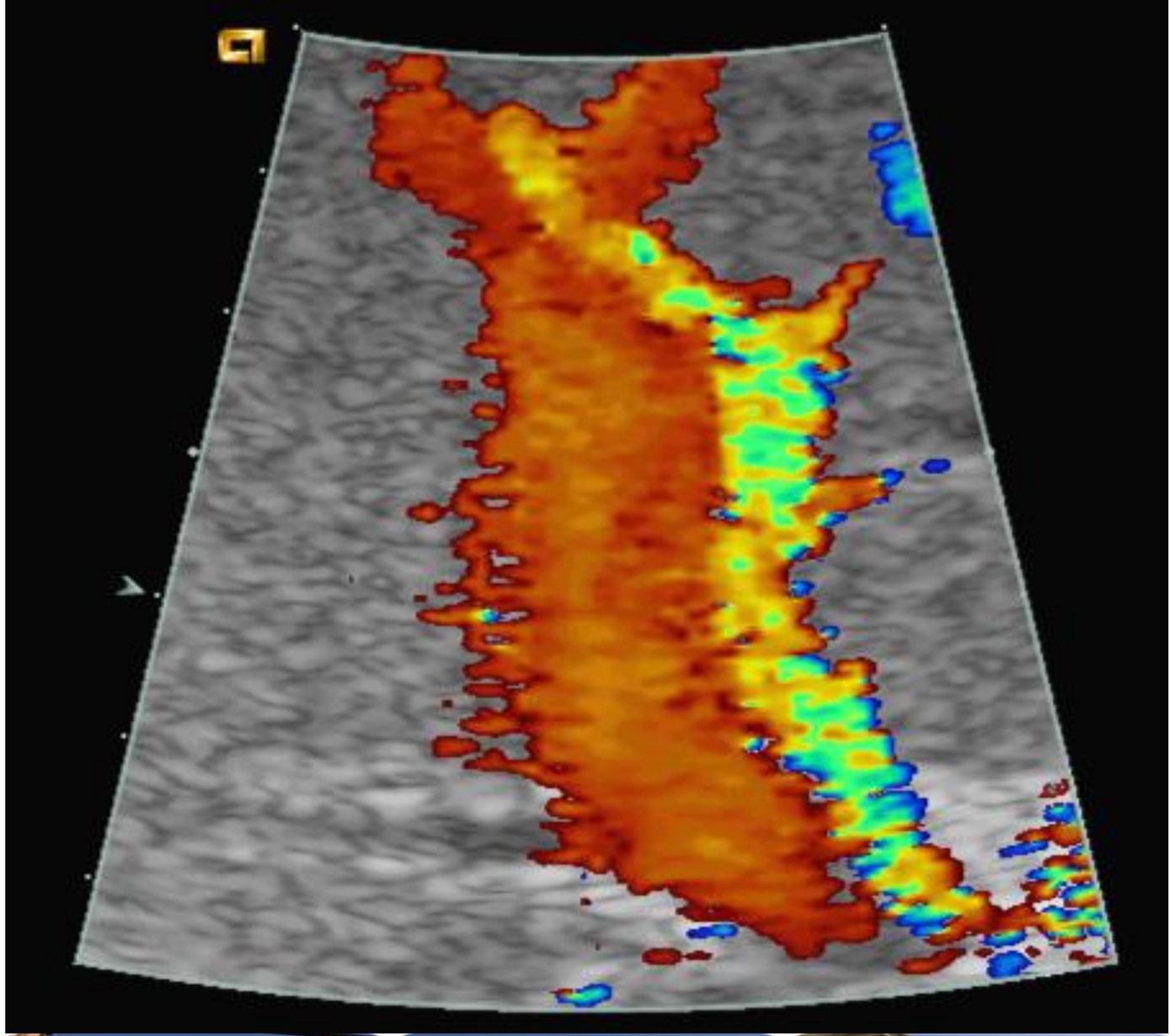
BMUS

Contrast Enhanced Ultrasound (CEUS)

