

# Portal Vein Embolisation

## Indications, techniques and complications

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# Why?

- Postoperative liver volume insufficiency is still a major concern after an extensive liver resection
- Sinusoidal injury caused by an abrupt increase in portal venous flow/pressure
- Cholestasis, ascites, and impaired synthetic function
- Fatal liver failure

- Obstructive jaundice
- Chemotherapy
- Underlying liver disease

# History

- First to demonstrate the regenerative capacity of the liver following portal vein occlusion were Rous and Lari-more in the 1920s.
- 1961- Honjo I, Kozaka S (1965) Extensive resection of the liver in two stages. Rev Int Hepatol 15:309–319



Makuuchi et al -1982

Kinoshita H, Sakai K, Hirohashi K et al (1986) Preoperative portal vein embolization for hepatocellular carcinoma. World J Surg 10:803–808

# Physiological changes

- Pressure in the nonembolized hemiliver is elevated immediately after PVE by  $4.9 \pm 2.7$  cm H<sub>2</sub>O
- Elevation is believed to be transient, with pressure gradually returning to the baseline value in 2 to 3 weeks
- *Hepatic arterial buffer response*

- *Hyperplasia vs hypertrophy*
- *Functional ?*
- *Tumour biology*

- In case of right hemiliver PVE, regeneration rate of the noncirrhotic liver was 12 cm<sup>2</sup>/day 2 weeks after PVE ([Lee et al, 1993](#); [Nagino et al, 1995](#)), decreasing to 11 cm<sup>2</sup>/day at 4 weeks ([Nagino et al, 1995](#)) and then 6 cm<sup>2</sup>/day at 32 days ([De Baere et al, 1996](#)).
- In cirrhotic patients, regeneration is reportedly slower, at a rate of 9 cm<sup>2</sup>/day at 2 weeks ([De Baere et al, 1996](#); [Lee et al, 1993](#)).
- In noncirrhotic and cirrhotic livers, regeneration processes are thought to be blunted by approximately 50% compared with that after hepatectomy.



- *Hepatology. 2001 Aug;34(2):267-72.*
- *Proliferative activity of intrahepatic colorectal metastases after preoperative hemihepatic portal vein embolization.*
- *Kokudo et al*
- Department of Surgery, Cancer Institute Hospital, Tokyo, Japan
  
- Long-term survival was similar in the PVE and non-PVE groups, however, disease-free survival was significantly poorer in the PVE group than in the non-PVE group (P =.004)
  
- ***PVE increases tumor growth and probably is associated with enhanced recurrence of disease.***
- ***Although PVE is effective in extending indications for surgery, patient selection for PVE should be cautious.***

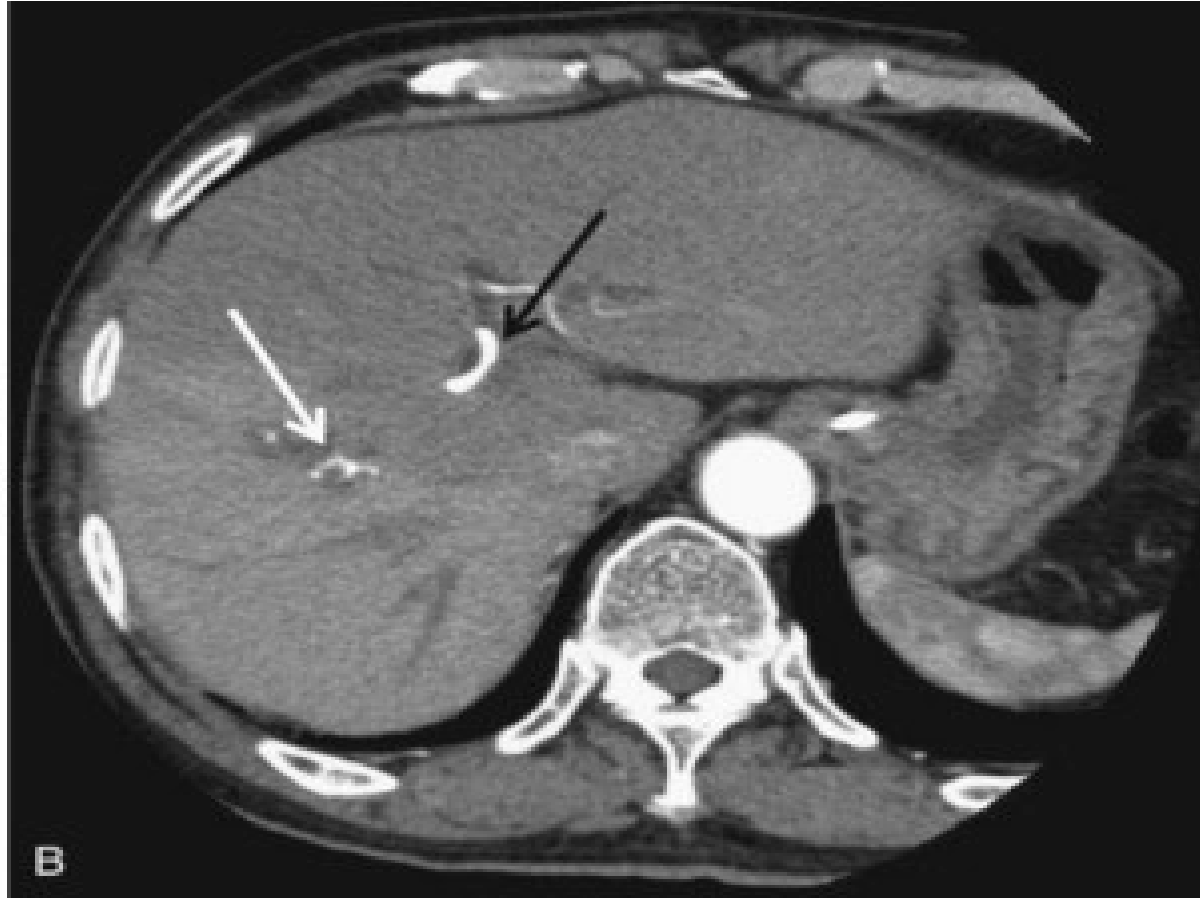
- First, the primary tumor is resected, if necessary;
- Next, left liver limited metastasectomies are performed;
- Then right portal vein ligation or PVE are carried out.
- After an interval of several weeks, (extended) right hepatectomy is performed

