Technical Considerations in Liver Transplantation

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Types

- **OLTX**: Orthotopic liver Tx; placed in the anatomically correct position
- **ALTX**: Auxiliary liver Tx; placement of donor liver in the presence of native liver (part or all).
  - Orthotopic: in correct position after partial removal of native organ.
  - Heterotopic: in other place.
- **SLTX**: Segmental liver Tx; placement of portion of donor-liver.
- **Cadaveric** (whole or split) & **Living-donor**
- **Donor with Cardiac-Death (DCD)**

Technique

- Hepatectomy is the most difficult part of the procedure (bleeding, adhesions, reperfusion coagulopathy, risk of bowel violation); veno-venous bypass can help with bleeding by decompressing portal pressure.
- After [hepatectomy + retrohepatic IVC removal], a cadaveric [liver graft + donor IVC] is placed with a subdiaphragmatic end-to-end IVC interposition.
- Portal vein anastomosis: end-to-end
- Hepatic artery anastomosis: end to end
- Biliary reconstruction: duct-to-duct or hepatico-jejunostomy.

Hepatectomy

Technique
Hepatectomy

- Dissection of hilium is most important part.
- Preserve as much length of hepatic artery & portal vein as possible.
- Recipient's Hepatic artery dissection:
  - starts at Rt & Lt branches, then
  - runs to the confluence,
  - then gastro-duodenal art,
  - finally to common hepatic artery;
  - avoid traction & intimal dissection

Technique Hepatectomy

- Dissection of cystic duct & CBD:
  - with preservation of surrounding tissue to prevent ischemia/necrosis.
- Portal vein dissection:
  - is done after Hepatic artery and bile duct division;
  - all soft tissue around is removed from liver hilium until pancreas head.

Technique
Hepatectomy Precautions

- Avoid injury to Rt adrenal gland:
  - may cause massive bleed and need adrenalectomy.
- Avoid injury to Rt renal vein during IVC dissection.
- Avoid injury to Rt phrenic nerve:
  - may cause paralysis of Rt hemidiaphragm.

Anhepatic Phase

Technique
Anhepatic Phase

- **Veno-veno bypass:**
  - to decrease hemodynamic instability after clamp of IVC & PV,
  - bypass is done before hepatectomy, from IVC & PV to SVC,
  - heparin bonded cannulae and a motor.
- **Advantages of v-v bypass**:
  - 1. Avoids cardiovascular instability, specially in FHF & non-cirrhotics (no porto-systemic collateral circulation),
  - 2. Decompresses portal v. pressure, decreasing blood loss,
  - 3. Avoids mesenteric stasis/bowel edema, which may cause bacterial translocation,
  - 4. Protects renal function (no Renal vein stasis),
  - 5. Facilitates a safer & longer anhepatic phase, for proper dissection/hemostasis.

Technique
Anhepatic Phase

- **Potential Indications for Veno-Venous bypass:**
  - Fulminant hepatic failure.
  - Severe retroperitoneal collateralization.
  - Poor pre-operative renal function.
  - Hypotension after “test-clamp” of IVC, despite adequate volume loading.
  - Intestinal or mesenteric edema.
  - Inexperience with the procedure.

Technique
Anhepatic Phase

- **Disadvantages of v-v bypass**:
  Complications in 10-30%
  - Lymphocoele in inguinal/axillary incision
  - Seroma in cannulae insertion site
  - Hematoma
  - Wound infection
  - DVT
  - Nerve injury
  - Air embolus with death (cannulae removal)
- **Possible alternative: Piggyback technique.**

Implantation

Technique
Implantation

- 1. IVC end-to-end anastomosis:
  - donor's IVC is interposed into the severed recipient's IVC (vs piggy-back into recipient's supra-hepatic veins "common tunnel")
- 2. Portal vein end-to-end anastomosis:
  - donor to recipient.
  - In PV thrombosis (0.6-64%), can do:
    - a) eversion thrombectomy,
    - b) interposition graft to SMV,
    - c) cavo-portal hemitransposition,
    - d) anastomosis to large venous collateral,
    - e) arterialization of Portal vein