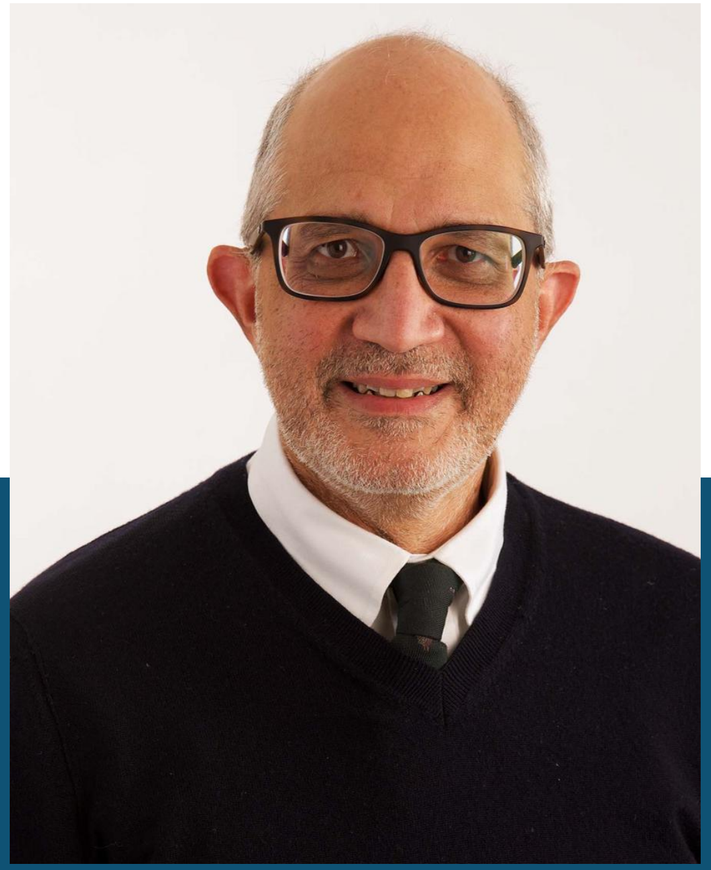
Liver Transplant Assessment

Professor Paul S. Sidhu



King's

Professor Paul S. Sidhu



Professor of Imaging Sciences
King's College London

BSc MBBS MRCP FRCR FAIUM FCRISE DTM&H

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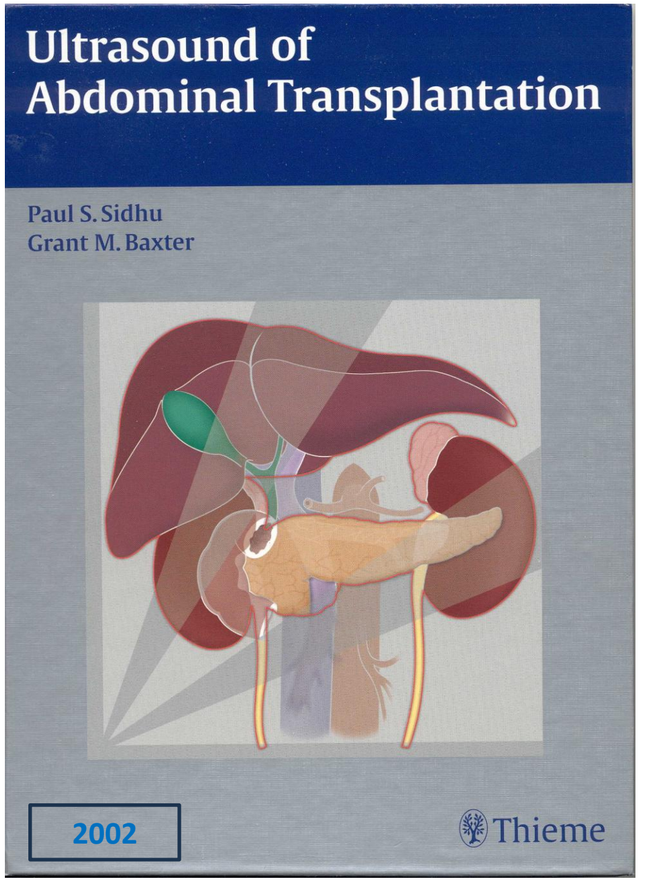
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation:

Lecture Aims

1. Pre-assessing the liver transplant candidate
   - Portal vein flow
   - Incidental focal liver lesions
2. Background to the surgical procedures
3. Conventional B-mode and colour Doppler ultrasound
4. When and where to add CEUS?
5. Advantages and limitations of ultrasound and CEUS
6. What can go wrong and where?
   - Vascular – arterial and venous
   - Biliary – obstruction and sepsis
   - General surgical complications
   - Post-transplant lymphoproliferative disorders



Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

Eur. Radiol. 10, 1114–1126 (2000) © Springer-Verlag 2000

European Radiology

Pictorial review

Clinical use of Levovist, an ultrasound contrast agent, in the imaging of liver transplantation: assessment of the pre- and post-transplant patient

P.S. Sidhu, M.M. Marshall, S.M. Ryan, S.M. Ellis

Department of Diagnostic Radiology, King's College Hospital, Denmark Hill, London SE5 9RS, UK

Received: 15 April 1999; Revised: 21 June 1999; Accepted: 22 June 1999

2000

Clinical Radiology (2001) **56**: 579–587
doi:10.1053/crad.2001.0650, available online at http://www.idealibrary.com on IDEAL®

Hepatic Artery Pseudoaneurysms Following Liver Transplantation: Incidence, Presenting Features and Management

MICHELE M. MARSHALL*, PAOLO MUIESAN†, PARTHI SRINIVASAN†, PAULINE A. KANE†, MOHAMED RELA†, NIGEL D. HEATON†, JOHN B. KARANI*, PAUL S. SIDHU*

**Department of Radiology, King's College Hospital, London, U.K. and †Department of Liver Transplant Surgical Service, King's College Hospital, London, U.K.*