Reference	Number	Cancer Type	Embolizing Materials	Interval (weeks)	Volume Increase (%)
<a href="#">Makuuchi et al, 1991</a>	54	32 HCC, 12 HBD, 8 CLM, other 2	Gelfoam, Urografin, gentamicin	2 to 3	14
<a href="#">Nagino et al, 1995</a>	19	14 GB, 5 HBD	Fibrin glue, Lipiodol	1	11
<a href="#">De Baere et al, 1996</a>	31	22 CLM, other 9	Histoacryl, Gelfoam, or coils	4-5	12
<a href="#">Shimamura et al, 1997</a>	7	7 HCC	Absolute ethanol	7	27
<a href="#">Imamura et al, 1999a</a>	84	49 HBD, 22 GB, 7 CLM, 5 HCC, other 1	Gelfoam, thrombin, Urografin, Lipiodol, or gentamicin	2	10
<a href="#">Azoulay et al, 2000a</a>	10	10 HCC	Histoacryl, Lipiodol	9	16
<a href="#">Azoulay et al, 2000b</a>	30	30 CLM	Histoacryl, Lipiodol	9	11
<a href="#">Wakabayashi et al, 2002</a>	43	25 HCC, 10 CLM, 81 CC	Gelfoam	3	9
<a href="#">Elias et al, 2002</a>	68	69 metastatic	Histoacryl, Lipiodol	4	13
<a href="#">Abdalla et al, 2002</a>	18	9 metastatic, 9 primary (normal liver)	Polyvinyl alcohol, microcoils	3-6	8
<a href="#">Farges et al, 2003</a>	27	14 HCC	Histoacryl, Lipiodol	4-8	9
		11 CC, 10 CLM, 2 others	Histoacryl, Lipiodol	4-8	16
<a href="#">Aoki et al, 2004</a>	17	17 HCC	Gelfoam, thrombin, Urografin, gentamicin	3	9
<a href="#">Ogata et al, 2006</a>	36	36 HCC	Histoacryl, Lipiodol	4-8	8
<a href="#">Seo et al, 2007</a>	32	32 HCC	Liquid embolic material (Embol-78)	3	0

- Greater the FLRV before PVE, the smaller the volume increase after PVE
- Modest when biologic materials such as gelfoam and fibrin glue
- Absolute ethanol -highest degree of regeneration but at the expense of marked increases in AST and ALT levels secondary to liver necrosis
- Diabetes, obstructive jaundice, active hepatitis, and cirrhosis - hamper the regeneration process

- The liver parenchyma after neoadjuvant chemotherapy using irinotecan is often steatotic, fibrotic, and sometimes cirrhotic.
- Similarly, sinusoidal obstruction syndrome associated with oxaliplatin has been reported.
- Such hepatotoxicity is assumed to have an inhibitory effect on the hypertrophy of the nonembolized FLR

- Dilation of sinusoids with decreased hepatocyte density and hepatocyte apoptosis -pericentral area ([Harada et al, 1997](#)).
- No signs of necrosis or inflammation
- Absolute ethanol- tissue showing clear evidence of necrosis ([Shimamura et al, 1997](#))
- Cyanoacrylate-causes peribiliary fibrosis



Computed tomographic images of a 76-year-old man with hilar bile duct carcinoma. **A**, Before portal vein embolization (PVE). **B**, The same patient 2 weeks after PVE at the right hemiliver using gelatin sponge, thrombin, and coils (*white arrow*). The *black arrow* indicates the biliary drainage tube. Note the cessation of portal flow and attenuation difference by hepatic arterial buffer response in the right hemiliver.

- Despite a technically successful PVE, lack of hypertrophy is most likely explained as *failure to increase portal flow to the FLR* because of the presence or development of collateral vessels to the systemic circulation.
- In most patients showing adequate hypertrophy, the actual interval between PVE and resection can be less than 4 weeks



# Volumetry

- TLV
- FLR
- FLRV/TLV ratio
- SLV

# Indications

- Cholangiocarcinoma
- HCC
- Liver metastasis
- General indications

- In patients with normal liver (ICG retention rate at 15 minutes [ICG R15] < 10%) if FLRV/TLV is less than 40%
- In patients with an injured liver (10% < ICG R15 < 20%), if FLRV/TLV is less than 50%
- Patients undergoing an extensive resection
- Major synchronous surgical procedure
- Minor hepatectomies involving the FLR lobe

# HCC & Liver metastasis

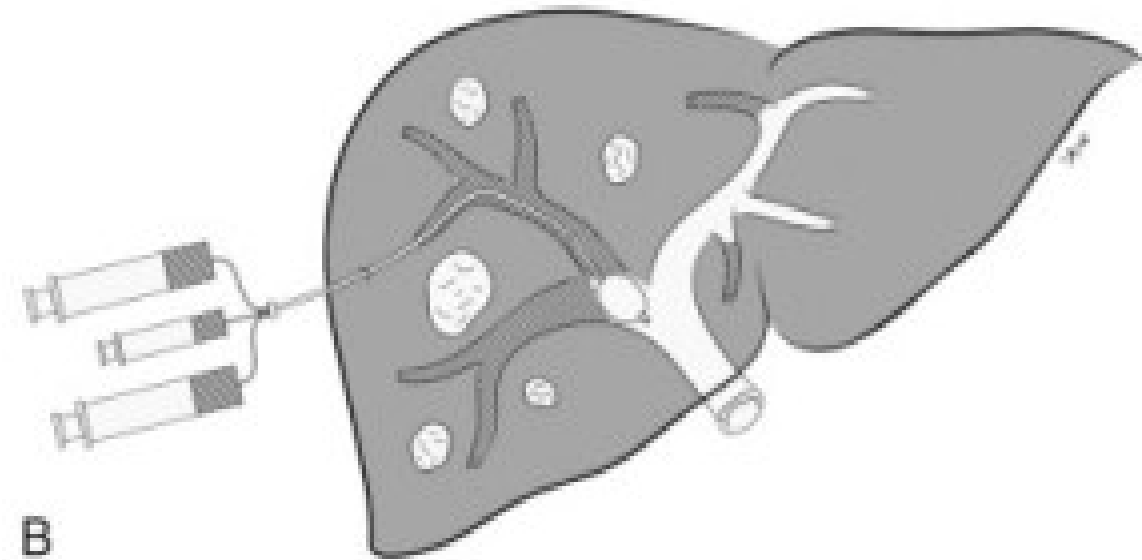
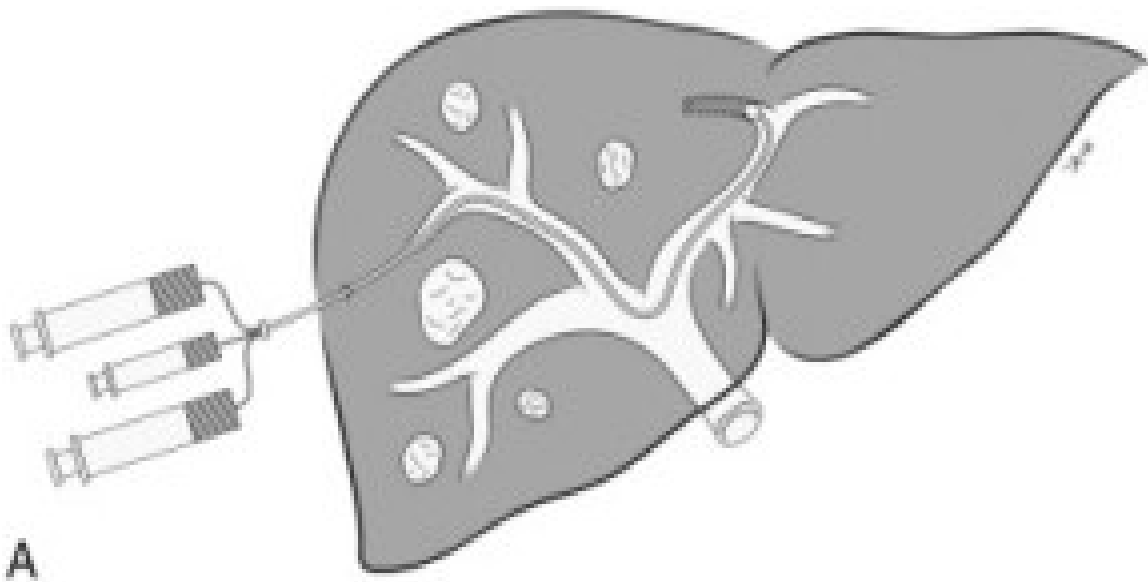
- Massive liver tumors -right liver
- Small multiple metastases in the right hemiliver, solitary tumor located adjacent to the hilum of the liver, or for bilateral tumors
- Simultaneous major gastrointestinal procedure
- Liver injury -systemic or locoregional chemotherapy