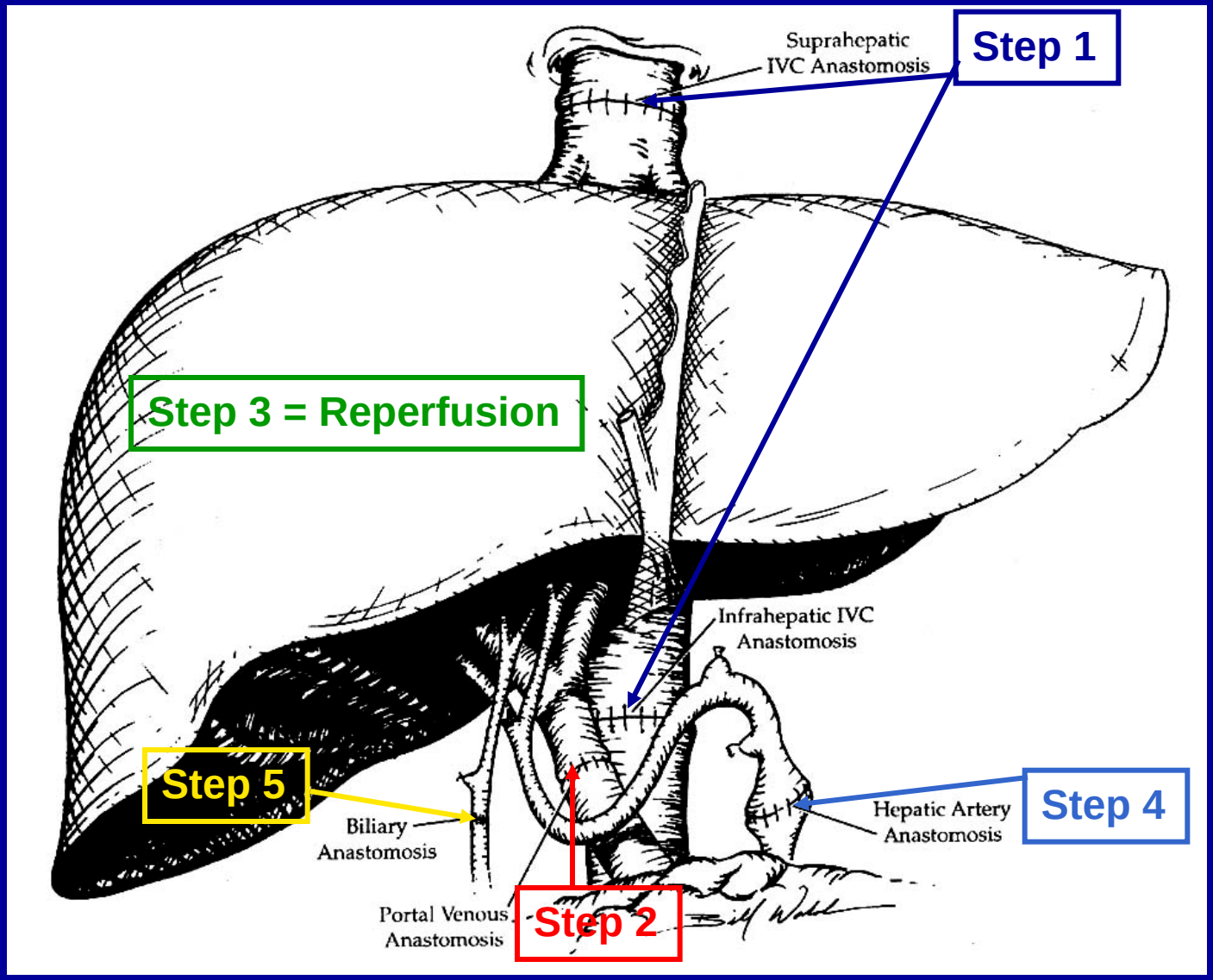
Technique
Implantation

- 3. Reperfusion of liver with recipient's blood;
  - unstable time with risk of arrhythmia, hypotension, pulmonary edema, hyperkalemia;
  - liver is pre-perfused with Lactate Ringer or albumin to decrease risk.
- 4. End-to-end hepatic artery anastomosis.
  - In celiac axis stenosis: use a "donor iliac artery conduit graft" from infrarenal or supra-celiac aorta, to the donor's HA.
  - **Do not use artificial grafts** (high risk for thrombosis or infection).