2001

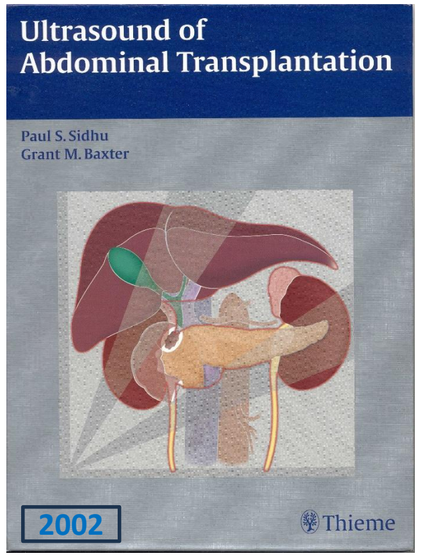
Clinical Radiology (2002) **57**: 377–383
doi:10.1053/crad.2001.0839, available online at http://www.idealibrary.com on IDEAL®

Assessment of Portal Venous System Patency in the Liver Transplant Candidate: A Prospective Study Comparing Ultrasound, Microbubble-Enhanced Colour Doppler Ultrasound, with Arteriography and Surgery

M. M. MARSHALL*, R. C. BEESE*, P. MUIESAN†, D. I. SARMA*, J. O'GRADY‡, P. S. SIDHU*

**Department of Radiology, King's College Hospital, London, U.K., †Liver Transplant Surgical Service, King's College Hospital, London, U.K. and ‡Institute of Liver Studies, King's College Hospital, London, U.K.*

2002



Clinical Radiology (2003) **58**: 672–680
doi:10.1016/S0009-9260(03)00127-2, available online at www.sciencedirect.com

Pictorial Review

Ultrasound of Non-vascular Complications in the Post Liver Transplant Patient

A. S. SHAW, S. M. RYAN, R. C. BEESE, P. S. SIDHU

Department of Radiology, King's College Hospital, London, UK

Clinical Radiology (2002) **57**: 789–799
doi:10.1053/crad.2002.0969, available online at http://www.idealibrary.com on IDEAL®

Hepatic Artery Stenosis Following Liver Transplantation: Significance of the Tardus Parvus Waveform and the Role of Microbubble Contrast Media in the Detection of a Focal Stenosis

P. S. SIDHU, S. M. ELLIS, J. B. KARANI, S. M. RYAN

Department of Diagnostic Radiology, King's College Hospital, London, UK

2002

Eur Radiol Suppl (2004) 14[Suppl 8]:P96–P103
DOI 10.1007/s10406-004-0082-5

Jonathan D. Berry
Paul S. Sidhu

Microbubble contrast-enhanced ultrasound in liver transplantation

2004

Eur Radiol (2004) 14:21–30
DOI 10.1007/s00330-003-1981-x

HEPATOBILIARY–PANCREAS

Paul S. Sidhu
Ashley S. Shaw
Stephen M. Ellis
John B. Karani
Suzanne M. Ryan

Microbubble ultrasound contrast in the assessment of hepatic artery patency following liver transplantation: role in reducing frequency of hepatic artery arteriography

2004

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

PRE TRANSPLANT ASSESSMENT

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: *Pre-transplant*

Clinical Radiology (2002) **57**: 377–383
doi:10.1053/crad.2001.0839, available online at http://www.idealibrary.com on IDEAL®

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2002

Portal vein patency

Thrombosis – bland/malignant

Low flow – 'to-and-fro flow'

DOI: 10.1097/HEP.0000000000000558

ORIGINAL ARTICLE

AASLD

Contrast-enhanced ultrasound liver imaging reporting and data system: clinical validation in a prospective multinational study in North America and Europe

Andrej Lyshchik[1] | Corinne E. Wessner[1] | Kristen Bradigan[1] | John R. Eisenbrey[1] | Flemming Forsberg[1] | Misung Yi[2] | Scott W. Keith[2,3] | Yuko Kono[4] | Stephanie R. Wilson[5] | Alexandra Medellin[5] | Shuchi K. Rodgers[1,6] | Virginia Planz[7] | Aya Kamaya[8] | Lisa Finch[9] | David T. Fetzer[10] | Annalisa Berzigotti[11] | Paul S. Sidhu[12,13] | Fabio Piscaglia[14,15] | CEUS LI-RADS Trial Group

2024

Screening for HCC

New nodules –HCC or RGN

Avoid CT or MR imaging

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

Clinical Radiology (2002) **57**: 377–383
doi:10.1053/crad.2001.0839, available online at http://www.idealibrary.com on IDEAL®

Assessment of Portal Venous System Patency in the Liver Transplant Candidate: A Prospective Study Comparing Ultrasound, Microbubble-Enhanced Colour Doppler Ultrasound, with Arteriography and Surgery