# Techniques and materials

- Intraoperative portal branch ligation
  - Transileocolic PVE
  - Percutaneous transhepatic ipsilateral
  - Contralateral PVE technique.
- 
- Polyvinyl alcohol particles
  - Coils
  - Gelatin sponge
  - N-butyl cyanoacrylate
  - Lipiodol
  - Fibrin glue

# Percutaneous Transhepatic Ipsilateral Approach

- FLR is not instrumented
- Segment IV branches
- The anterior segment of the right portal vein is preferred, because its use is associated with a lower complication rate
- Reverse-curve catheters or balloon occlusion catheters with multiple lumina

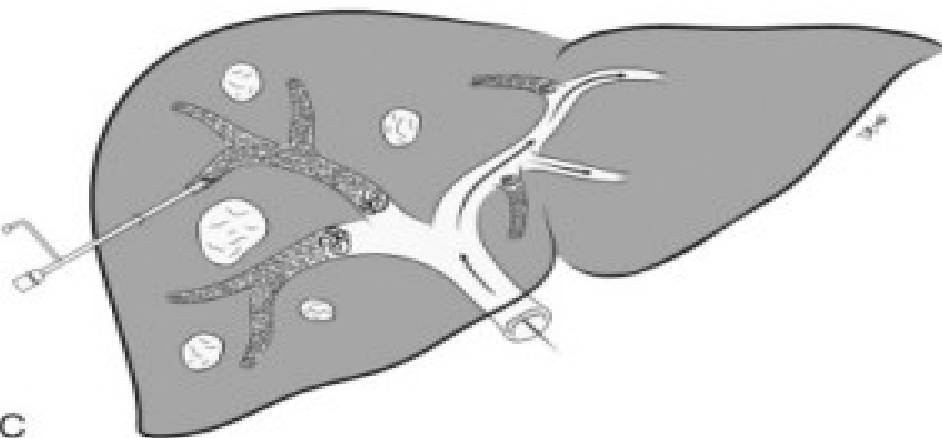
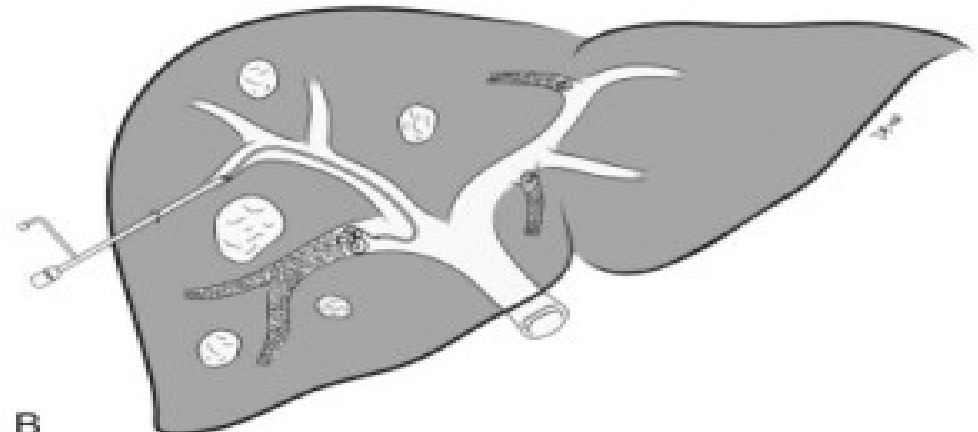
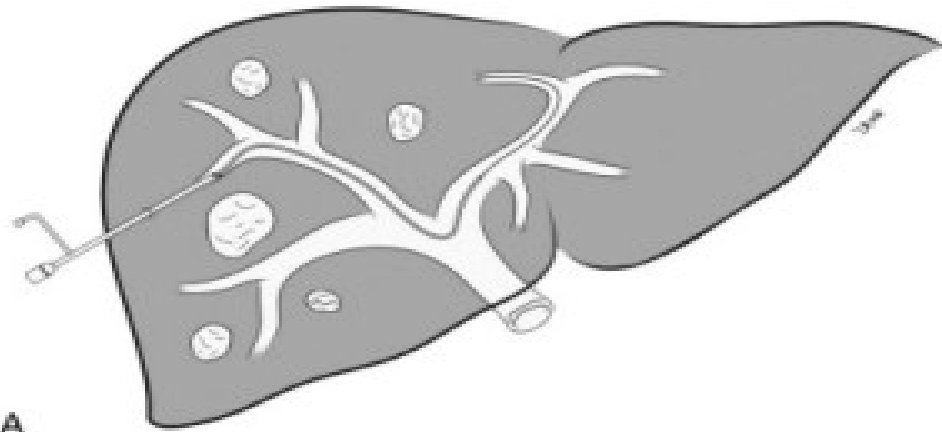


- Schematic representation of the ipsilateral approach for right portal vein embolization (PVE) and segment IV as described by Nagino and coworkers. Different balloon catheters are used for antegrade embolization of segment IV veins (**A**) and for retrograde delivery of the embolic agent into the right portal system (**B**).