Technique
Implantation

- 5. Biliary anastomosis (“Achilles tendon” of LTX):
  - a) Choledochocholedochostomy: frequently over T-tube,
  - b) Roux-en-Y Choledochojejunostomy

Standard Technique



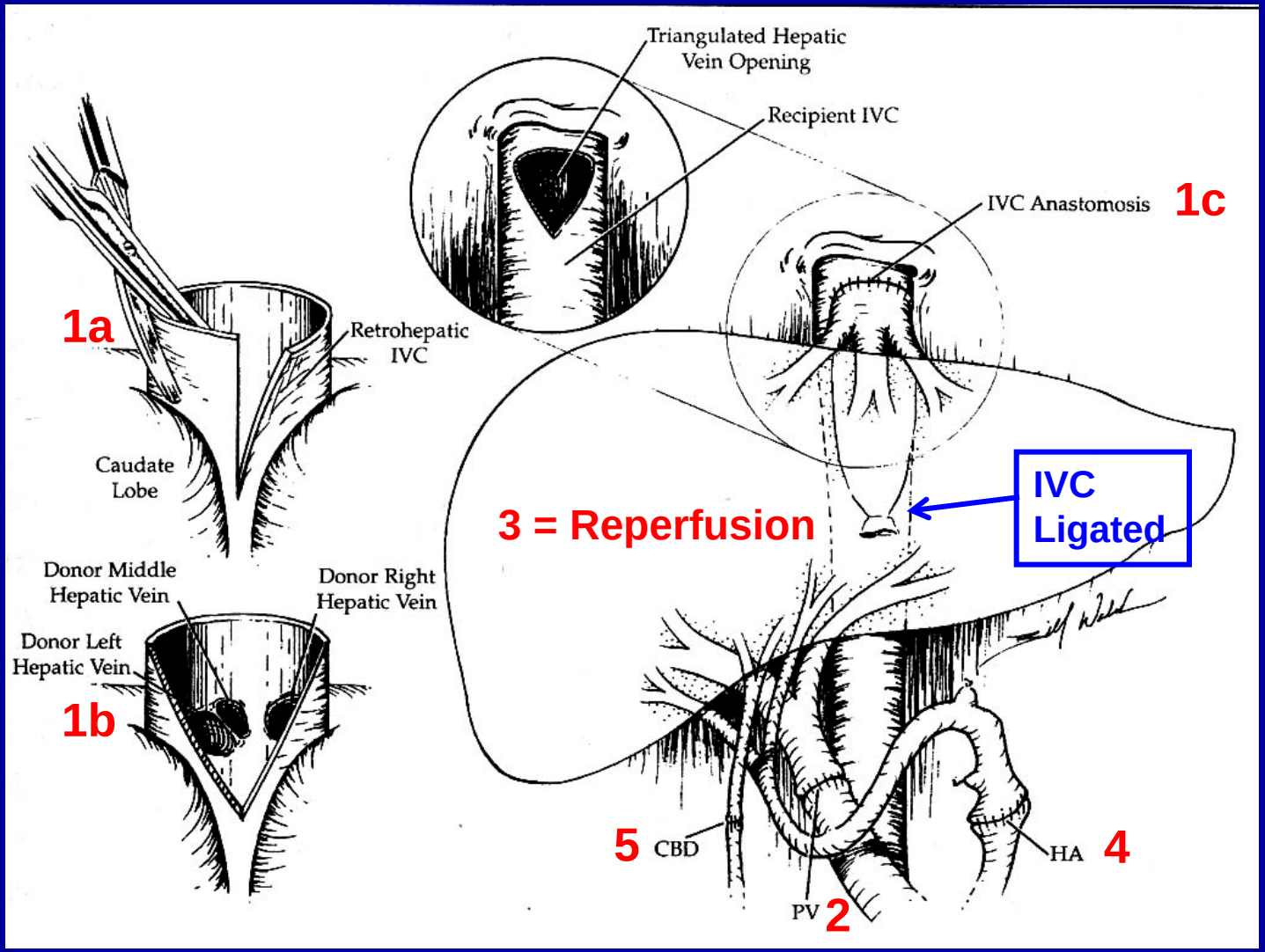
Technique
Anhepatic Phase

- **Piggy-back technique** can help to avoid veno-venous bypass.
  - Dissection of recipient's caudate & Rt lobe from retrohepatic IVC to expose Rt, middle & Lt suprahepatic veins.
  - Clamp at IVC junction, then cut of all 3 veins leaving as much afferent hepatic veins as possible.
  - All 3 afferent veins are interconnected to make a single hepatic vein tunnel cuff which opens into the recipient's IVC.
  - Tunnel cuff will later be connected to the donor's efferent IVC (afferent donor's IVC will be ligated).

