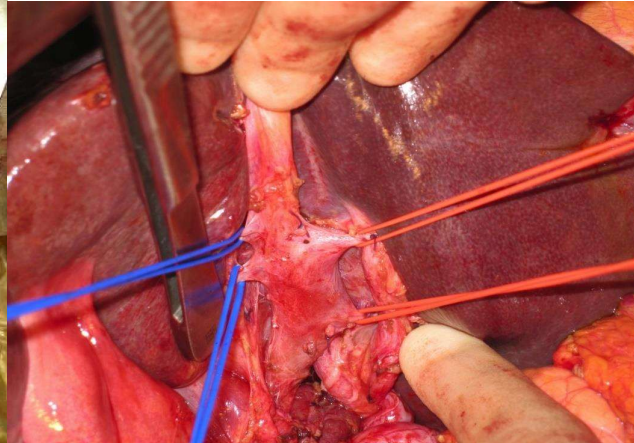
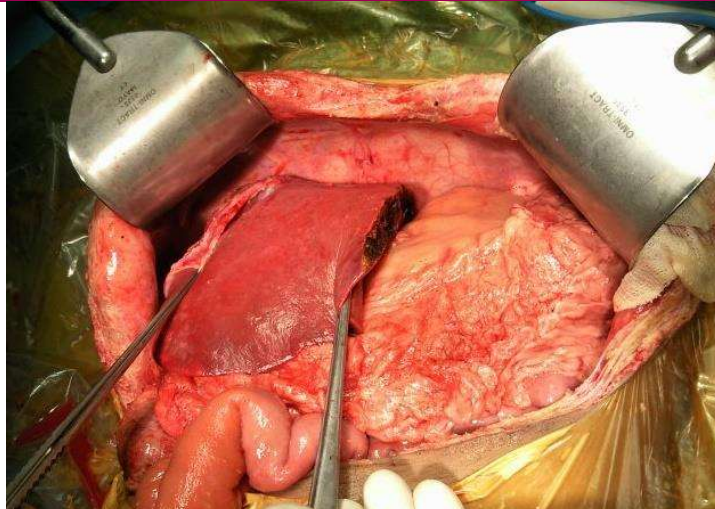


Complex cases

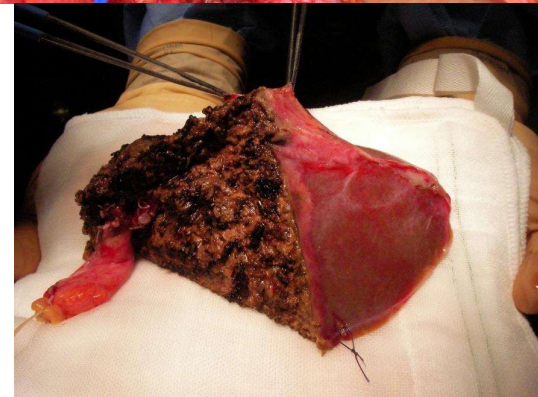
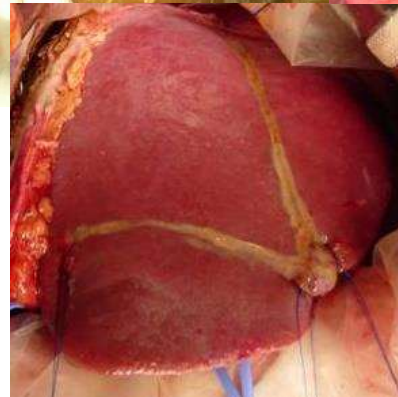
Recent progress

