RADIOLOGICAL IMAGING OF LIVER TRANSPLANTATION

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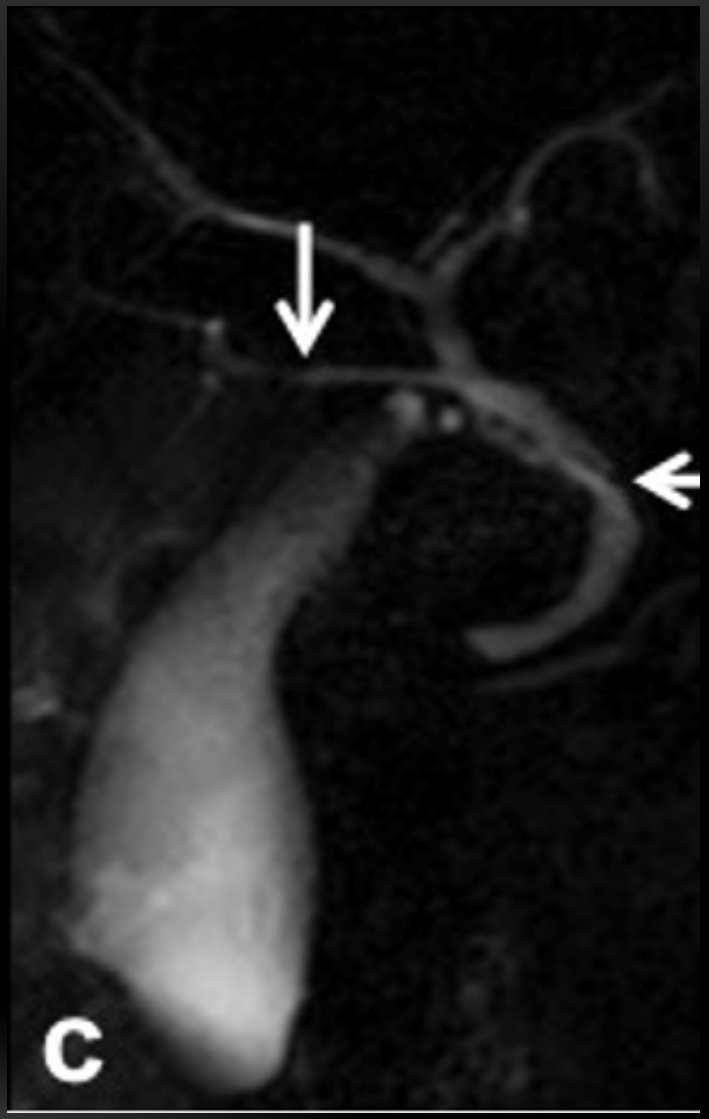
INTRODUCTION

- Liver transplantation (LT) is now regarded as the therapy of choice for:
  - Chronic end-stage liver disease
  - Fulminant hepatic failure
  - Early stage hepatocellular carcinoma (HCC).

- Two variants of liver transplantation (LT) Depending on the type of donor:
  1. Orthotopic liver transplantation (OLT)
     - Cadaveric LT or split-liver cadaveric LT
  2. Living donor liver transplantation (LDLT).
     - Right hemiliver graft transplantation or left hemiliver

IMAGING TECHNIQUES

- **Noninvasive techniques**
  1. US and Doppler
  2. CEUS
  3. CT
  4. MRI and MRCP
- **Invasive techniques**
  1. Conventional angiography.
  2. Endoscopic retrograde cholangiopancreatography (ERCP)
  3. Percutaneous transhepatic cholangiography (PTC)



- CECT … MIP images MRCP

- Preoperative imaging
  - Imaging of the recipient
  - Imaging of the donor
- Postoperative imaging
  - Hepatic artery complications
  - Portal vein complications
  - Venous complications
  - Biliary complications
  - Abscess
  - Malignancies

PREOPERATIVE IMAGING

Aims:

- Proper selection of recipients and donors.
- Surgical planning aiming for achieving an effective procedure with minimal morbidity.