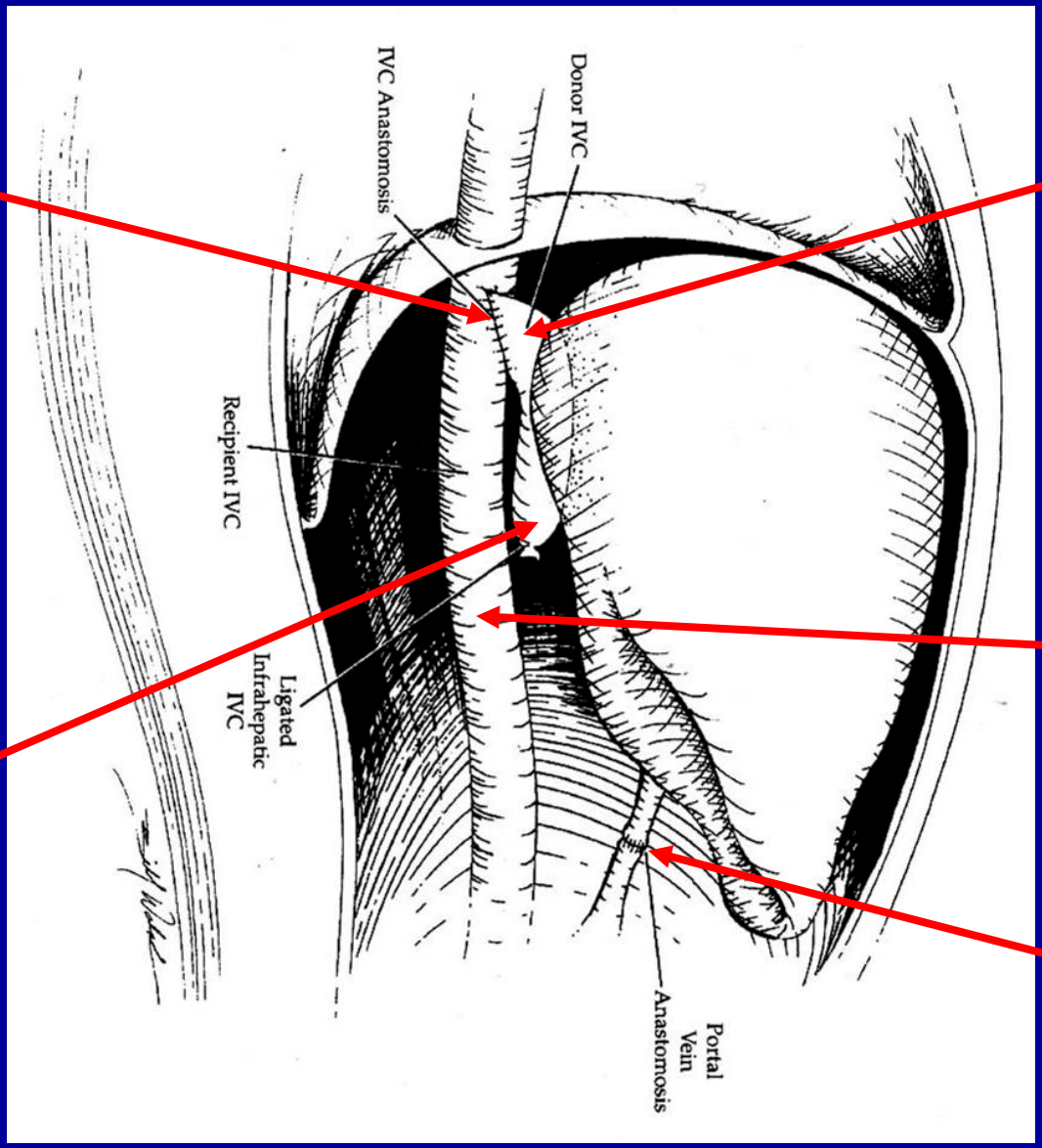
Technique
Anhepatic Phase

- **Advantages of "Piggy-back" technique**:
  - No need for lower IVC anastomosis
  - Less risk of adrenal gland injury
  - Less risk of renal v. injury
  - Less bleeding
  - Shorter anhepatic phase
  - Less hemodynamic instability; v-v bypass needed only if portal vein clamp causes instability
  - In FHF & non-cirrhotics, temporary porto-caval shunt may be needed to decompress the bowel (no porto-systemic collaterals)
- **Disadvantages of "Piggy-back" technique:**
  - Compression of IVC causing thrombosis (Budd-Chiari like)

Piggyback Technique #2



Piggyback Technique



IVC Anastomosis

Suprahepatic Donor IVC

Recipient IVC

Ligated Donor Infrahepatic IVC

Portal Vein Anastomosis

Indications for Choledochojejunostomy

- Donor-recipient duct size discrepancy
- Diseased recipient bile duct
  - Primary sclerosing cholangitis
  - Secondary biliary cirrhosis
  - Choledocholithiasis
- Biliary duct malignancy
- Poor blood supply to recipient's bile duct.
- Inability to pass bile-probe through ampulla.

Post-Procedure

Intraoperative Signs of Hepatic Function

- Restoration of hemodynamic stability
- Adequate urine output
- Acid-base stabilization
- Normalization of coagulation
- Normalization of body temperature
- Maintenance of glycemia
- Adequate bile production
- Good texture & color of liver.

Early Post-operative Signs of Hepatic Function in ICU

- Hemodynamic stability
- Awakening from anesthesia
- Clearance of lactate
- Resolution of hypoglycemia
- Normalization of coagulation/ Factor V
- Resolution of elevated aminotransferases
- Good quantity of golden-brown bile.

Complications