- In Nagino's approach
- The right anterior portal vein -sonographic guidance-6-Fr sheath
- The first catheter, “type 1,” was designed with one lumen connected to the balloon and two lumina connected to the tip.
- The second catheter, “type 2,” had two separate lumina opening proximal to the balloon, and the balloons were used to prevent any backflow of embolic material.
- proximal right portal vein segment at least 1 cm in length remain patent.
- The type 1 catheter was used for embolization of branches distal to the catheter tip, whereas the type 2 catheter was used for embolization of branches proximal to the catheter tip



- Four-lumen balloon catheter
- Technique using angiographic catheters commercially available worldwide
- 22-gauge Chiba needle -distal branch of the right portal system.
- 5- or 6-Fr vascular
- Flush portography -5-Fr angiographic flush
- Segment IV embolization should be performed first

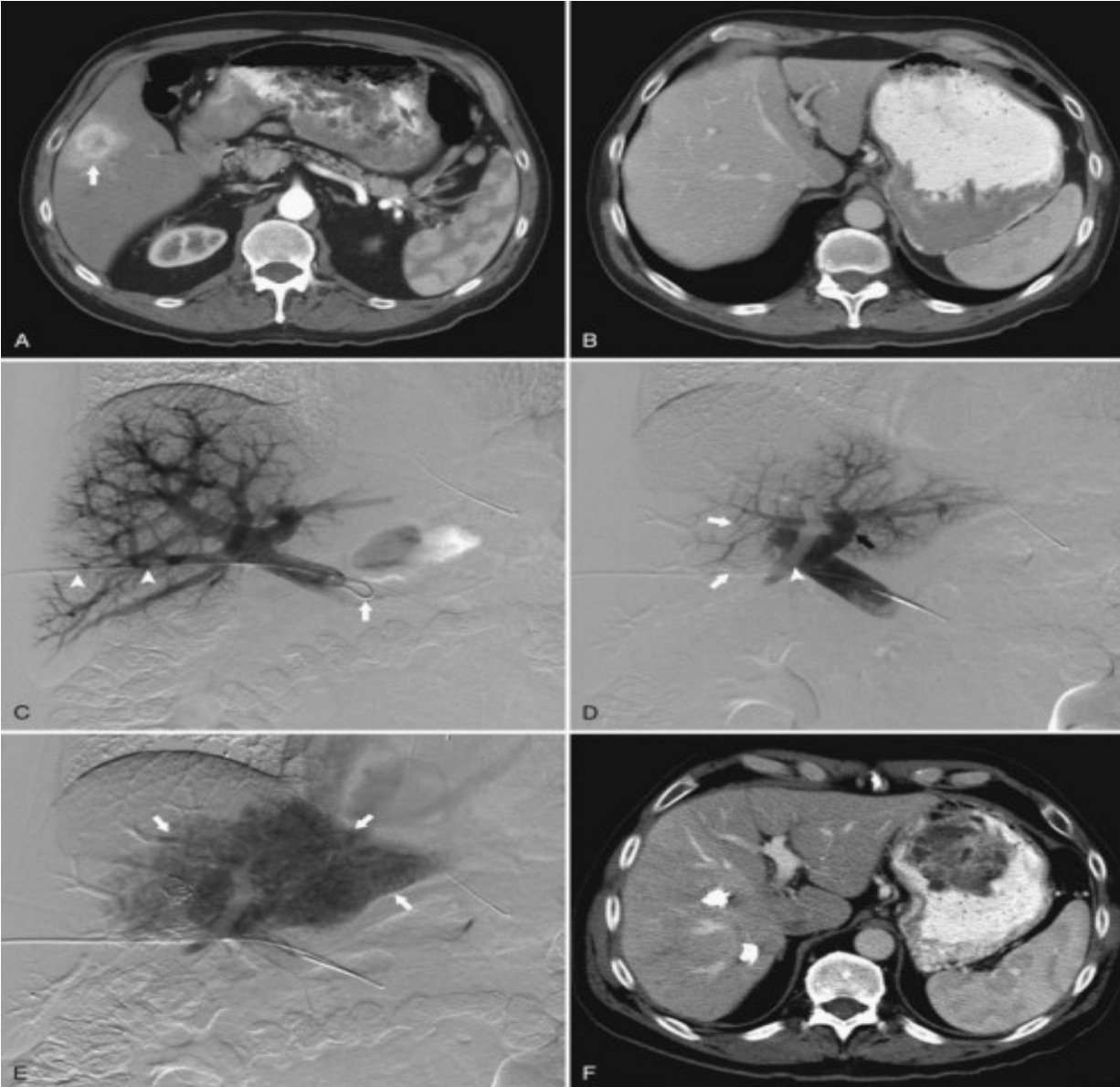


Schematic representation shows modification of the ipsilateral technique for right portal vein embolization (RPVE) extended to segment IV.

**A,** Placement of a 6-Fr vascular sheath into the right portal branch. An angled 5-Fr catheter is placed into the left portal system with coaxial placement of a microcatheter into a segment IV branch. Particulate embolization is performed followed by placement of coils, until all the branches are occluded.

**B,** After segment IV embolization is completely occluded, a 5-Fr reverse-curve catheter is used for RPVE.

**C,** After embolization of the right and segment IV portal veins are complete, the access tract is embolized with coils to prevent subcapsular hemorrhage



A 67-year-old man with pancreatic insulinoma metastatic to the liver who had transhepatic ipsilateral right portal vein embolization (RPVE) with particles and coils prior to right hepatectomy. **A**, Contrast-enhanced computed tomographic (CT) scan of the liver shows a hypervascular mass in the right liver consistent with metastatic disease (*arrow*).