IMAGING OF THE RECIPIENT

Primary goals

1. Exclude contraindications to LT:
   - Extended thrombosis of the portal tract
   - Hepatic and extrahepatic malignancies other than HCC
   - Intermediate-to-advanced HCC.
2. Assess the patency and anatomy of the vascular inflow and outflow of the liver for preoperative planning.

- According to Milan criteria, LT is indicated for:
  1. Solitary HCC <5 cm in size,
  2. Less than 3 HCCs sized 1–3 cm.
- Regardless of the criteria of choice, **macrovascular invasion** contraindicates LT.

IMAGING OF THE DONOR

- The **goal** of imaging liver donors is to identify causes of contraindications to donation including:
  1. Diffuse liver disease.
  2. Inadequate volume of the liver remnant or graft
  3. Focal liver lesions (FLLs).

Diffuse liver disease

- Hepatic steatosis is the most frequent condition in this setting (up to 25% of donors).
- Upper tolerated limit of steatosis for LT is 30%.
- Standard of reference for assessing steatosis is still liver biopsy.
- Biopsy is prone to sampling errors and a potential cause for comorbidities in donors.
- CT and MRI are under investigation

- **Unenhanced CT:**

Liver parenchyma attenuation<40 Hounsfield units (HU) or10 HU smaller than the spleen.

- **MRI:**

Calculate signal dropout on in-phase and out of-phase chemical shift imaging

VOLUMETRY

- Performing **volumetry** of the donor's liver using dedicated software is of importance in estimating the volumes of the entire liver, remnant liver and graft.

POSTOPERATIVE IMAGING

- Aims to prompt identification of **complications** classified into early or late.
- Vascular and biliary causes are the most frequent ones.
- Recurrent diseases after LT (e.g., HCC, cirrhosis of the graft, and primitive sclerosing cholangitis)

HEPATIC ARTERY COMPLICATIONS

- **Include:**
  1. Hepatic artery thrombosis (HAT)
  2. Hepatic artery stenosis (HAS)
  3. Hepatic artery pseudoaneurism (HAP).

HEPATIC ARTERY THROMBOSIS (HAT)

- Most common vascular complication.
- HAT can occur early (within 1–2 months) or late from LT.
- Hepatic artery remains the only blood supply to the **bile ducts** Thus, HAT causes b**iliary ischemia** and hepatic necrosis, which in turn translate into bile leak, sepsis and graft failure.

- **Serial Doppler US** examinations following LT are of great importance for **early assessment** of absence of flow in the hepatic artery.
- **False positive** cases on Doppler US
  - ✓Low cardiac output,
  - ✓Arterial spasm,
  - ✓Severe parenchyma edema.
- **False negatives** are associated to the development of collaterals
- **CEUS** may be needed in doubtful cases.

CT angiography:

- A filling defect or an abrupt cut-off of the vessel caliber (usually at the anastomotic site).
- Associated parenchymal areas of infarction.
- Signs of biliary ischemia or infection.

- **MRI angiography** has limited role in practice as it is less available and difficult to be performed in critical patients.

HEPATIC ARTERY STENOSIS (HAS)