Graft Complications

- **Primary Nonfunction**:

– Occurs in 4-10% LTX.
– **Features**: hepatocyte necrosis, ***without*** vascular complication
  - hepatic encephalopathy,
  - coagulopathy,
  - minimal bile output,
  - renal & multisystem failure,
  - persistent hypothermia,
  - hemodynamic instability,
  - high lactate & liver enzymes.
– Those with hemodynamic instability or multiorgan failure need urgent retransplantation.

Graft Complications

- **Primary Nonfunction**:

– **Donor risk factors**:

- **prolonged cold ischemia,**
- **unstable donor,**
- **high steatosis,**
- **older age,**
- **hypernatremia,**
- **non-heartbeating donor**

Criteria for 1A Status
Primary Non-Function

- Non function in first 7 days, and:
- AST > 3000 IU and at least one:
  - INR >/= 2.5
  - Arterial pH </= 7.3 or Venous pH </= 7.25, and/or Lactate >/= 4 mMol/L
- Anhepathic Phase

- No AST requirement for recipient of segmental grafts of LDLT

Graft Complications

- **Small-for-Size Syndrome**

– Partial liver graft unable to meet functional demands of recipient: poor early graft function in absence of ischemia.

– **Prevention**: in cirrhotic “Graft-Weight to Body-Weight Ratio” (GWBWR) must be =/> 0.85%

– **Manifestations**:

- Poor bile production
- Prolonged cholestasis
- Significant ascites
- Coagulopathy

Graft Complications

- **Small-for-Size Syndrome**

– **Biochemical profile**:
  - Elevated Direct (& total) bili
  - Mild/moderate elevation of ALT & AST
  - Prolonged PT
– **Histologic Features**:
  - Cholestasis with “bile plugs”
  - Areas of regeneration & ischemia with patchy necrosis.
– **Prognosis**: 50% of recipients will die of sepsis within 4-6 weeks.