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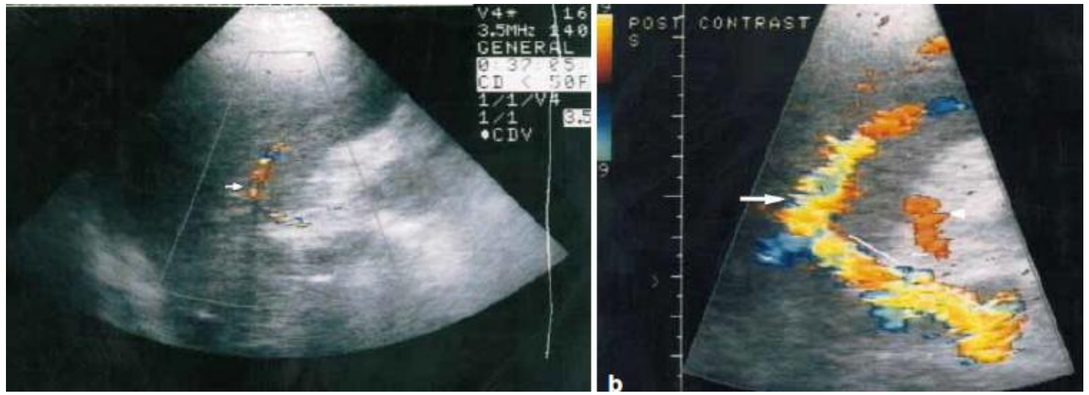
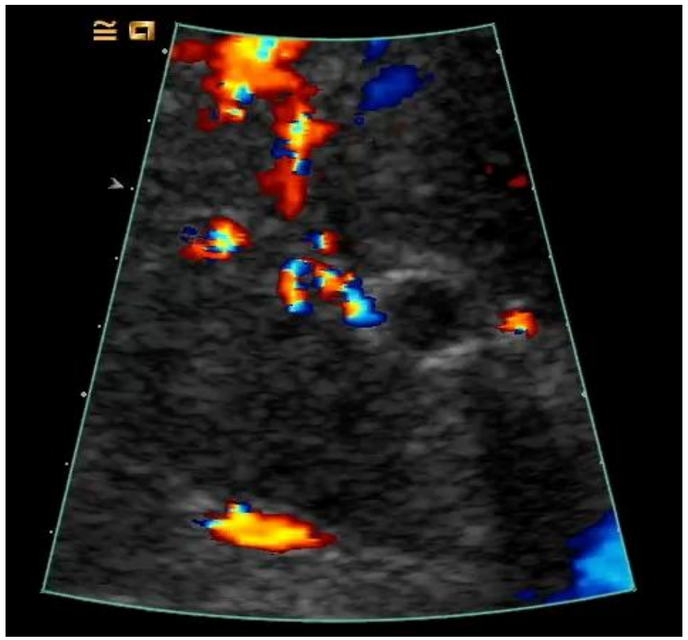
**Department of Radiology, King's College Hospital, London, U.K., †Liver Transplant Surgical Service, King's College Hospital, London, U.K. and ‡Institute of Liver Studies, King's College Hospital, London, U.K.*

Portal vein patency

Low flow – 'to-and-fro flow'





PV thrombosis is a relative contraindication to liver transplantation

10% incidence in cirrhosis

Low flow in portal hypertension decreases the sensitivity of all imaging techniques and increases the risk of thrombosis

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

European Radiology (2020) 30:2871–2880
https://doi.org/10.1007/s00330-019-06649-z

HEPATOBILIARY-PANCREAS

Portal vein patency

Contrast-
thrombo
review a

Jifan Chen[1] ·

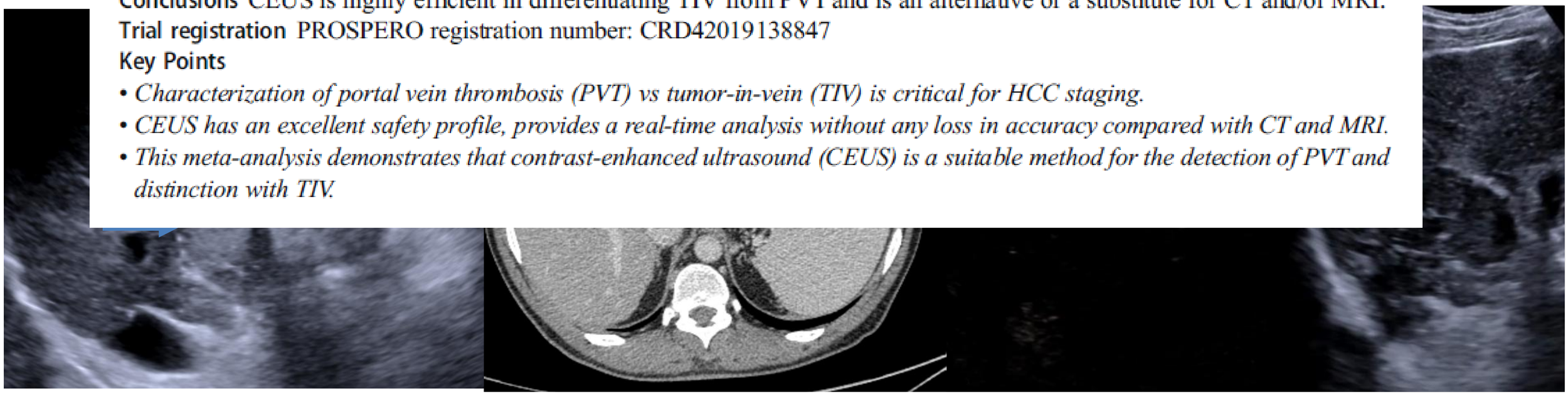
Results Seven studies including 425 participants were analyzed after screening 986 articles searched from databases. The pooled sensitivity and specificity of CEUS in diagnosing TIV were 0.94 (95%CI, 0.89–0.97) and 0.99 (95%CI, 0.80–1.00), respectively. The area under the curve (AUC) of SROC curve was 0.97 (95%CI, 0.95–0.98). The pooled sensitivity and AUC were consistent across all the subgroups of different subject numbers, country, study design, CEUS contrast agents, and diagnostic criteria.