- **Doppler US:**

- Increased peak systolic velocity (> 200 cm/ sec) at the stenotic site.
- Distally, arterial flow becomes turbulent and shows a “parvus-tardus” waveform at the intrahepatic branches with a resistance index (RI) < 0.5.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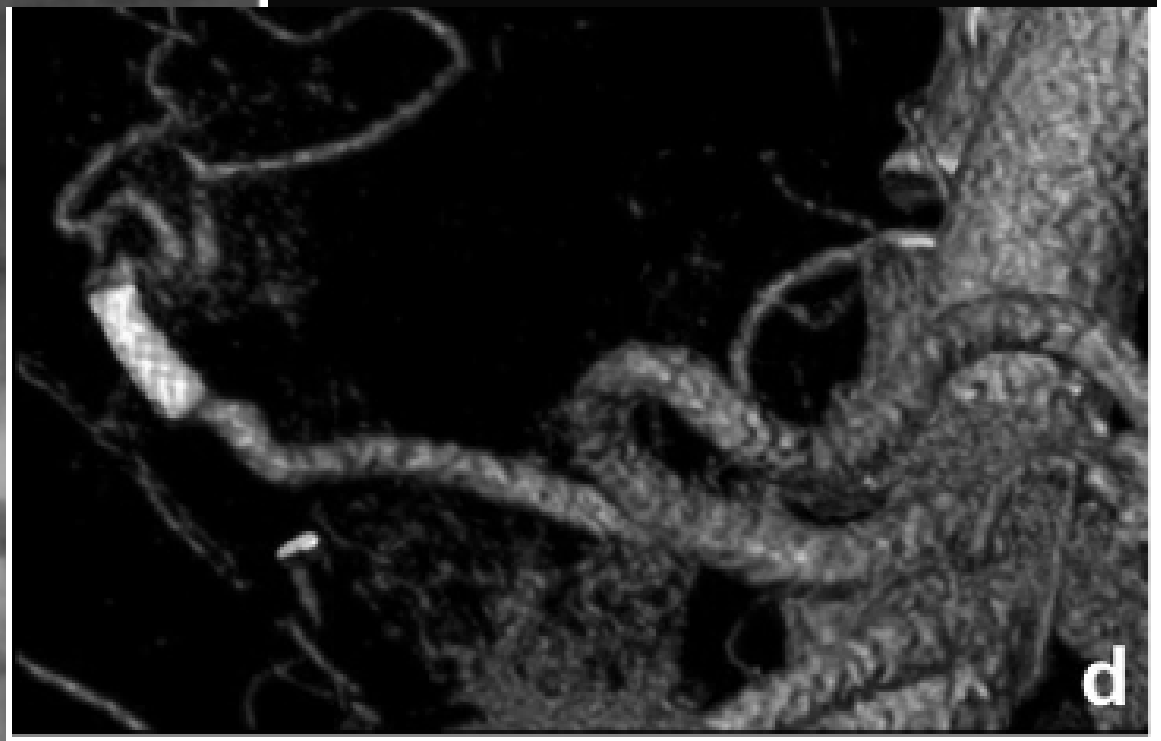
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HEPATIC ARTERY PSEUDOANEURYSM (HAP).

- Rare complication predominantly mycotic or iatrogenic occurring at:
  - Anastomotic site (usually after angioplasty)
  - Intrahepatic branches (after biopsy or biliary intervention).
- **Color Doppler US:**
  - Characteristic , turbulent “yinyang” flow within an anechoic, small “collection-like” structure at the hepatic hilum or near the vessels course.
- **CT or MRI angiography**
  - Confirm diagnosis