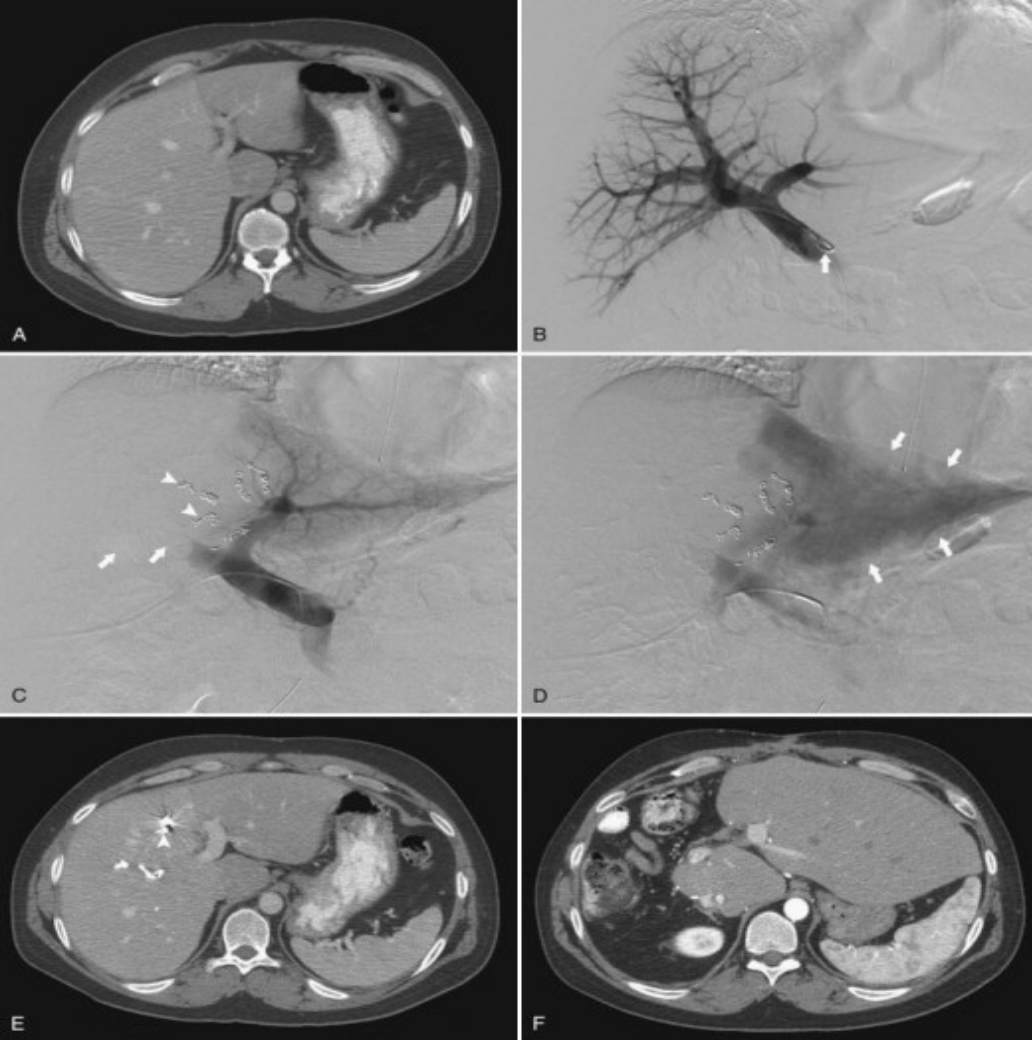
**B**, Contrast-enhanced CT scan of the liver shows a small left liver within the shaded area (functional liver remnant/total estimated liver volume ratio [FLR/TELV] of 16%).

**C**, Anteroposterior flush digital subtraction portogram shows a 6-Fr vascular sheath (*arrowheads*) in a right portal vein branch and a 5-Fr flush catheter (*arrow*) in the main portal vein.

**D**, Postprocedure anteroposterior flush portogram shows occlusion of the portal vein branches to segments V through VIII (*white arrows*) with continued patency of the vein supplying the left liver (*black arrow*). An *arrowhead* shows subtracted contrast within a right portal vein branch overlying the left liver.

**E**, A later phase of portogram confirms persistent flow to the left liver (*arrows*).

**F**, Contrast-enhanced CT scan of the liver performed 1 month after RPVE shows hypertrophy of the left liver within the shaded area (FLR/TELV of 34%). The patient soon after underwent an uneventful right hepatectomy.



A 38-year-old man with metastatic colorectal cancer to the liver who had transhepatic ipsilateral right portal vein embolization with particles and coils extended to segment IV prior to extended right hepatectomy.

**A**, Contrast-enhanced computed tomography (CT) scan of the liver shows a small left lateral liver (functional liver remnant/total estimated liver volume ratio [FLR/TELV] of 16.9%; *shaded area*).

**B**, Anterior–posterior flush portogram from the ipsilateral approach shows a 6-Fr vascular sheath in a right portal vein branch and a 5-Fr flush catheter (*arrow*) in the main portal vein.

**C**, Postprocedure portogram shows complete occlusion, with particles and coils, of the portal vein branches to segment IV (*arrowheads*) and the right liver (*arrows*) with continued patency of the veins supplying the left lateral liver.