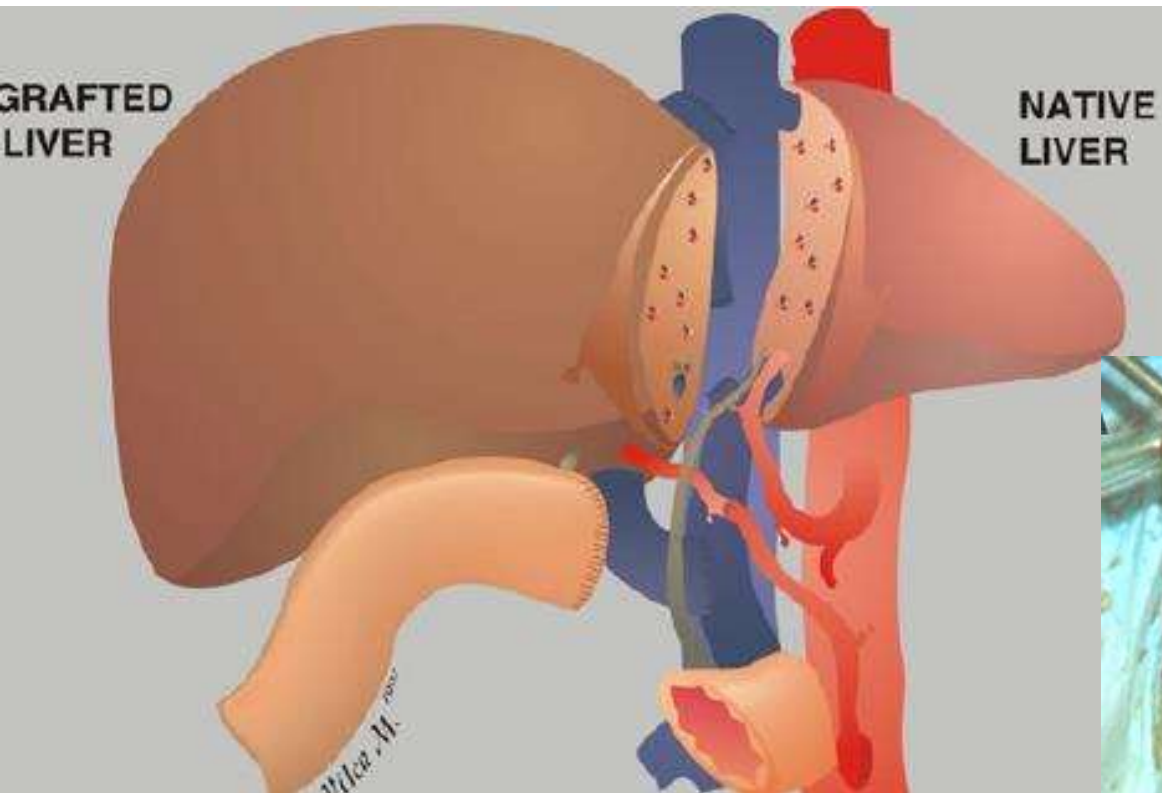
Large for size grafts

- Large left lateral segment
- < 10 kg recipients
- Portal flow < 100ml/100g

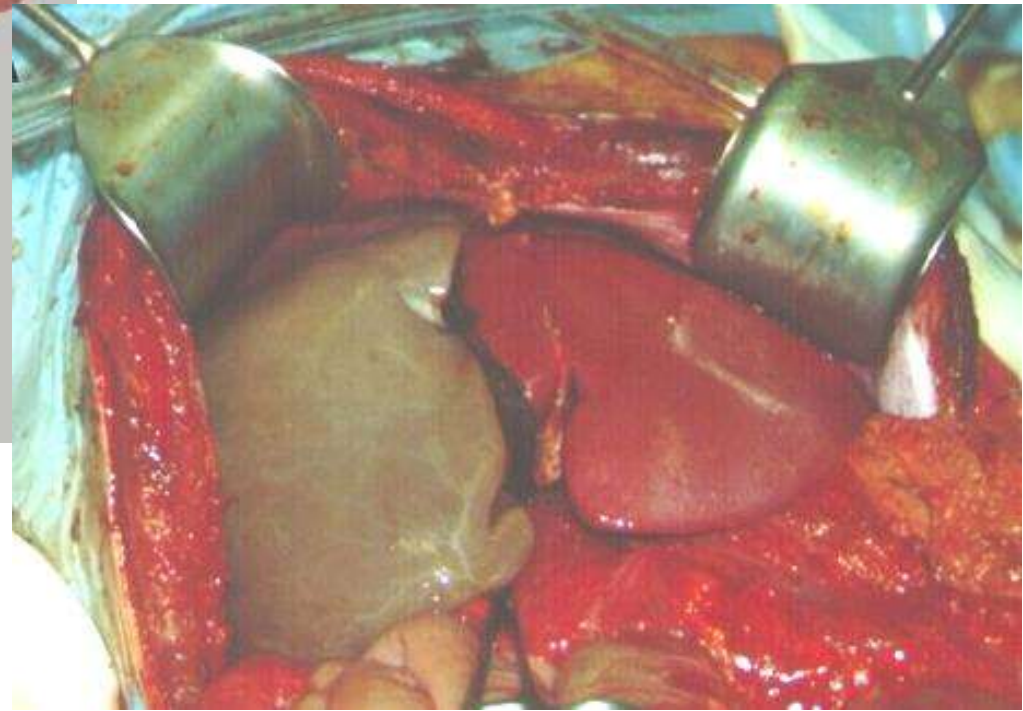


- PTFE graft
- Skin closure alone





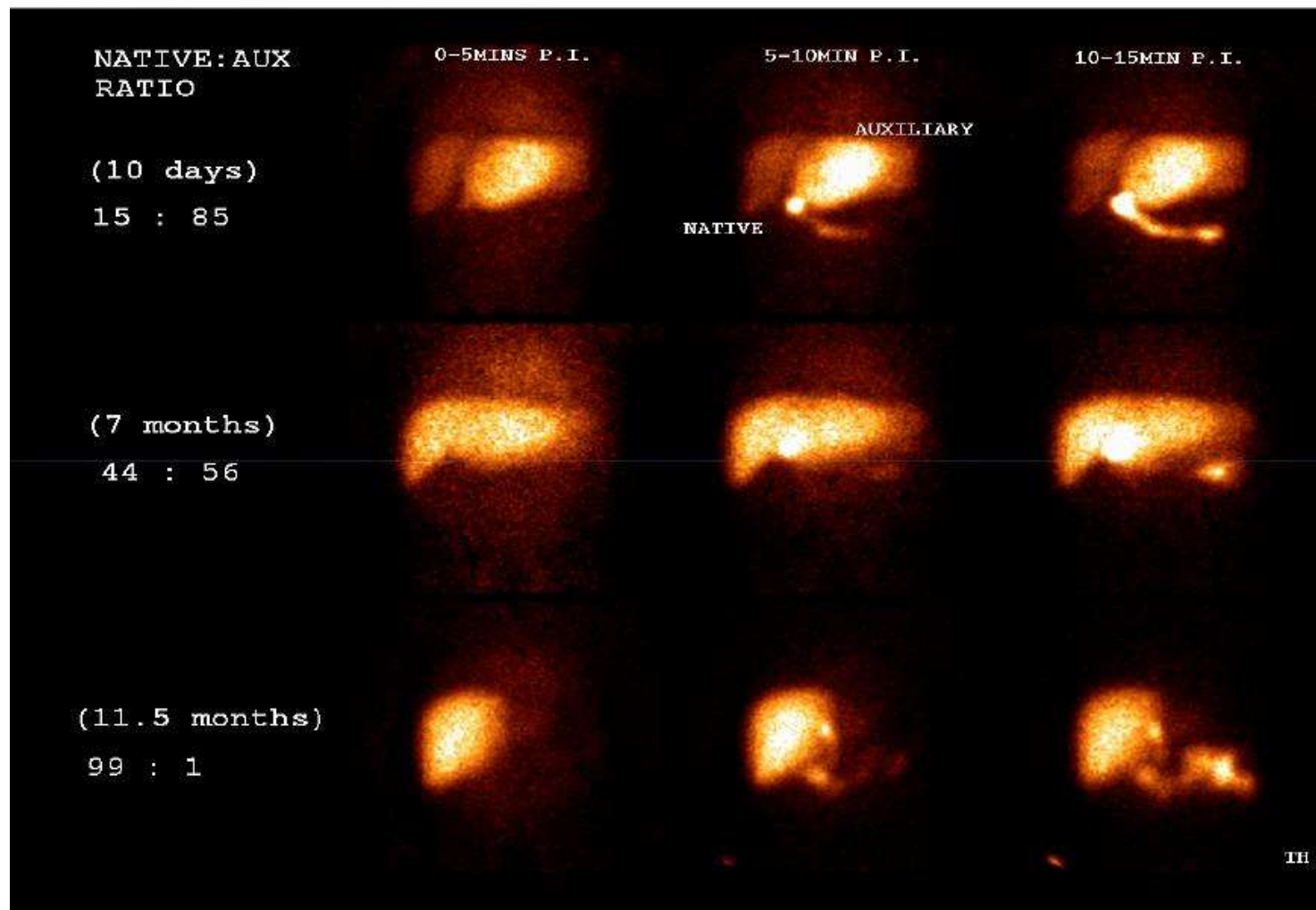
Auxiliary Partial Orthotopic (APOLT)



- Partial recipient hepatectomy
- Partial graft transplanted

APOLT

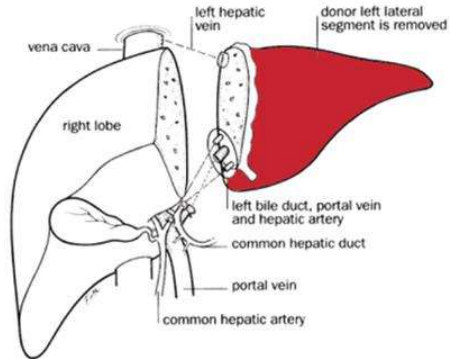
- Gradual taper successful in 65% of patients
- No long-term immunosuppression related side effects
- Pediatric