Graft Complications

- **Small-for-Size Syndrome**

- Recipient Factors Predictive of poor-outcome/ SFSS
  - Graft total mass
  - Poor metabolic & physical recipient condition
  - Advanced chronic liver disease & severe portal hypertension
  - Impaired venous inflow and/or outflow.

Vascular Complications

Hepatic Artery Stenosis

- Caliber decrease of > 50%;
- Occurs in 5%.
  - Asymptomatic or elevated liver enzymes.
  - U/S doppler: resistive index < 0.5 with increase in focal peak velocity.
- Therapy:
  - early: surgical repair;
  - weeks later: angioplasty (90% success)

Vascular Complications

Hepatic Artery Thrombosis

- Pathogenesis: intimal dissection due to vigorous manipulation or clamping.
  - In children may be asymptomatic (rare in adults).
  - Manifestations:
    - acute, massive necrosis,
    - intrahepatic duct necrosis with central biloma,
    - multiple strictures, or
    - **intermittent bacteremia.**

Vascular Complications

Hepatic Artery Thrombosis

- HAT may be segmental;
  - Lt HAT is usually benign.
  - Rt HAT causes biliary strictures.
- DX: angiography.
- Treatment:
  - urgent revascularization;
  - may need retransplantation (biliary sepsis, intraabdominal infection)

Criteria for 1A Status
HAT with Primary Non-Function

- Non function in first 7 days, and:
- AST > 3000 IU and at least one:
  - INR >/= 2.5
  - Arterial pH </= 7.3 or Venous pH </= 7.25, and/or Lactate >/= 4 mMol/L
- Anhepathic Phase

- No AST requirement for recipient of segmental grafts of LDLT
- List with MELD of 40 if HAT does not cause PNF or if between 7-14 days post-op.

Vascular Complications

Portal Vein Stenosis

- **Manifestations:** post-LTX ascites or elevated enzymes.
  - U/S doppler or CT angiography are diagnostic.
  - Confirmed by SMA angiography (late films).
- **Treatment:** Without therapy may evolve to thrombosis.
  - a) early: surgical,
  - b) late presentation: angioplasty or stenting.

Vascular Complications

Portal Vein Thrombosis

- Rare.
- May cause graft dysfunction or massive ascites.
- Due to:
  - kinked or redundant vein, or
  - anastomotic stricture/twist, or
  - poor mesentery flow due to “steal syndrome” from venous collaterals.
- Treatment: revascularization, +/- ligation of large collaterals.

Vascular Complications

Hepatic Outflow Obstruction

- More common after “piggy-back” technique.
- 2.5-6% have iatrogenic Budd-Chiari.
- High morbidity and mortality.
- Due to “rotation” of liver graft or to anastomotic stricture.
- Suprahepatic cava stenosis can cause:
  - liver dysfunction,
  - ascites, or
  - impaired renal function.
- Side-to-side cavo-cavoplasty may be protective.
- **DX**: cavagram with measurement of pressure gradient
- **Treatment:** angioplasty, stent, or surgical repair

Biliary Complications

- Incidence: 15-20%.
- Mortality: 10%.
- Presentation: nonspecific; elevation of bili, alk. phosph & GGT.

- **Biliary stenosis**:

- Is the most common complication;
- Due to imperfect anastomosis or ischemia.
- May cause abnormal enzymes or recurrent cholangitis.
- Treatment:
  - Dilatation + stent (ERCP or PTC).
  - May need creation of, or revision of choledochojejunostomy.

Biliary Complications

- **Ampullary dysfunction**:
- Due to cut of hepatic branch of vagus ?
- Causes Donor+Recipient Bile Duct dilation.
- **Treatment**:
  - sphyncterotomy or conversion to choledochojejunostomy.