**D**, A later phase of portogram confirms persistent flow to the left liver (*arrows*).

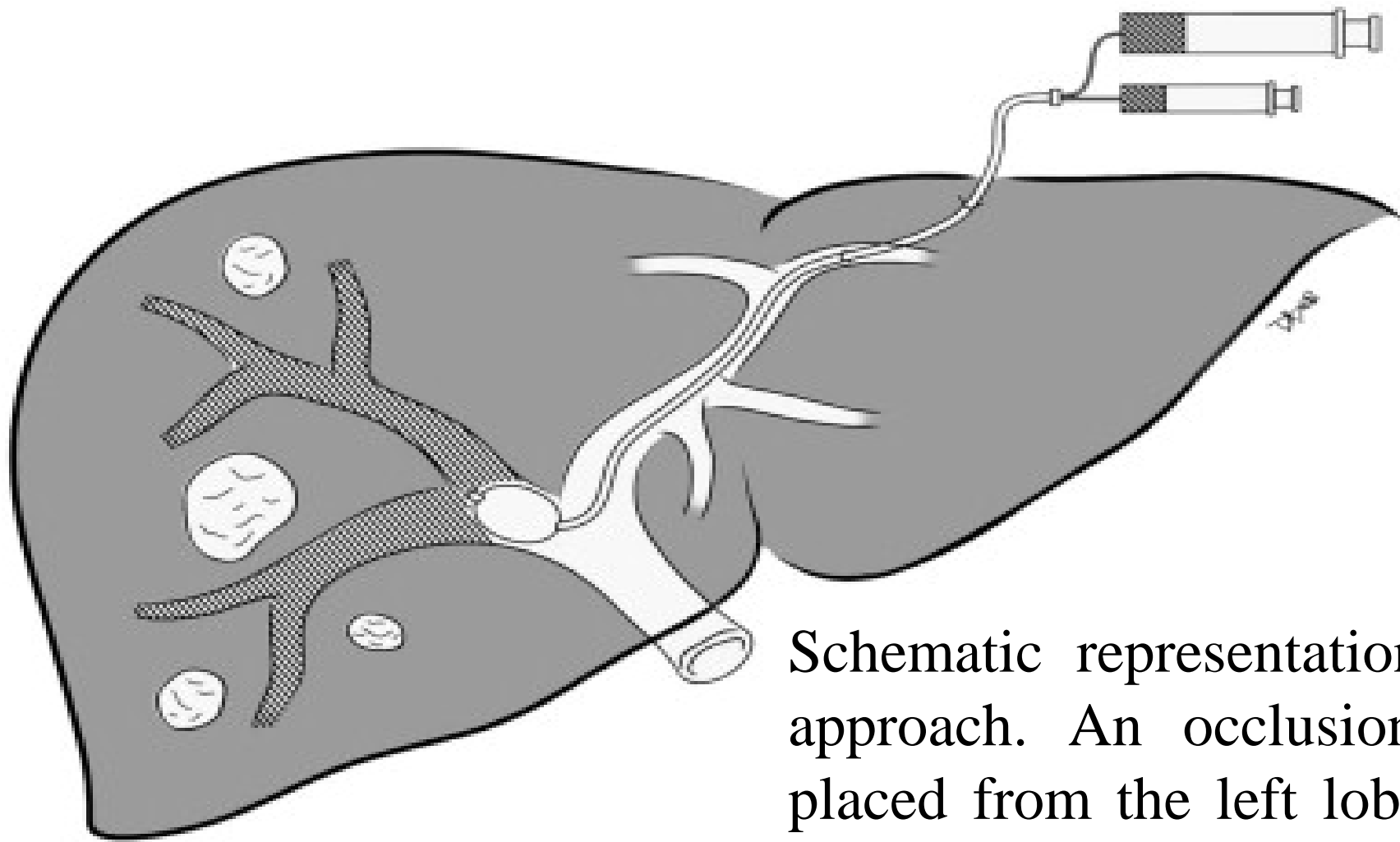
**E**, Contrast-enhanced CT scan performed 4 weeks after portal vein embolization shows hypertrophy of the left lateral liver (FLR/TELV is now 27.2%, a degree of hypertrophy of 10.3%) with rounded margins (*shaded area*). A coil within segment IV (*arrowhead*) and coils within the right liver are seen.

**F**, Contrast-enhanced CT scan of the liver performed after successful extended right hepatectomy shows hypertrophy of the liver remnant.

# Contralateral Approach

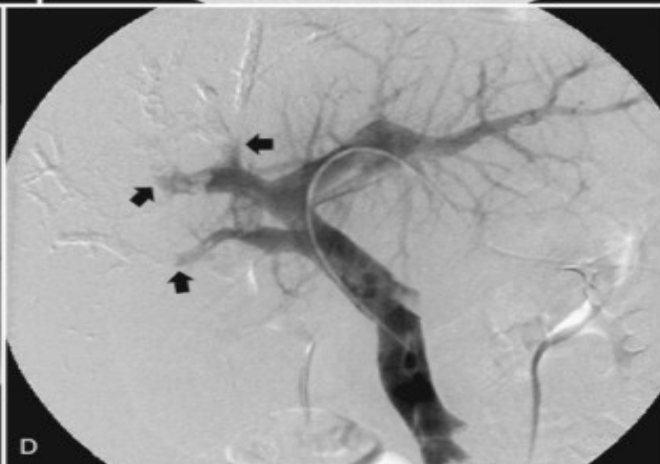
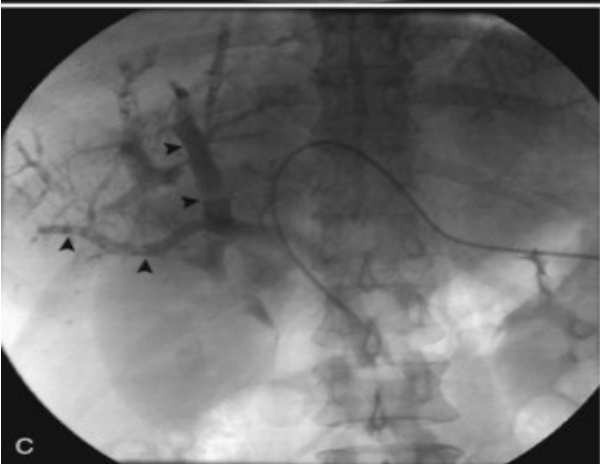
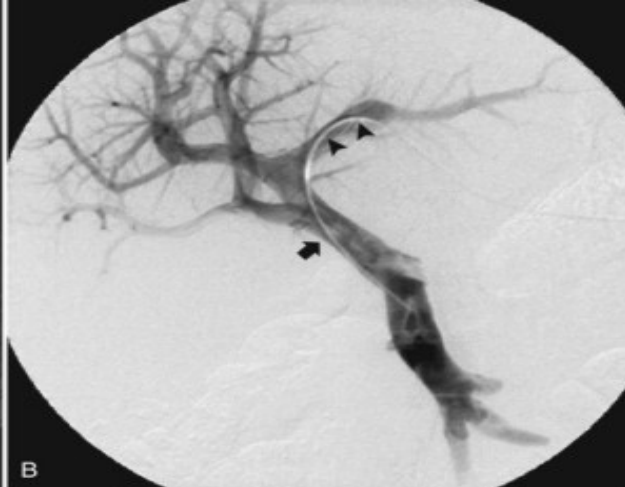
- Because access is gained through the FLR, great care is taken to limit the number of punctures, and as with the ipsilateral approach, the most peripheral branch possible is targeted to avoid damage to the central structures. introducer sheath
- A standard 5-Fr polyethylene catheter is inserted over a guidewire and placed with its distal tip within the main portal trunk to allow for flush portography.
- Depending on the specific targeted portal veins, embolization is carried out using either standard angiographic or balloon occlusion catheters.
- A short catheter between 25 and 30 cm in length is commonly used, as it is easier to handle and provides a smaller “dead space,” which is especially important when using liquid embolics, such as n-butyl cyanoacrylate (NBCA) for embolization.