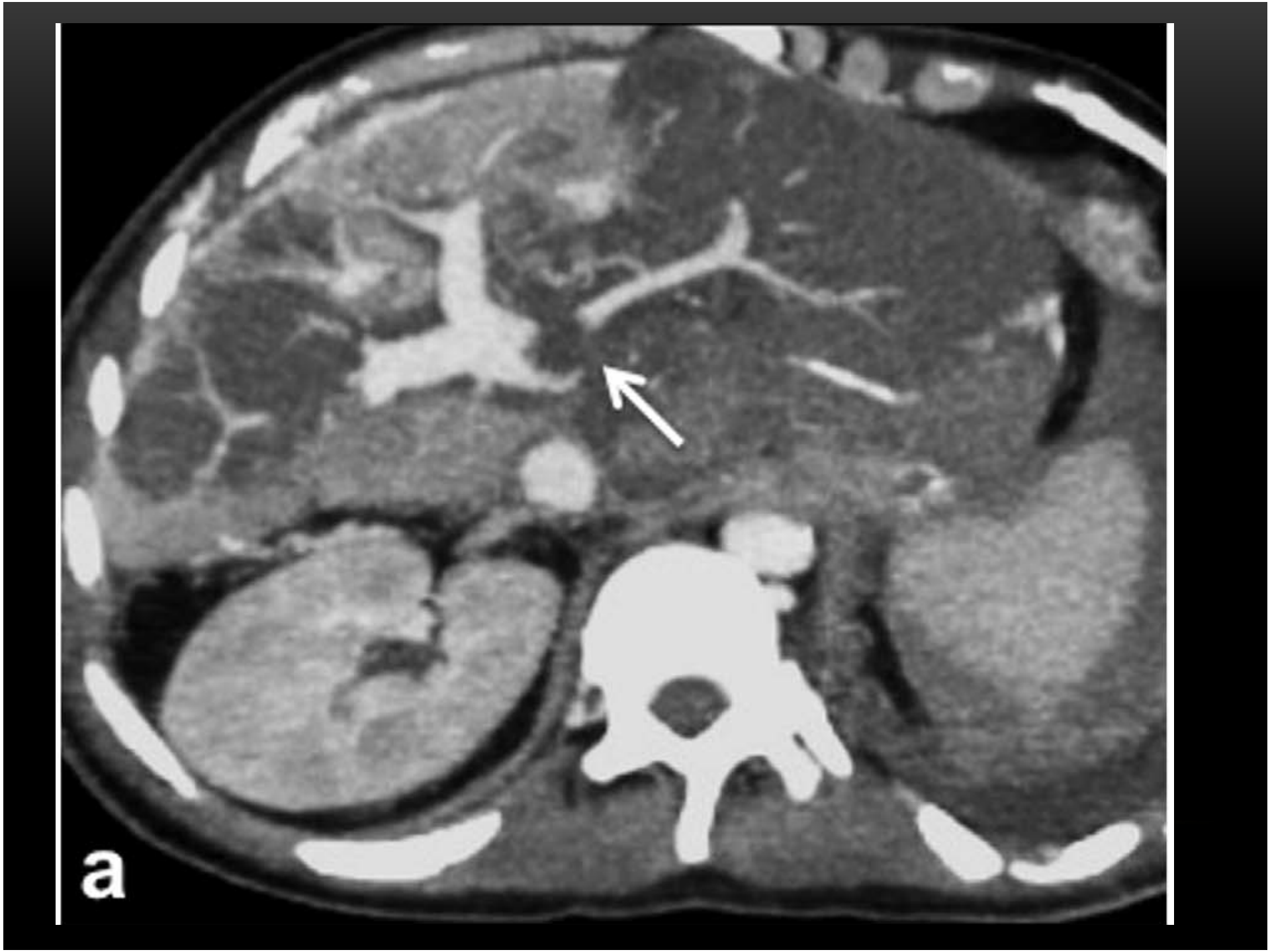
PORTAL VEIN COMPLICATIONS

- They are rare (1–2% of patients),
- Include portal vein thrombosis (PVT) and portal vein stenosis (PVS).

PORTAL VEIN THROMBOSIS (PVT)

- Usually presents as an early complication.
- **Color Doppler US:**
  - Absent flow, with our without direct demonstration of an intraluminal echogenic thrombus.
- **Chronic thrombosis:**
  - Portal carvernoma, with hypertrophic hepatic artery and multiple, thin portal collaterals at porta hepatis

- **CT or MRI:**
- Better delineate the extension and degree of intravascular filling defects for the purpose of therapy.
  - **Partial thrombosis** may benefit from medical therapy.
  - **Complete thrombosis** requires a variety of treatments ranging from thrombolysis to retransplant.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PORTAL VEIN STENOSIS (PVS)

- **Doppler US:**
  - increased peak anastomotic velocity **>125 cm/s** at the site of anastomosis.
  - anastomoticto- preanastomotic velocity ratio equal or larger than **3:1.**
- **Direct transhepatic portography:**
  - Pressure gradient across the stenosis **>5 mm Hg** is considered diagnostic.
- **CT or MRI** confirmation is usually easy.