Conclusions CEUS is highly efficient in differentiating TIV from PVT and is an alternative or a substitute for CT and/or MRI.

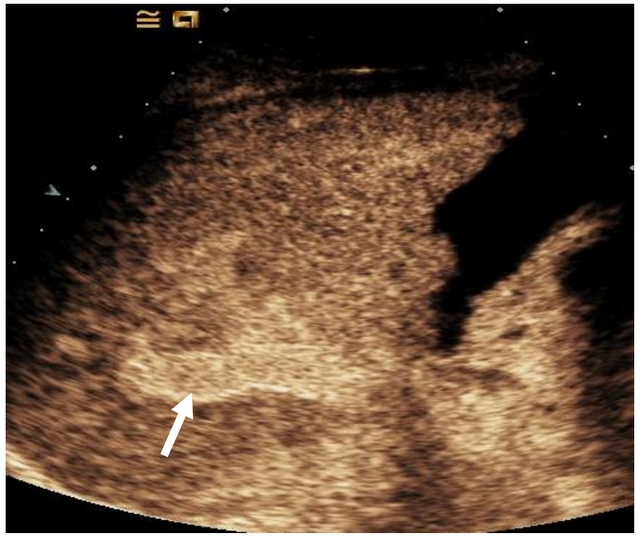
Trial registration PROSPERO registration number: CRD42019138847

Key Points

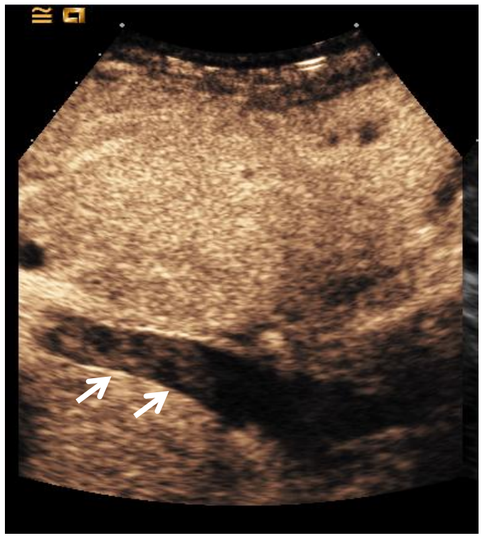
- *Characterization of portal vein thrombosis (PVT) vs tumor-in-vein (TIV) is critical for HCC staging.*
- *CEUS has an excellent safety profile, provides a real-time analysis without any loss in accuracy compared with CT and MRI.*
- *This meta-analysis demonstrates that contrast-enhanced ultrasound (CEUS) is a suitable method for the detection of PVT and distinction with TIV.*



Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation



Transjugular Intrahepatic Portosystemic Shunt (TIPS) patency



Abdominal Imaging

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Abdom Imaging (2012) 37:252–260
DOI: 10.1007/s00261-011-9763-4

Contrast-enhanced ultrasound: a new method for TIPS follow-up

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[2]Department of Medical Information and Research Evaluation, Hospices Civils, Lyon, France
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Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: *Pre-transplant*

DOI: 10.1097/HEP.0000000000000558

ORIGINAL ARTICLE

Contrast-enhanced ultrasound liver imaging reporting and data system: clinical validation in a prospective multinational study in North America and Europe

Andrej Lyshchik[1] | Corinne E. Wessner[1] | Kristen Bradigan[1] | John R. Eisenbrey[1] | Flemming Forsberg[1] | Misung Yi[2] | Scott W. Keith[2,3] | Yuko Kono[4] | Stephanie R. Wilson[5] | Alexandra Medellin[5] | Shuchi K. Rodgers[1,6] | Virginia Planz[7] | Aya Kamaya[8] | Lisa Finch[9] | David T. Fetzer[10] | Annalisa Berzigotti[11] | Paul S. Sidhu[12,13] | Fabio Piscaglia[14,15] | CEUS LI-RADS Trial Group

2024

Screening for HCC

New nodules –HCC or RGN

Avoid CT or MR imaging

Radiology

ORIGINAL RESEARCH · GASTROINTESTINAL IMAGING

Contrast-enhanced US of High-Risk Indeterminate Focal Liver Observations Categorized as LR-4 or LR-M at CT/MRI

Andrej Lyshchik, MD, PhD • Cristina Kuon Yeng Escalante, MD • Tania Siu Xiao, MD • Fabio Piscaglia, MD, PhD • Yuko Kono, MD, PhD • Alexandra Medellin-Kowalewski, MD • Shuchi K. Rodgers, MD • Virginia Planz, MD • Aya Kamaya, MD • David T. Fetzer, MD • Annalisa Berzigotti, MD • Iuliana-Pompilia Radu, MD • Paul S. Sidhu, MD • Corinne E. Wessner, MS, RDMS • Kristen Bradigan, RN • John R. Eisenbrey, PhD • Flemming Forsberg, PhD • Stephanie R. Wilson, MD • for the CEUS LI-RADS Trial Group[1]