Domino LDLT



Adult Liver Donor



Siya



Shourya

A Part of Liver

Full Liver



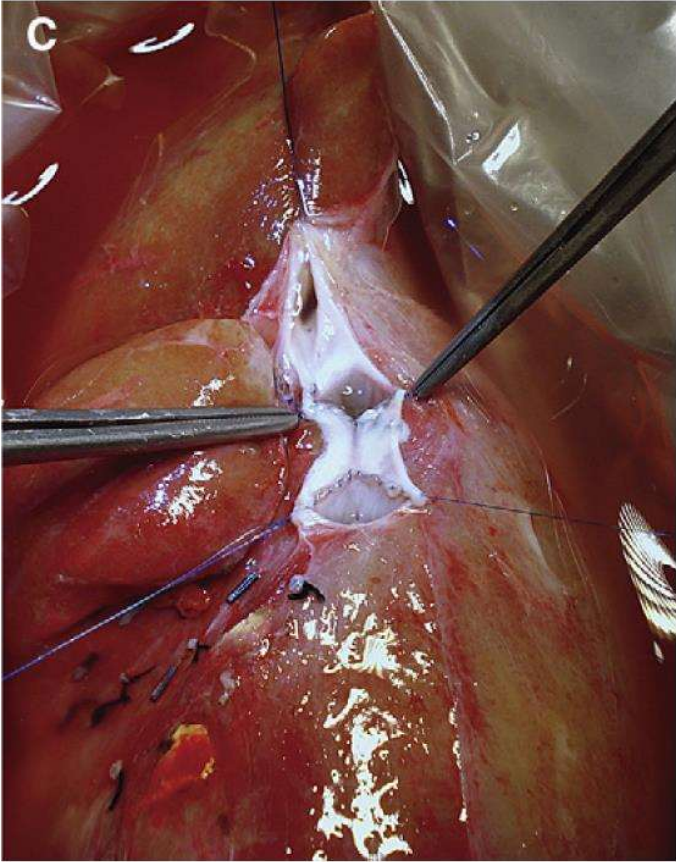
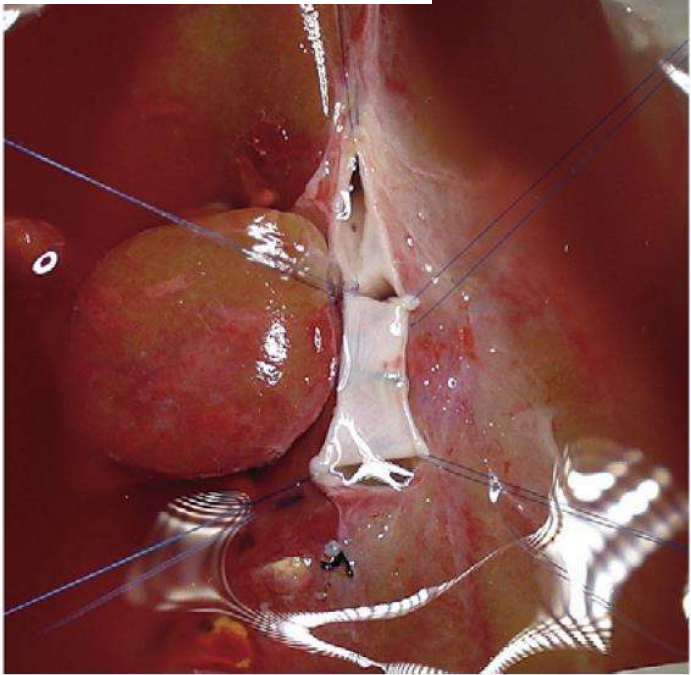
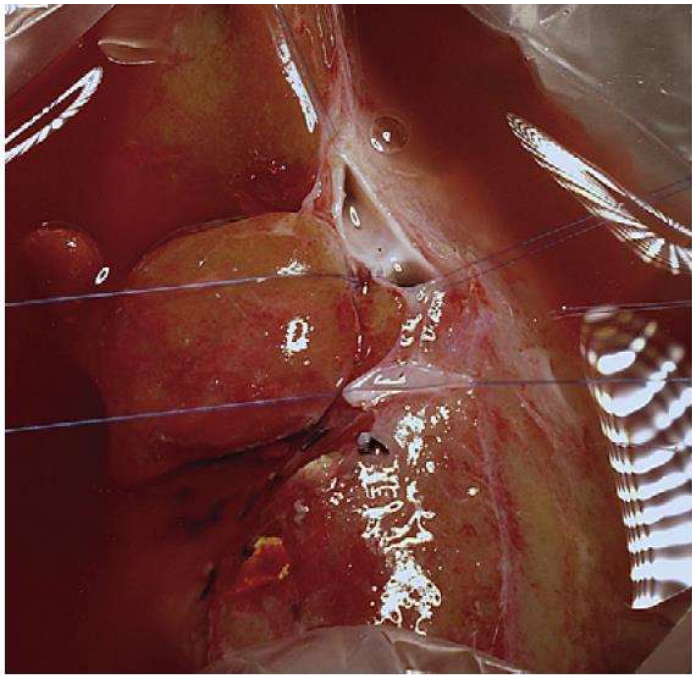
MSUD liver used as Domino

Surgical Technique

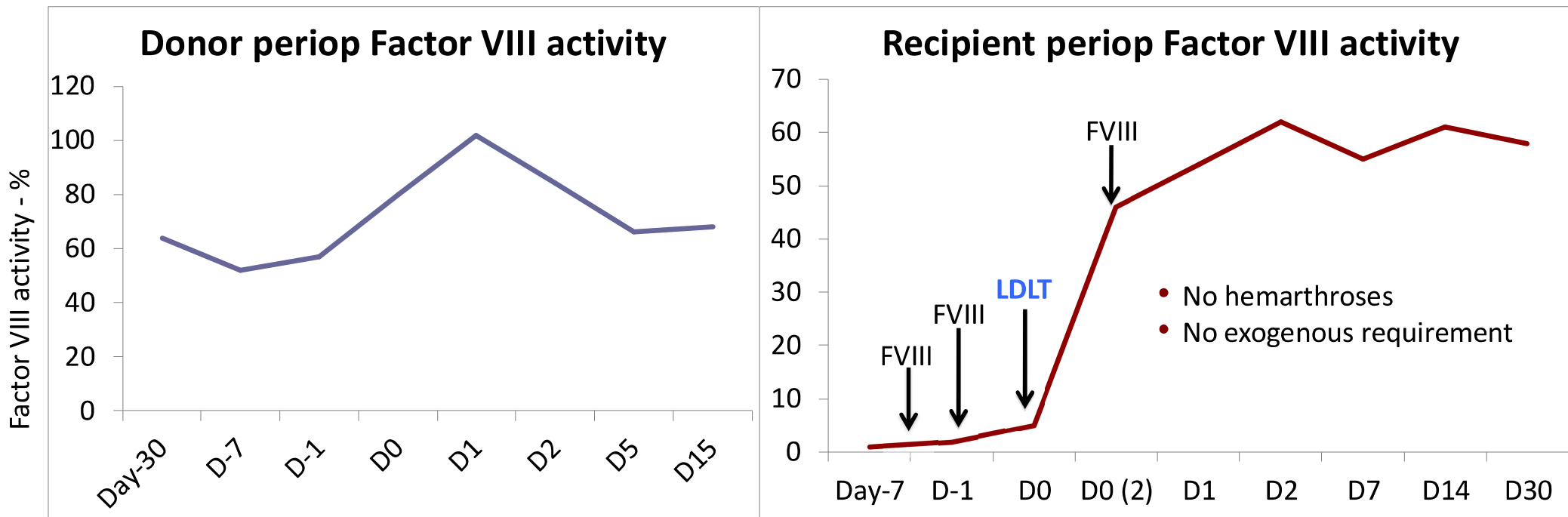
*Surgery July 2010
Volume 148, Number 1*

Bridge venoplasty: A new technique to simplify venous outflow reconstruction in living donor domino liver transplantation

Arvinder Soin, MBBS, MS, FRCS, Vinay Kumaran, MBBS, MS, MCh,
Ravi Mohanka, MBBS, MS, DNB, Naimish Mehta, MBBS, MS, Neelam Mohan, MBBS, DNB,
and Samiran Nundy, MBBS, MS, New Delhi, India



LDLT for factor VII deficiency

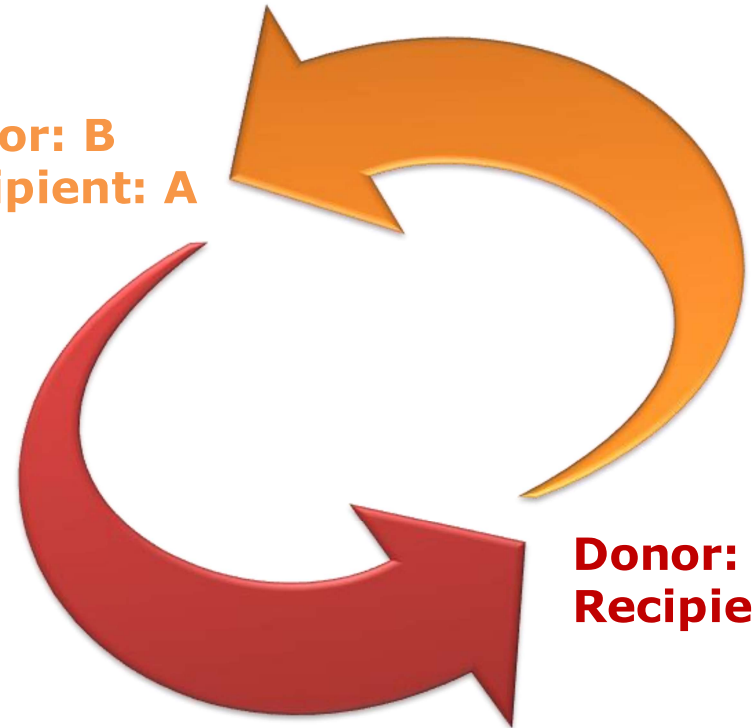


Mohan, Mohanka, et al. First living-related liver transplant to cure factor VII deficiency. *Pediatr Transplant*. 2015 Sep;19(6):E135-8