VENOUS COMPLICATIONS

- Complications involving IVC and hepatic veins are uncommon (1–4% of patients).
- They include thrombosis or stenosis.

VENOUS THROMBOSIS

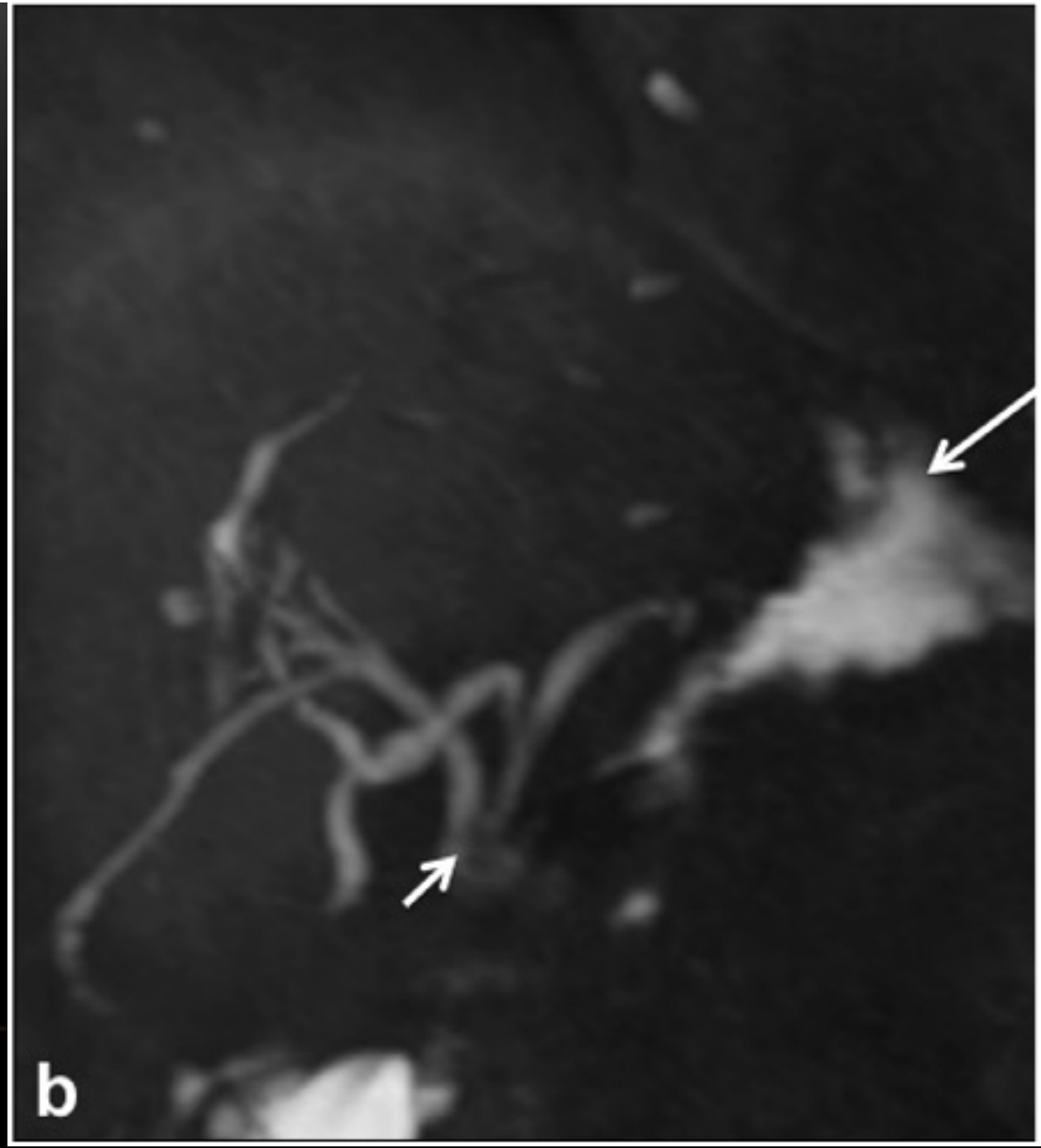
- Clinical manifestations varying from lower extremity edema to Budd-Chiari syndrome, depending on the degree of venous obstruction.
- **Doppler US** assessment raises the suspicion of **thrombosis** when an echogenic, intravascular thrombus is observed.
- **CT and MRI**: used to confirm the diagnosis