From the Department of Radiology, Thomas Jefferson University Hospital, 132 S 10th St, 763G Main Bldg, Philadelphia, PA 19107 (A.L., C.K.Y.E., T.S.X., S.K.R., C.E.W., K.B., J.R.E., F.F.); Division of Internal Medicine, Hepatobiliary and Immunoallergic Diseases, IRCCS Azienda Ospedaliero-Universitaria di Bologna, Bologna, Italy (F.P.); Department of Medical and Surgical Sciences, University of Bologna, Bologna, Italy (F.P.); University of California San Diego, San Diego, Calif (Y.K.); University of Calgary, Calgary, Canada (A.M.K., S.R.W.); Einstein Medical Center, Philadelphia, Pa (S.K.R.); Vanderbilt University, Nashville, Tenn (V.P.); Stanford University, Stanford, Calif (A.K.); UT Southwestern Medical Center, Dallas, Tex (D.T.F.); Department of Visceral Surgery and Medicine, Bern University Hospital, University of Bern, Bern, Switzerland (A.B., I.P.R.); Department of Imaging Sciences, School of Biomedical Engineering and Imaging Sciences, Faculty of Life Sciences and Medicine, King's College London, London, United Kingdom (P.S.S.); and Department of Radiology, King's College Hospital, London, United Kingdom (P.S.S.). Received April 2, 2024; revision requested June 3; revision received November 21; accepted November 27. **Address correspondence to**

2025

Screening for HCC

Indeterminate Lesions

Benign Lesions

King's

BMUS

Ultrasound in Early Detection of Hepatocellular Carcinoma

American College of Radiology
Contrast Enhanced Ultrasound Liver Imaging Reporting and Data System (CEUS LI-RADS) for the diagnosis of Hepatocellular Carcinoma: a pictorial essay

American College of Radiology
Contrast Enhanced Ultrasound Liver Imaging Reporting and Data System (CEUS LI-RADS) für die Diagnose von Hepatozellulären Karzinomen: ein Bild-Essay

Authors
Fabio Piscaglia[1], Stephanie R. Wilson[2], Andrej Lyshchik[3], David Cosgrove[4], Christoph F. Dietrich[5], Hyun-Jung Jang[6], Tae Kyoung Kim[6], Veronica Salvatore[1], Juergen Karl Willmann[7], Claude B. Sirlin[8], Yuko Kono[9]

Abdominal Radiology

Published online: 18 November 2017

Abdom Radiol (2018) 43:861–879
https://doi.org/10.1007/s00261-017-1392-0

Contrast-enhanced ultrasound of the liver: technical and lexicon recommendations from the ACR CEUS LI-RADS working group

Andrej Lyshchik,[1] Yuko Kono,[2] Christoph F. Dietrich,[3] Hyun-Jung Jang,[4] Tae Kyoung Kim,[4] Fabio Piscaglia,[5] Alexander Vezeridis,[6] Juergen K. Willmann,[7] Stephanie R. Wilson[8]

CEUS Diagnostic Table

Arterial phase hyperenhancement (APHE)	No APHE		APHE (not rim [b], not peripheral discontinuous globular [c])	
Nodule size (mm)	< 20	≥ 20	< 10	≥ 10
No washout of any type	CEUS LR-3	CEUS LR-3	CEUS LR-3	CEUS LR-4
Late and mild washout	CEUS LR-3	CEUS LR-4	CEUS LR-4	CEUS LR-5

a. CEUS LR-M criteria – any of following:
- rim APHE **OR**
- early (< 60 s) washout **OR**
- marked washout

b. rim APHE indicates CEUS LR-M
c. peripheral discontinuous globular indicates hemangioma (CEUS LR-1)

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Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