Blood group / weight mismatch

- Swap (paired exchange)
- ABO incompatible transplant
- Dual lobe LDLT

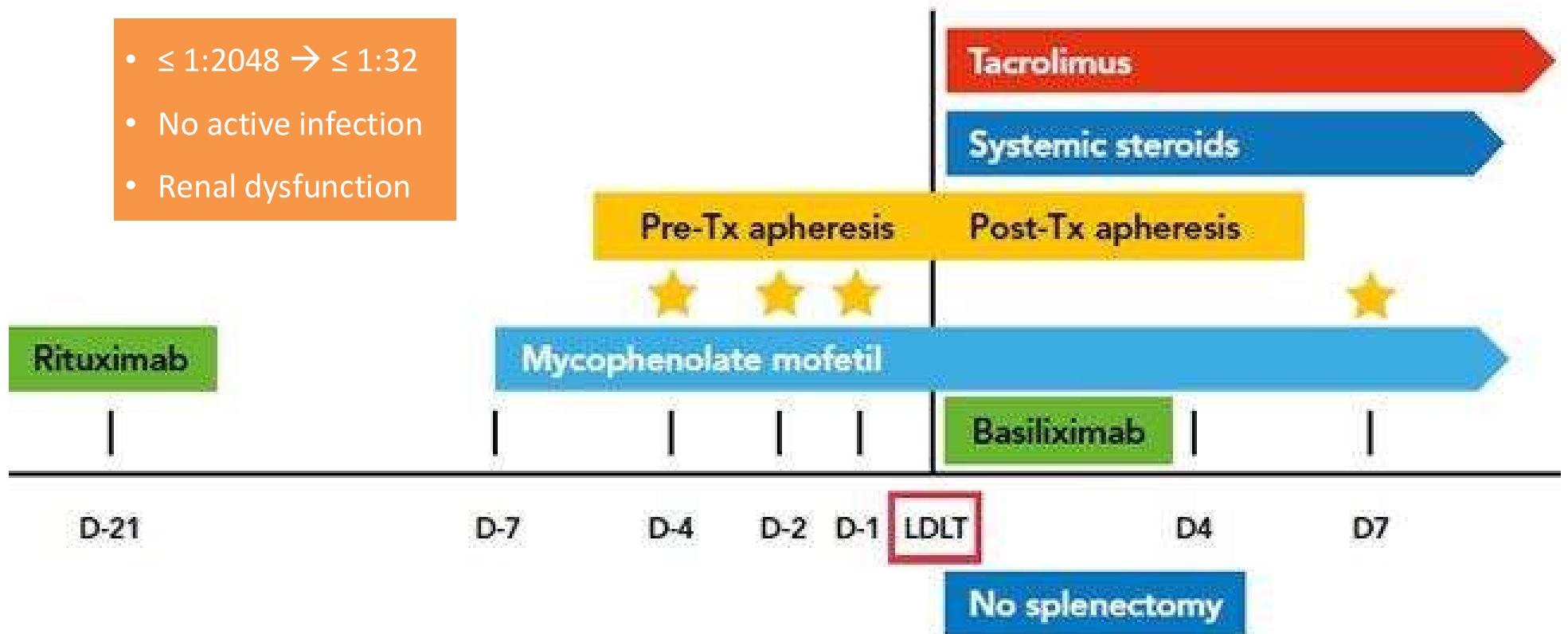
Donor: B
Recipient: A



Donor: A
Recipient: B

ABO incompatible LDLT

- $\leq 1:2048 \rightarrow \leq 1:32$
- No active infection
- Renal dysfunction

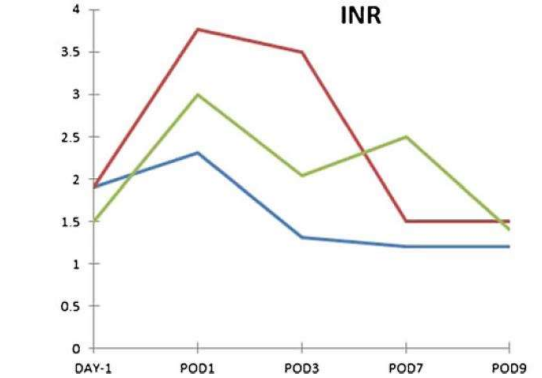
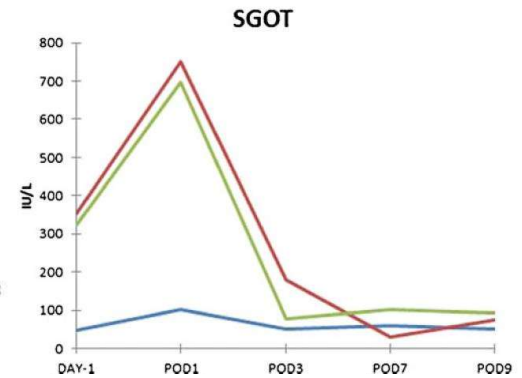
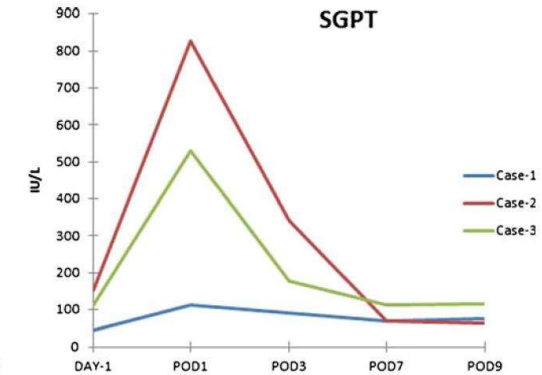
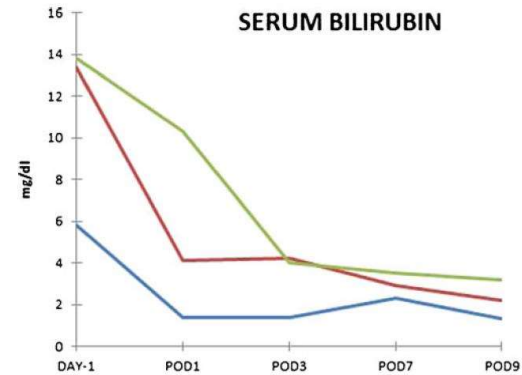
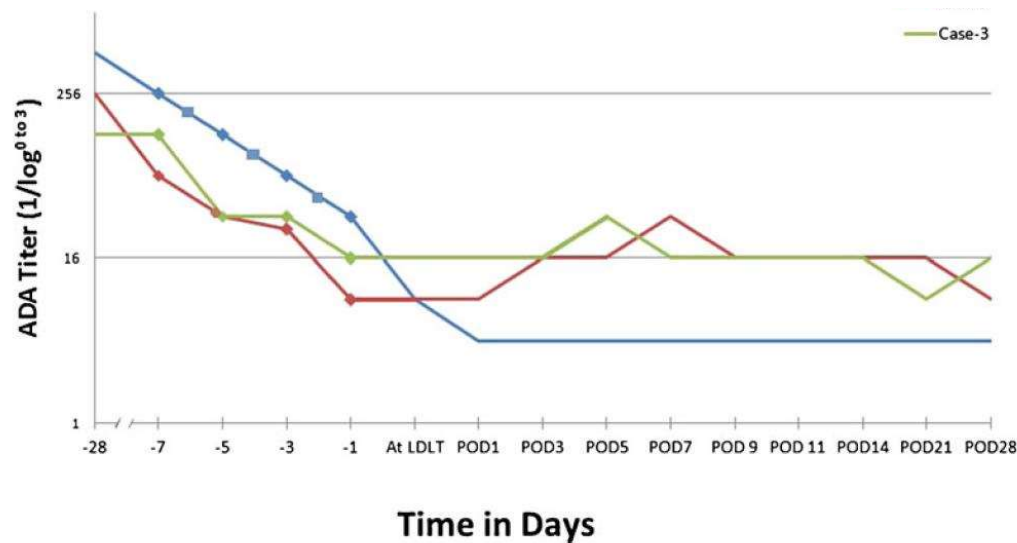