- Challenging -segment IV embolization
- From the Rex recess.
- Segment III is often easier to access than segment II
- After achieving complete occlusion of the targeted portal branches, the 5-Fr catheter is removed.
- Because the catheter entry site traverses the FLR, embolic material is not used to seal the puncture tract



Schematic representation of the contralateral approach. An occlusion balloon catheter is placed from the left lobe into the right portal branch, with delivery of the embolic agent in the antegrade direction.





Technique of transhepatic contralateral right portal vein embolization using n-butyl cyanoacrylate mixed with ethiodized oil.

**A**, Ultrasound view of needle puncture of a segment III portal branch (*arrowheads*).

**B**, Anteroposterior flush portogram shows a 5-Fr flush catheter within the main portal vein (*arrow*).

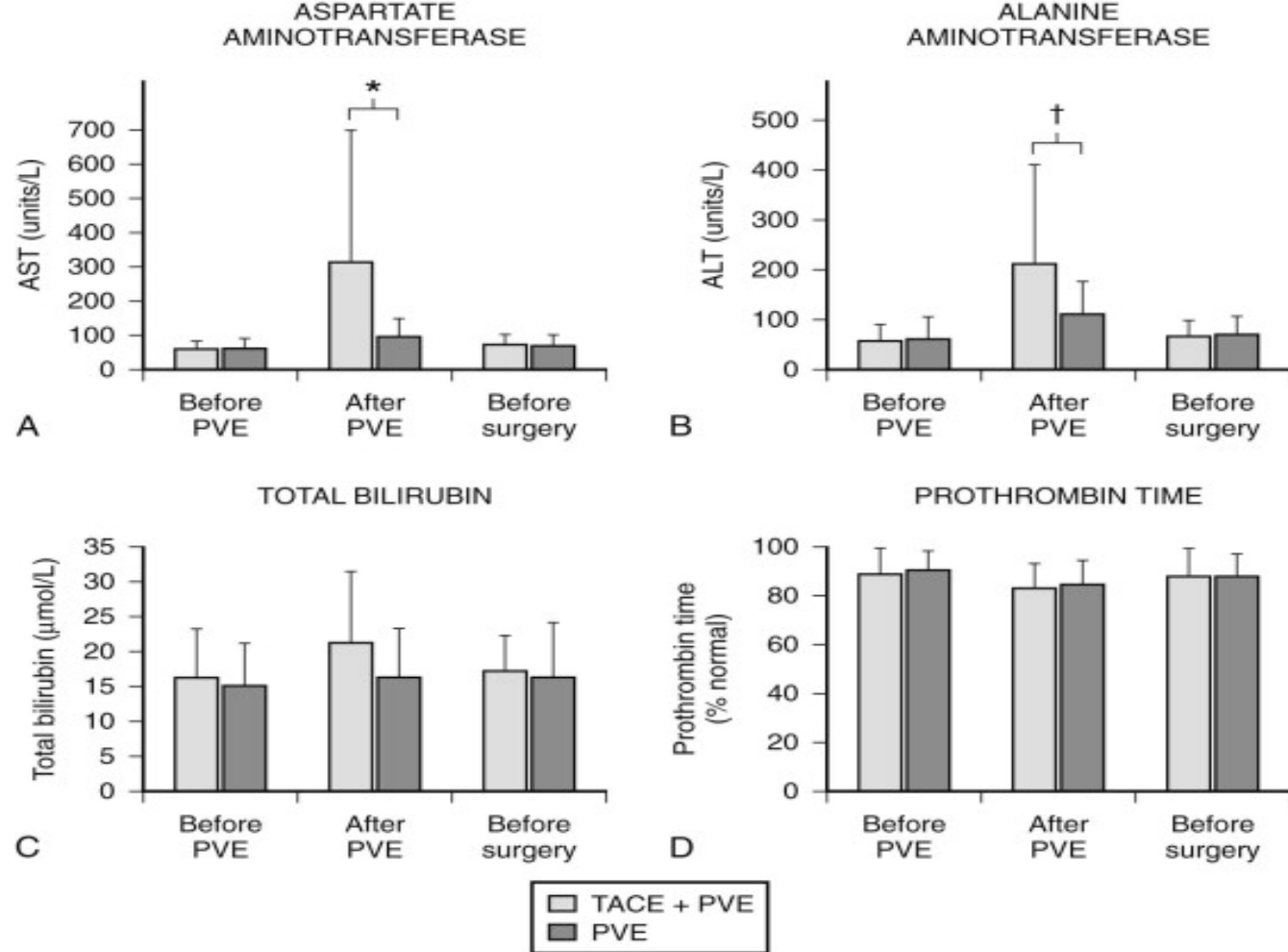
**C**, Single image obtained during fluoroscopy shows cast of embolic material within right portal vein branches (*arrowheads*).

**D**, Final portogram shows occlusion of the portal vein branches (*arrows*) to segments V through VIII with continued patency of the veins supplying the left liver.