DOI: 10.1097/HEP.0000000000000558

ORIGINAL ARTICLE

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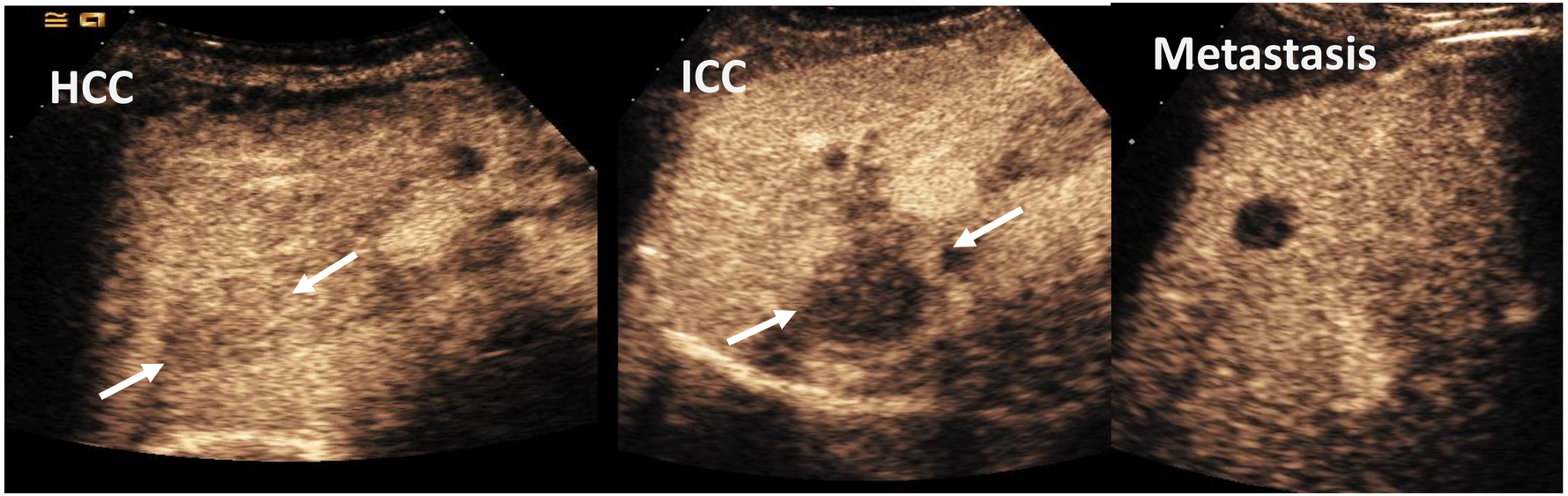
2024

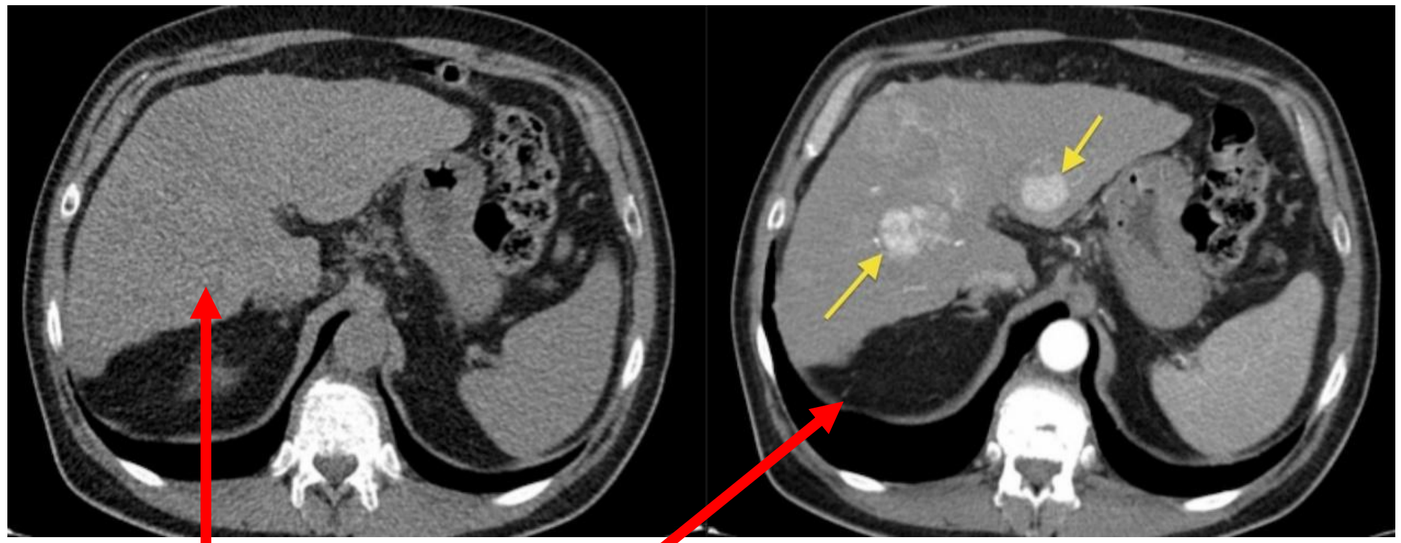
Screening for HCC

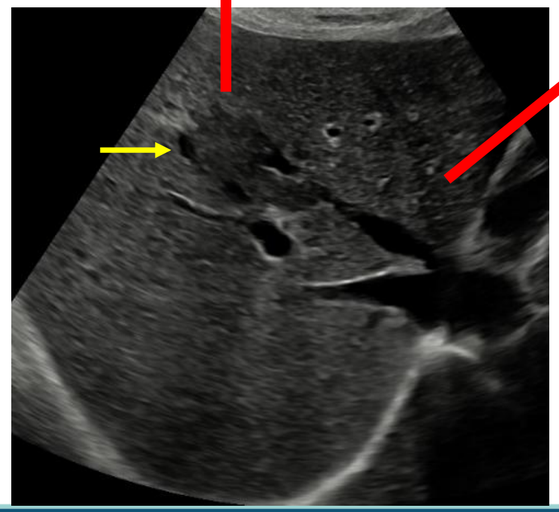
New nodules –HCC or RGN

Avoid CT or MR imaging



Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: *Pre-transplant*

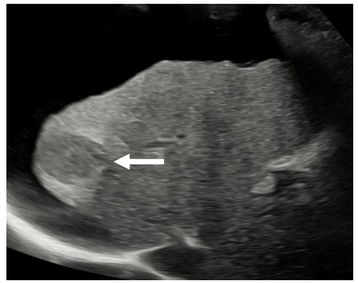




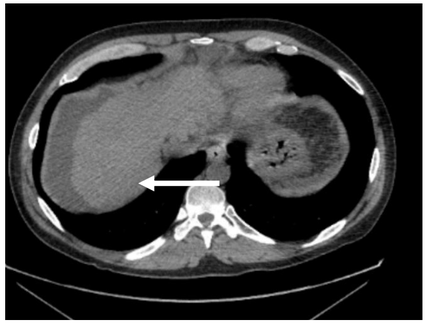
Would you 'assess' and 'report' a CT examination of the liver without contrast?