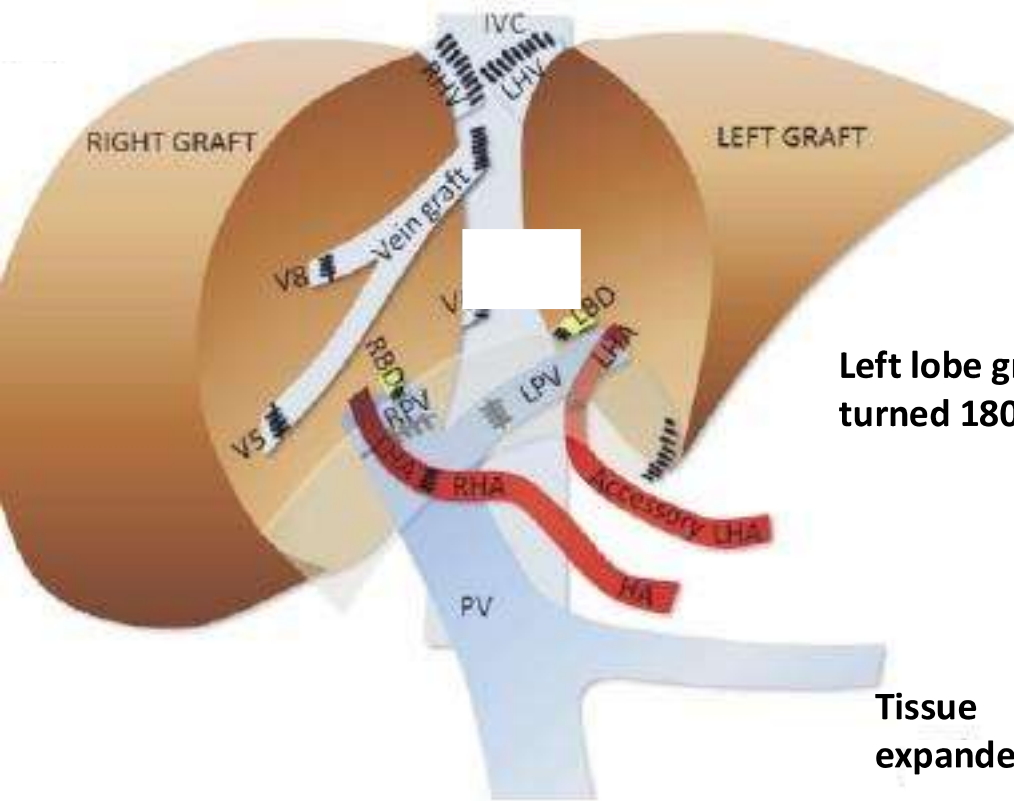
ABO incompatible liver transplant

The use of ABO-incompatible grafts in living donor liver transplantation—First report from India

A. S. Soin • V. Raut • R. Mohanka • A. Rastogi • S. Goja • M. Balachandran • S. Saigal • N. Saraf • P. Bhangui • K. R. Sumana • P. Singla • T. Srinivasan • N. Choudhary • A. Tiwari • V. Raina • D. Govil • N. Mohan • V. Vohra

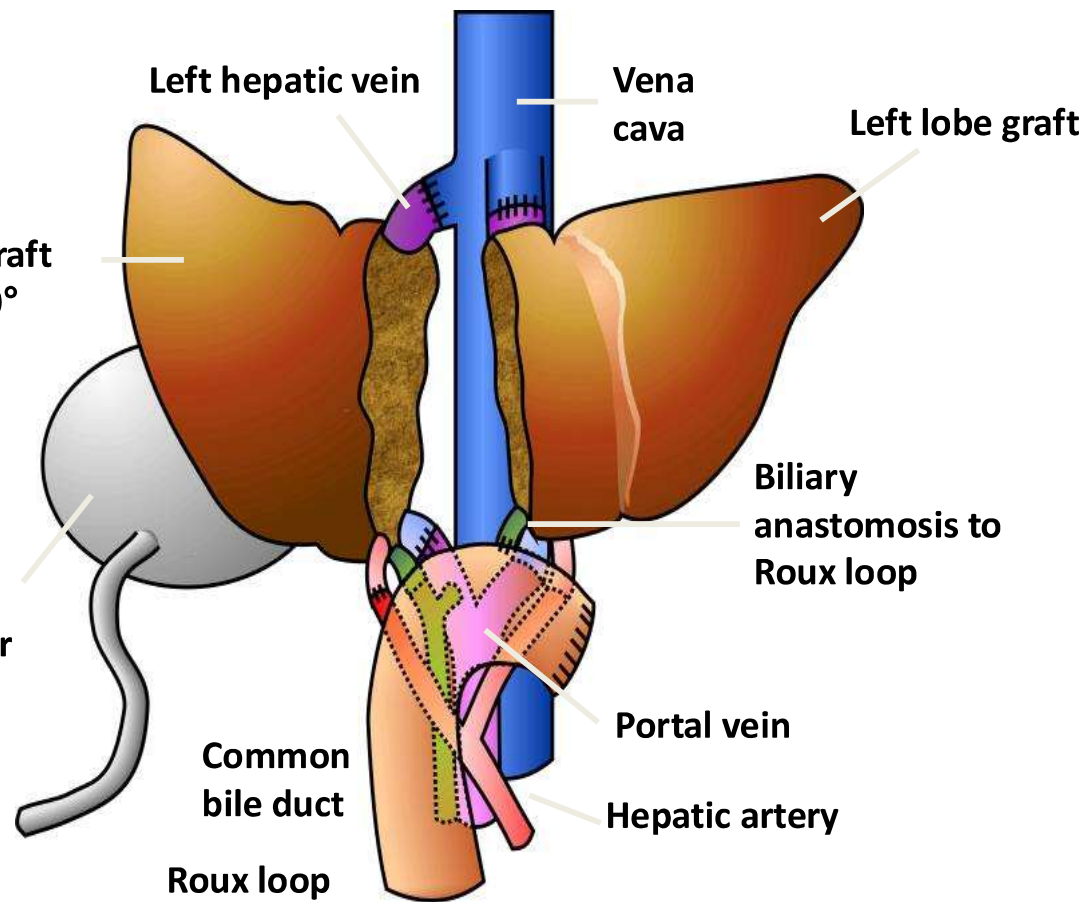
Indian J Gastroenterol (January–February 2014) 33(1):72–76