BILIARY COMPLICATIONS

- Biliary complications (BCs) are **frequent** (5–32% of patients), representing the major source of morbidity and graft dysfunction/loss after rejection.
- There are several explanations:
- **First**, some LT technical choices are “per se” a predisposing factor to complications: e.g., LDLT predisposes to cut-surface biliary leakage.
- **Second**, the arterial-only vascularization of the biliary tract depends from the hepatic artery patency, making bile ducts prone to ischemic cholangitis in the case of HAT or HAS.
- **Third**, bile ducts are sensitive to a variety of immunologically-related conditions, manifesting with microangiopathic injury.

BILE LEAKAGE

- The most frequent early BC (up to 25% of patients),
- Manifesting at:
  - The entry site after T-tube removal (80% of patients)
  - Biliary anastomosis,
  - Liver cut-surface after split-OLT or LDLT,
  - Perihepatic and subhepatic space,
  - Wherever along intra- or extrahepatic bile ducts in the case of HAT.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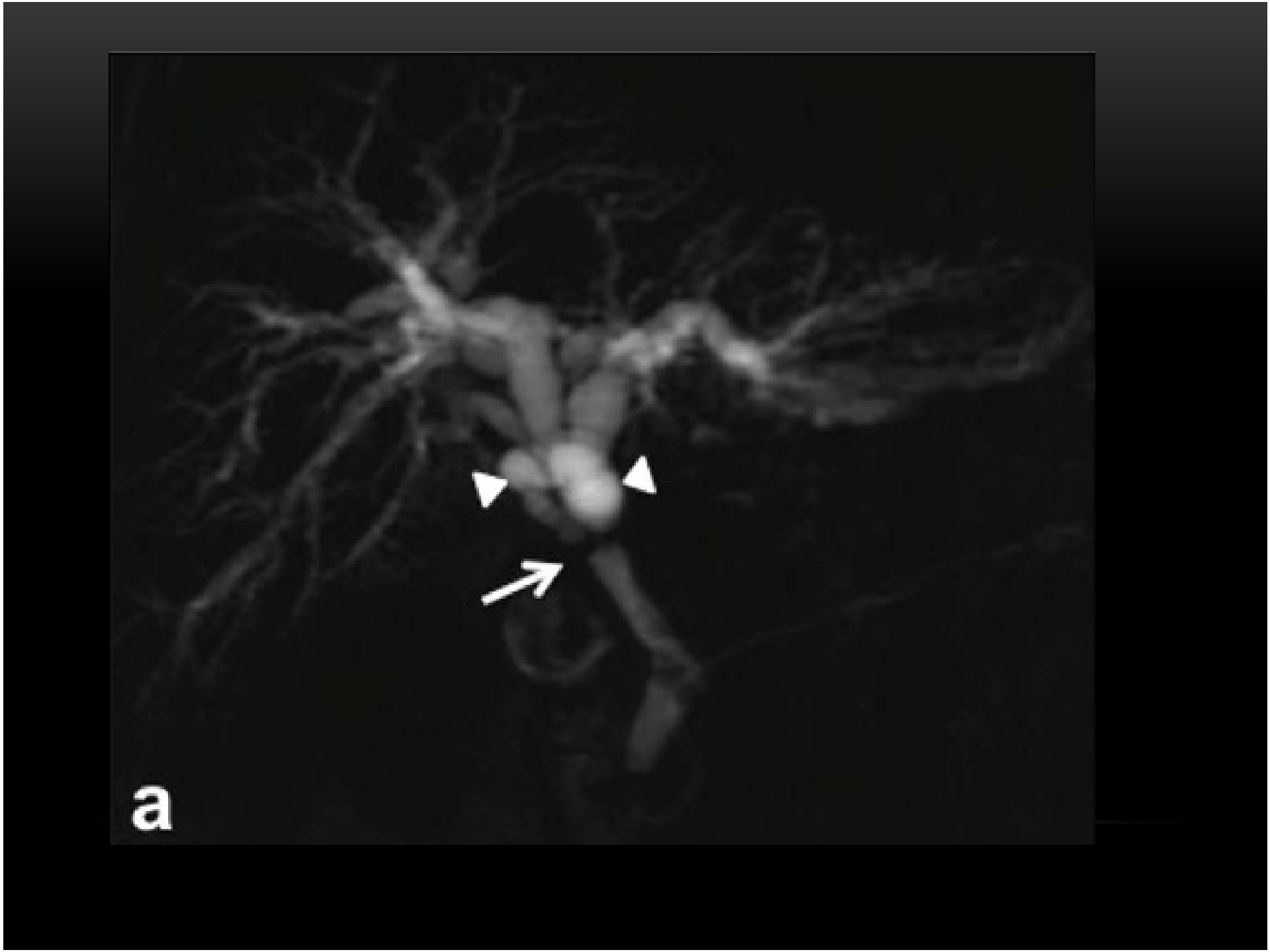
- Small leaks tend to resolve spontaneously and are managed conservatively,
- Larger ones translating into bilomas (with or without superinfection) should be treated with transhepatic biliary drainage, stenting, surgical repair or biliary reconstruction.