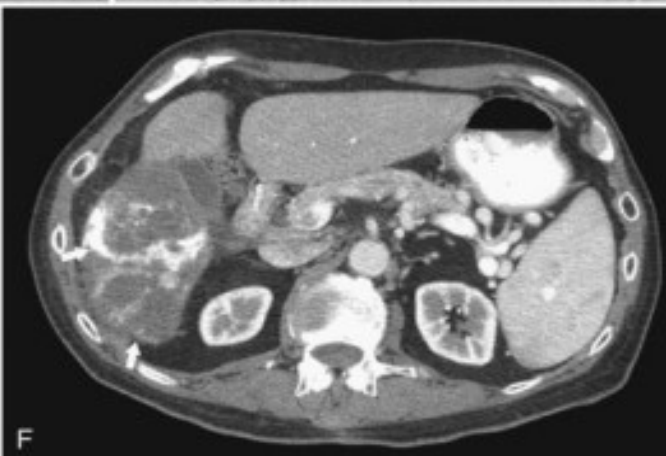
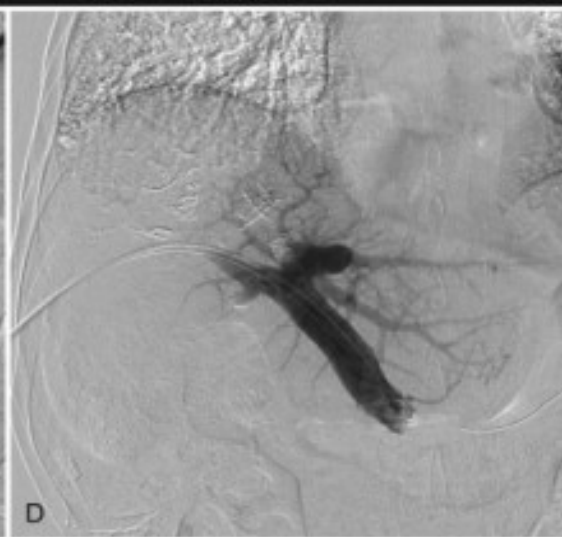
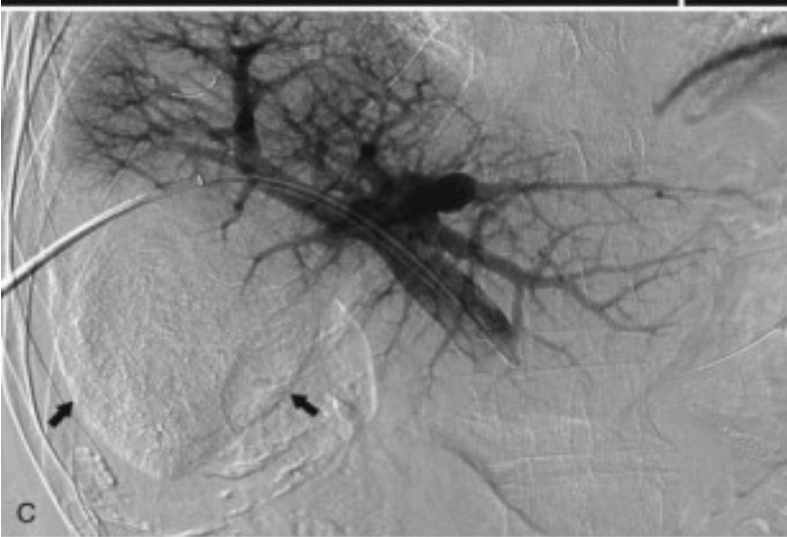
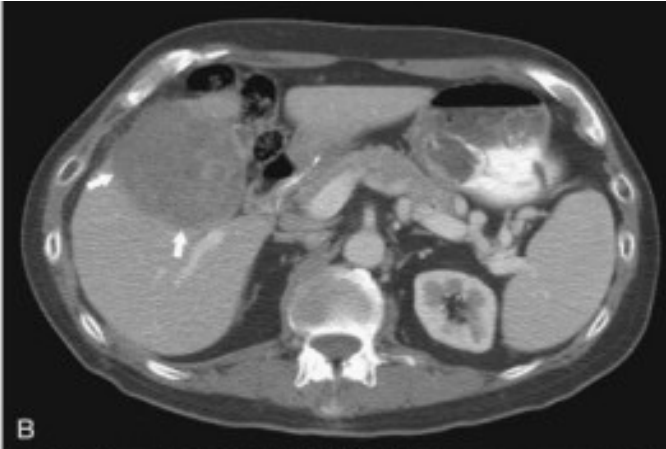
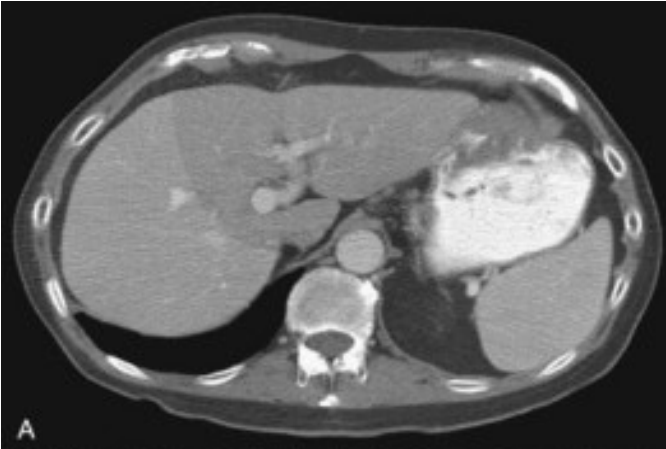
- Contralateral approach -technically easier and does not have to contend with awkward angles.
- Catheter pointed toward the direction of flow.
- Image quality of the final postembolization portography is similar
- Injury to the FLR parenchyma and/or to the left portal vein ([Madoff et al, 2005a](#)).

- Portal Vein Embolization with Transjugular Access
- Portal Vein Embolization Followed by Bland Transarterial Embolization
- Sequential TACE followed by PVE



Results of liver function tests before portal vein embolization (*PVE*), after *PVE*, and before surgery for patients who had transarterial chemoembolization (*TACE*) plus *PVE* and *PVE* alone. Values are mean (standard deviation). Peak values of (**A**) aspartate aminotransferase, (**B**) alanine aminotransferase, and (**C**) total bilirubin and (**D**) minimum value of prothrombin time were assessed before *PVE*, within 5 days after *PVE*, and within 5 days before surgery

- Br J Surg. 2006 Sep;93(9):1091-8. Sequential arterial and portal vein embolizations before right hepatectomy in patients with cirrhosis and hepatocellular carcinoma.
- Ogata et al
- Department of Hepato-Pancreato-Biliary Surgery, Hospital Beaujon-University Paris VII, Clichy, France.
- **CONCLUSION:** Sequential TACE and PVE before operation increases the rate of hypertrophy of the FLR and leads to a high rate of complete tumour necrosis associated with longer recurrence-free survival



- 1) using TACE to prevent tumor progression during the interval between PVE and the planned hepatectomy, in view of the fact that most HCCs are hypervascular tumors fed exclusively by arterial blood flow and
- 2) enhancing the effect of PVE by first using TACE to embolize the possible arterioportal shunt, which is frequently found in cirrhotic livers and HCC tumors. Others also advocate this double preparation

# Complications

- Subcapsular hematoma, hemoperitoneum, hemobilia, arterioportal shunts, arteriovenous fistula, pseudoaneurysm, portal vein thrombosis, transient liver failure, pneumothorax, and sepsis
- Given the potential for injury to the FLR when using the contralateral approach, the ipsilateral approach should be tried first.

Complication	Number
<b>Minor</b>	
Abdominal discomfort or pain	209
Fever	250
Nausea or vomiting	26
Ileus	9
Overflow of embolization materials	2
Coil displacement	1
<b>Major</b>	
Liver abscess	3
Cholangitis	2
Main or left portal vein thrombosis	2
Subcapsular hematoma	2
Portal hypertension	1
Septic necrosis from hepatic artery injury	1



*Thank you!*