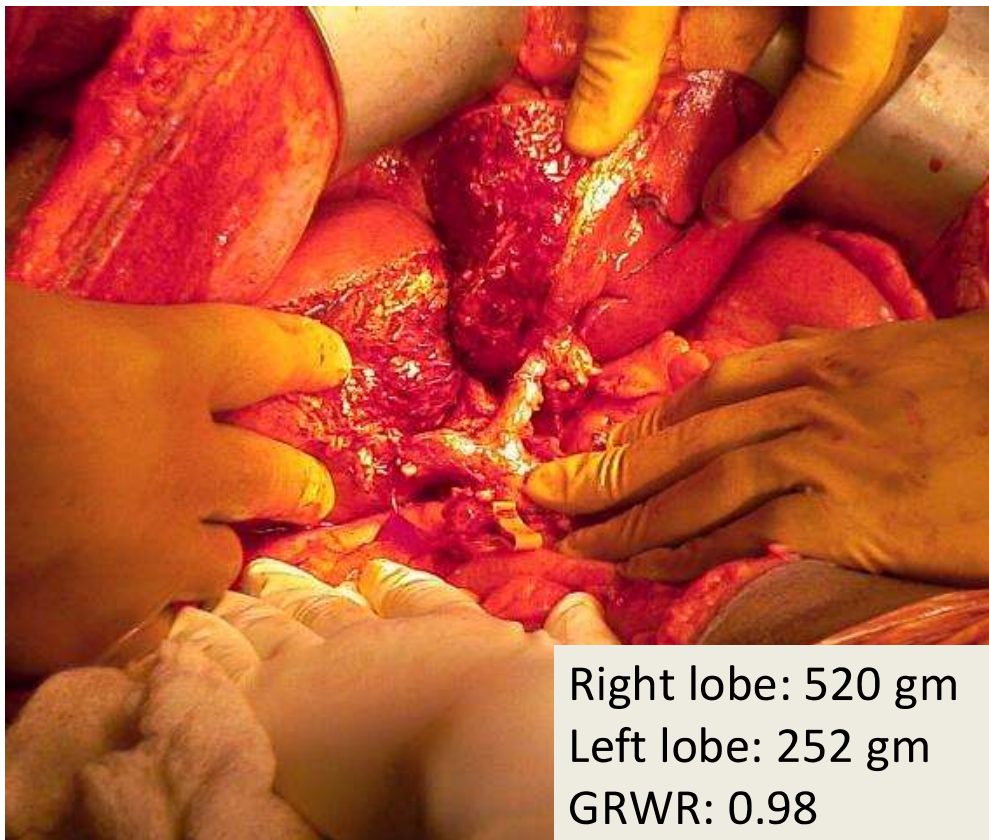
Left lobe graft turned 180°

Tissue expander

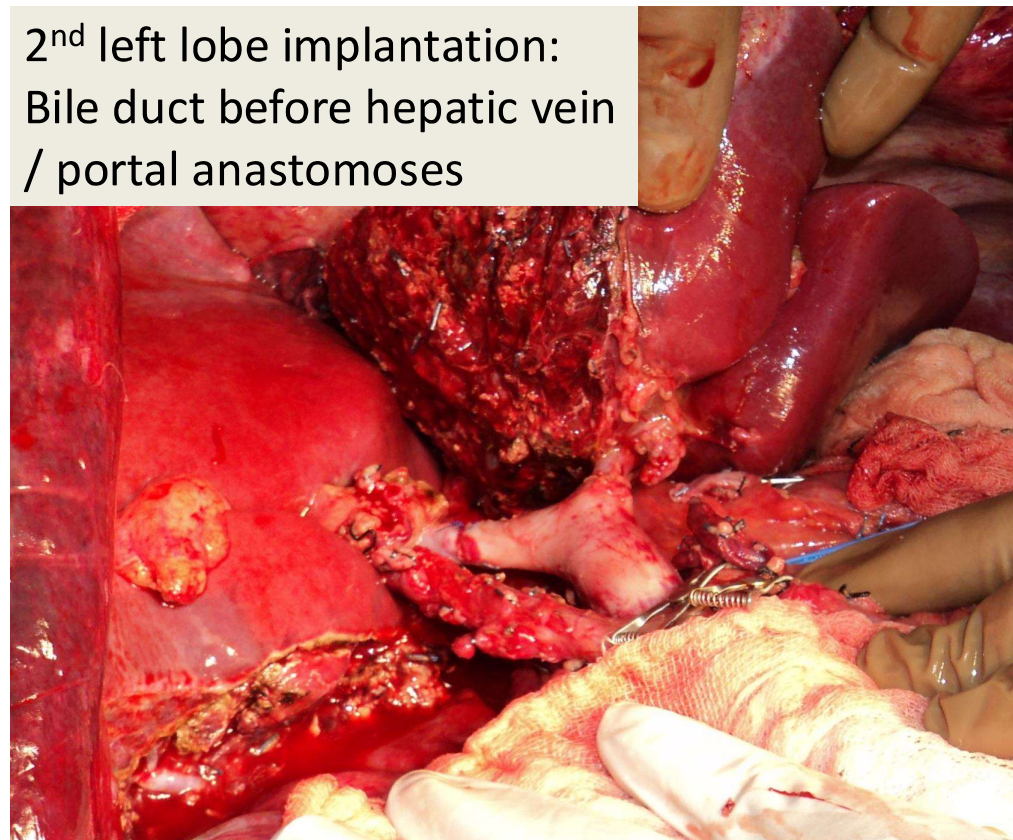


Dual lobe LDLT

Dual lobe LDLT



2nd left lobe implantation:
Bile duct before hepatic vein
/ portal anastomoses



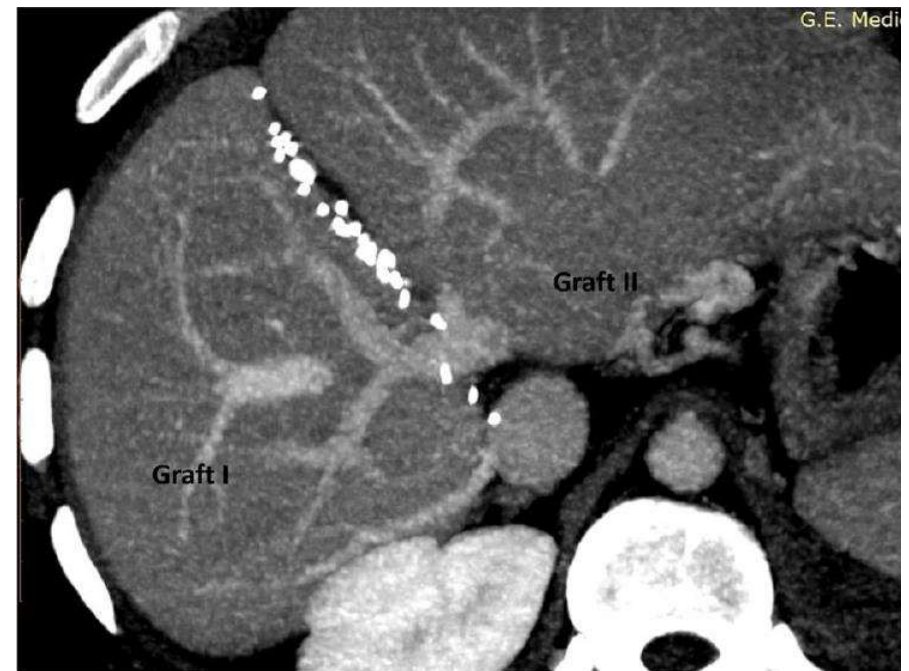
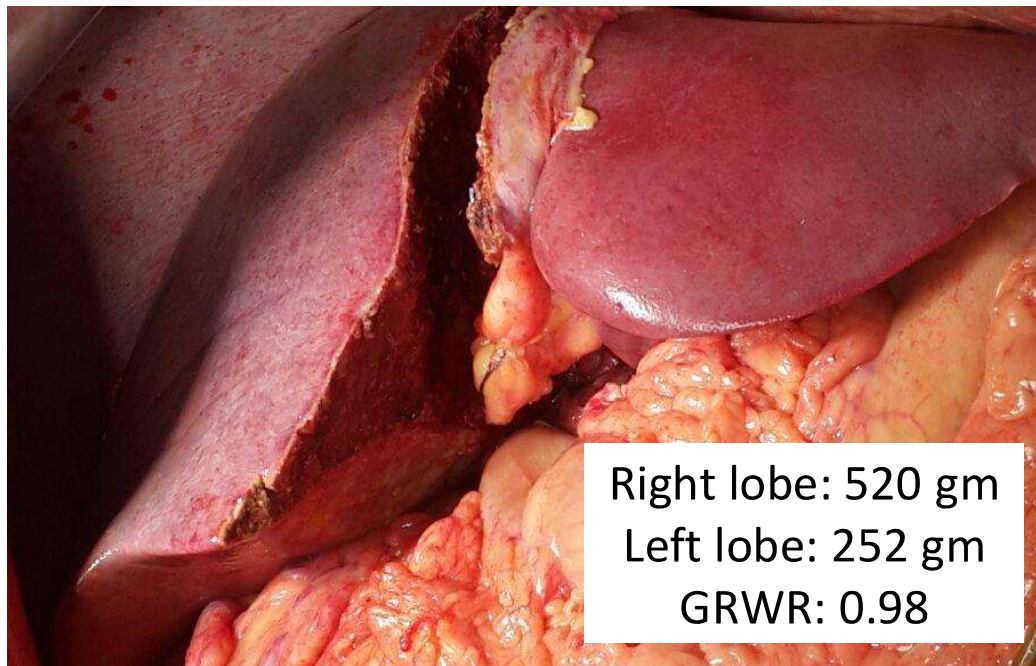
Dual graft living donor liver transplantation – a case report



Vinayak *et al. BMC Surgery* (2019) 19:149
<https://doi.org/10.1186/s12893-019-0606-5>