Biliary Complications

- **Multiple Intrahepatic Strictures**:
- May be due to:
  - HA thrombosis/stenosis (more frequent in non-heart-beating donors),
  - Preservation damage,
  - Immune injury (lymphocytotoxic (+) cross-match),
  - Recurrent PSC,
  - CMV/ cryptosporidium/ microspora infection.
  - **Treatment**:
    - antibiotic prophylaxis;
    - may need retransplantation.

Biliary Complications

- **Bile leak**:

– **In c-c anastomosis:**
  - usually at T-tube site & self-contained.

– **In c-j anastomosis:**
  - may be lethal due to infection that makes repair difficult (friable & edematous)
  - high risk of mycotic rupture of hepatic artery anastomosis.

Biliary Complications

- **Roux-en-Y loop complications**:

- **a) <u>Bleeding at jejunojejunostomy</u>**:
  - self limited in half; need surgical hemostasis in other half.
- **b) <u>Internal mesentery hernia at j-j anastomosis</u>**;
  - Causes unexplained abdominal distention and vomiting, due to small bowel volvulus.
  - May be lethal due to bowel necrosis.
  - **<u>DX</u>**: CT scan showing “closed loop obstruction”.
  - **<u>Treatment</u>**: surgical closure of mesentery defect.

Live-Donor Adult Liver Tx

- 5% of transplants in USA. (learning curve = 20 cases)
- Only 30-45% of potential donors donate;
- Aborted hepatectomy in 5% of donors
- Donor relation:
  - 30% offspring, - 20% sibling,
  - 20% parent, - 20% unrelated,
  - 10% other relative/unknown.
- Donor age: 50% > 50 years old.
- Donor risk: (14 death, 1 vegetative state, 2 LT/ 6-7000 live-donors)
  - 0.4% mortality,
  - 0.4-0.6% catastrophic complication, &
  - 35% morbidity
- Patient survival: equal to cadaver-donor.

Live-Donor Adult Liver Tx
Disease-Specific Considerations

- HCC:
  - Must fulfill Milan Criteria
- HCV:
  - Is acceptable indication, but appropriate timing needs further investigation (not too early).
- FHF:
  - Acceptable indication for emergency transplantation.

Live-Donor Adult Liver Tx
Donor Evaluation

- Complete history & physical with “ideal & actual body weight”.
- No smoking.
- Stop BCPs before surgery.
- Laboratory:
  - CBC, - CMP,
  - serologic testing, - comprehensive coagulation profile,
  - markers of liver disease, - other tests as indicated by Hx & PE.
- Psychosocial evaluation.

Live-Donor Adult Liver Tx
Donor Evaluation

- Radiology:
  - liver volume & vascular anatomy;
  - biliary anatomy pre-op or intra-op.
- Pre-op liver Bx is controversial. Do it if:
  - abnormal enzymes, or
  - steatosis by imaging, or
  - BMI > 30,
  - donor genetically related to patient with AIH, PSC, or PBC

Live-Donor Adult Liver Tx
Donor Evaluation

- Donor age-limit of 60 is considered appropriate.
- BMI > 30 may increase risk to donor, but is not absolute contraindication.
- Volumetric imaging analysis may overestimate liver volume by 10%.
- Calculated donor-remnant should be at least 30% of original liver volume & with complete venous drainage.
- Graft-liver-volume to recipient-body-weight ratio (GWBWR) should be =/> 0.8%
- GWBWR 0.85% or larger in portal-HTN/Child B or C to avoid SFSS.
- Without cirrhosis even 0.6% could be used in selected patients with normal liver function.
- Overall, 1-year survival is < 50% when GWBWR is < 0.8%)
- Later: Avoid excessive portal v. inflow and assure excellent hepatic vein outflow to prevent “graft flooding”.

Live-Donor Adult Liver Tx

Donor Evaluation

- ABO compatibility is recommended.
- ABO incompatible only in:
  - a) infants,
  - b) child < 1y/o without isoagglutinins,
  - c) emergency situation where no deceased-donor available
- Lab contraindications: HIV, HCV, HBsAg(+), anti-HBc(+)
- Thromboembolism & stress ulcer prophylaxis recommended.
- Autologous blood storage should be offered.