ANASTOMOTIC STRICTURES

- Occur in about 13–19% of patients
- **MRCP:**
  - The stricture appear as a short, focal absence of biliary signal at the common bile duct, lying between the donor and recipient cystic duct stumps, with biliary dilation upstream.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ABSCESS

- Causes:
  - Super-infection of intrahepatic collections (seromas, hematomas or bilomas)
  - Parenchymal infarcts in patients with HAT or HAS.
- **CECT:**
  - Complex areas with fluid or ambiguous attenuation, with a peripheral rim of contrast enhancement, intralesional gas in typical cases
- **Percutaneous drainage** is the treatment of choice.


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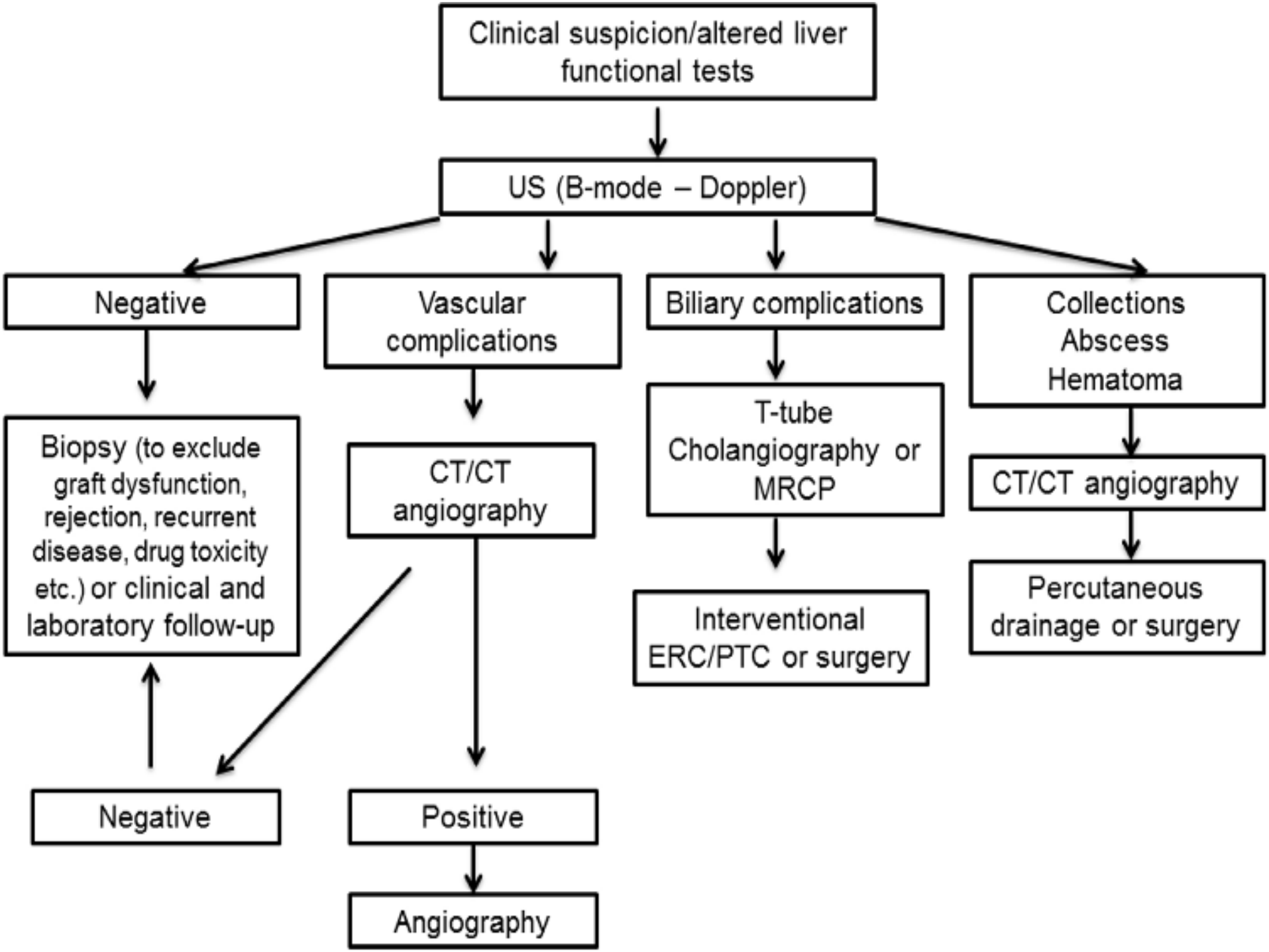
MALIGNANCIES

- LT patients are at higher risk to develop de novo malignancies compared to the normal population due to **co-existing risk factors** and the **immunosuppressive therapy.**
- Skin cancers and post-transplant lymphoproliferative disease (PTLD) are most frequent.
- **CT** provides a panoramic representation of the abdomen and should be considered the imaging modality of choice for diagnosis and staging.
- **Positron emission tomography-CT (PET-CT)** also plays a key-role both in diagnosis and follow-up.


Clinical suspicion/altered liver functional tests
US (B-mode – Doppler)
Negative
Vascular complications
Biliary complications
Collections Abscess Hematoma
Biopsy (to exclude graft dysfunction, rejection, recurrent disease, drug toxicity etc.) or clinical and laboratory follow-up
CT/CT angiography
T-tube Cholangiography or MRCP
CT/CT angiography
Interventional ERC/PTC or surgery
Percutaneous drainage or surgery
Negative
Positive
Angiography

THANK YOU