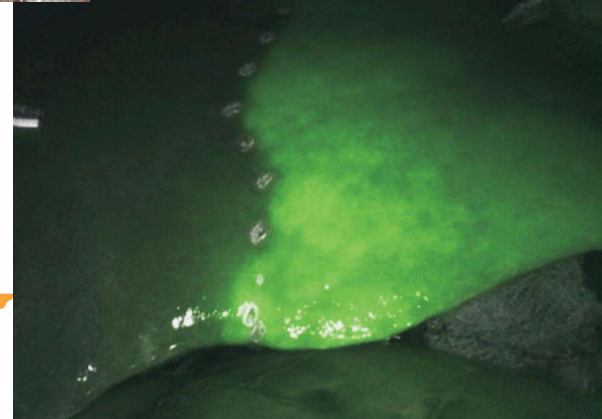
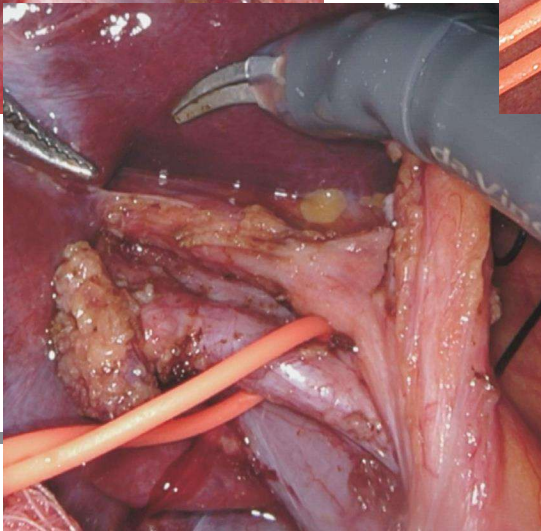
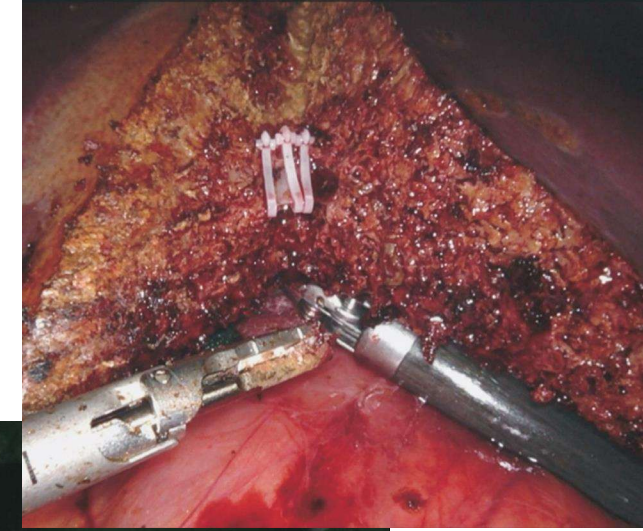
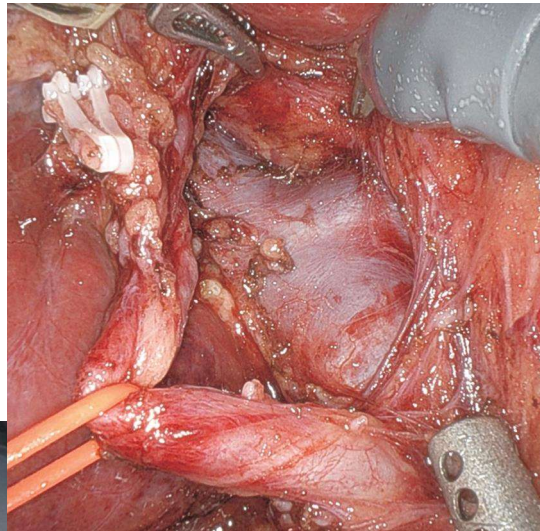
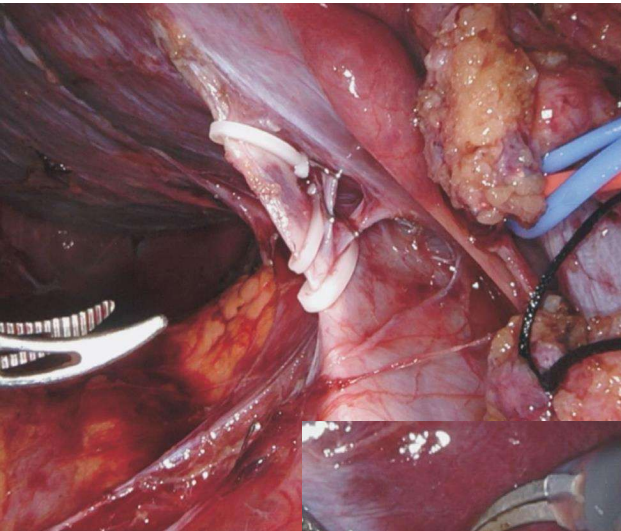
BMC Surgery

Nikam Vinayak^{*} , Mohanka Ravi, Golhar Ankush, Bhade Rashmi, Rao Prashantha, Gadre Parul and Shrimal Anurag



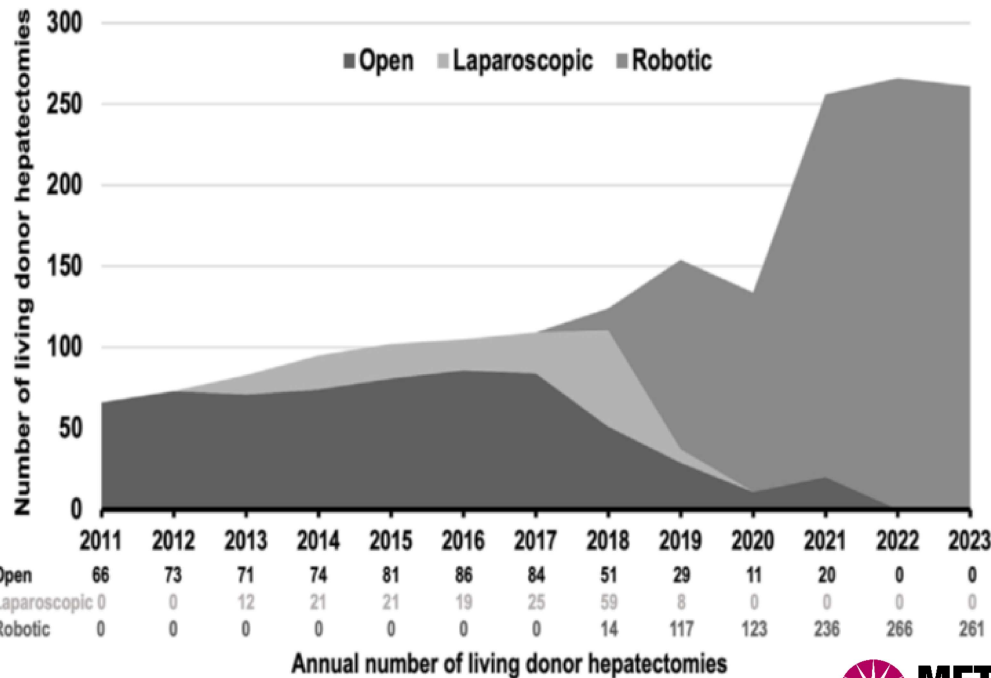
Minimally invasive donor hepatectomy

Surgical techniques for robotic right donor hepatectomy *Cheah et al. Clin Transplant Res. 2024 Mar 31;38(1):7-17*

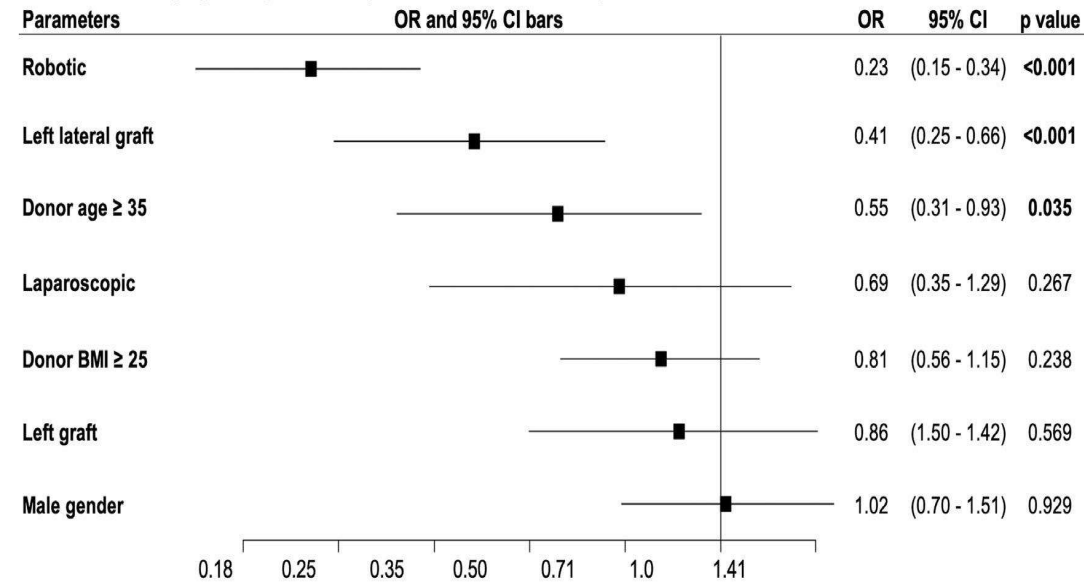


Minimally invasive donor hepatectomy

Robotic living donor hepatectomy is associated with superior outcomes for both the donor and the recipient compared with laparoscopic or open - A single-center prospective registry study of 3448 cases. *Raptis et al. Am J Transplant. 2024 May 7:S1600-6135(24)00293-4*



a. Multivariable binary logistic regression analysis for overall donor morbidity

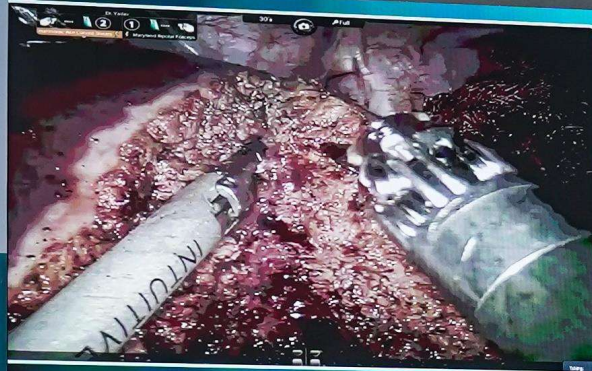




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Minimally invasive donor hepatectomy

Systematic review and meta-analysis of open versus laparoscopy-assisted versus pure laparoscopic versus robotic living donor hepatectomy Ziogas et al. Liver Transpl. 2023 Oct 1;29(10):1063-1078

Robotic and laparoscopic right lobe living donation compared to the open approach: A multicenter study on 1194 donor hepatectomies Troisi et al. Liver Transpl. 2024 May 1;30(5):484-492.

A systematic review and network meta-analysis of outcomes after open, mini-laparotomy, hybrid, totally laparoscopic, and robotic living donor right hepatectomy Yeow et al. Surgery. 2022 Aug;172(2):741-750

Minimally Invasive Donors Right Hepatectomy versus Open Donors Right Hepatectomy: A Meta-Analysis Mu et al. J Clin Med. 2023 Apr 17;12(8):2904

- Safe, conversions 1% robotic, 2% laparoscopic
- **Donor:** Less blood loss, less pain, better cosmesis, shorter LOS **Recipient:** Similar outcomes
- Complex procedures with learning curve: high volume/ experienced transplant centers

Minimally invasive donor hepatectomy



VCU Health Hume-Lee Transplant Center taps robot for partial living liver donor transplants

VCU Health plans for first fully robotic liver living-donor transplants in 2023.

March 06, 2023



Region's first robotic liver transplant; donor's second gifted organ

Robotic liver transplants, perfected in the Middle East, and now done in Colorado, promise fewer complications, faster recovery.

By: Todd Neff, for UHealth | September 12, 2023

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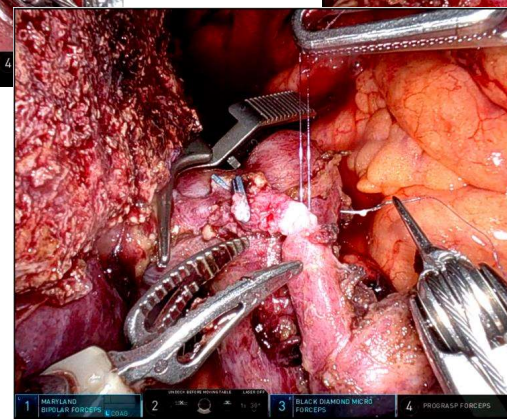
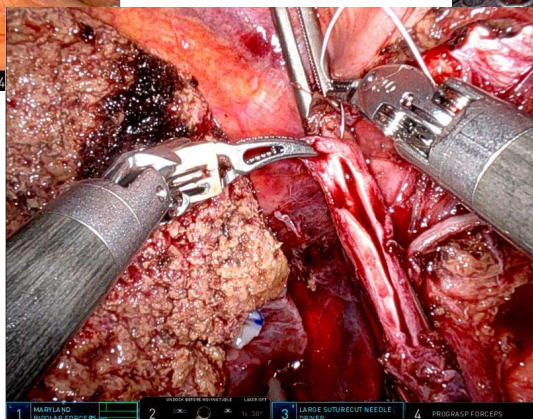
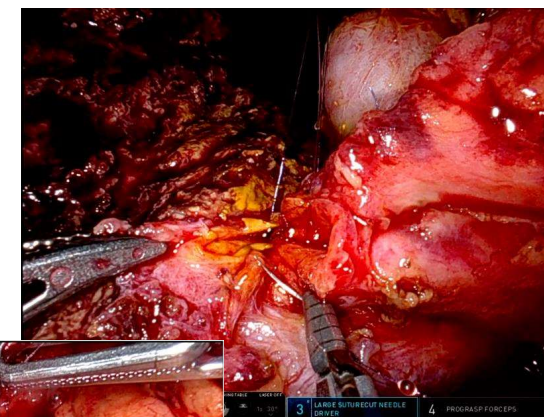
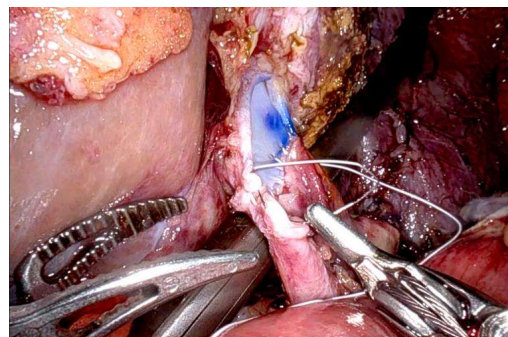
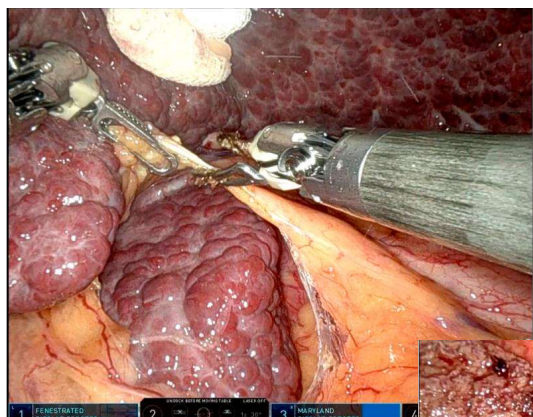


Pure laparoscopic living donor liver transplantation: Dreams come true

Kyung-Suk Suh¹ | Suk Kyun Hong¹ | Sola Lee¹ | Su young Hong¹ | Sanggyun Suh¹ |
Eui Soo Han¹ | Seong-Mi Yang² | YoungRok Choi¹ | Nam-Joon Yi¹ |
Kwang-Woong Lee¹

Pioneering fully robotic donor hepatectomy and robotic recipient liver graft implantation – a new horizon in liver transplantation

Dieter C. Broering, PhD*, Dimitri A. Raptis, PhD, Yasser Elsheikh, MD



Robotic recipient surgery

 Washington University School of Medicine in St. Louis

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NEWS RELEASE

First robotic liver transplant in U.S. performed by Washington University surgeons

Groundbreaking surgery performed at Barnes-Jewish Hospital in St. Louis

by **Tamara Bhandari** • July 12, 2023



Thanks Questions?



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