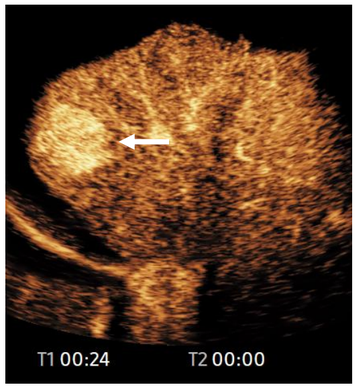
Why do you assess and report on an image produced by someone else as a snapshot in time when you can observe the changes dynamically yourself?

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

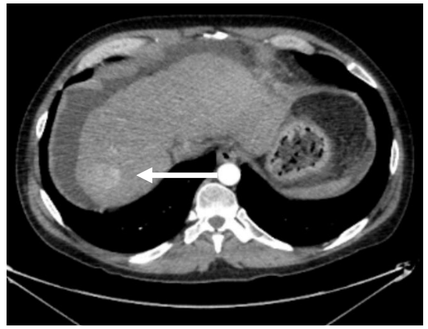


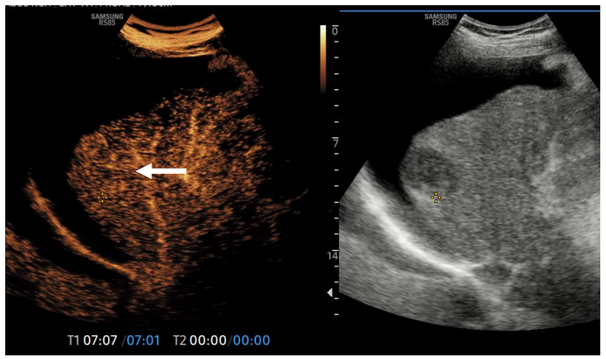
Baseline pre-contrast



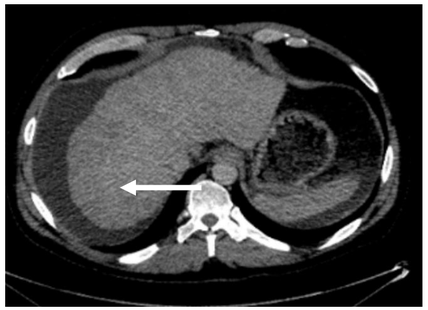


Arterial Phase





Venous Phase



- ***AASLD guidelines recommend US surveillance for HCC and diagnosis with CT/MIRI***
- ***2017 AASLD guidelines acknowledge but does not recommend CEUS for diagnosis of HCC***
- ***EASL and APASL recommends CEUS in the diagnosis of HCC***

Heimbach J, Kulik LM, Finn R et all. AASLD guidelines for the treatment of hepatocellular carcinoma. Hepatology https://doi.org/10.1002/hep.29086

Ultrasound in Early Detection of Hepatocellular Carcinoma

DOI: 10.1097/HEP.0000000000000558

ORIGINAL ARTICLE

Contrast-enhanced ultrasound liver imaging reporting and data system: clinical validation in a prospective multinational study in North America and Europe

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2024

nonacademic centers in North America and Europe. Patients at risk for HCC with at least 1 liver observation not previously treated, identified on ultrasound (US), or multiphase CT or MRI performed as a part of standard clinical care were eligible for the study. All participants were examined with CEUS of the liver within 4 weeks of CT/MRI or tissue diagnosis to characterize up to 2 liver nodules per participant using ACR CEUS Liver Imaging Reporting and Data System. Definite HCC diagnosis on the initial CT/MRI, imaging follow-up, or histology for CT/MRI-indeterminate nodules were used as reference standards. A total of 545 nodules had confirmed reference standards in 480 patients, 73.8% were HCC, 5.5% were other malignancies, and 20.7% were nonmalignant. The specificity of CEUS LR-5 for HCC was 95.1% (95% CI 90.1%–97.7%), sensitivity 62.9% (95% CI 57.9%–67.7%), positive predictive value 97.3% (95% CI 94.5%–98.7%), and negative predictive value 47.7% (95% CI 41.7%–53.8%). In addition, benign CEUS characterization (LR-1 or LR-2) had 100% specificity and 100% positive predictive value for nonmalignant liver nodules.

Conclusions: CEUS Liver Imaging Reporting and Data System characterization provides an accurate categorization of liver nodules in participants at risk for HCC.

Ultrasound in Early Detection of Hepatocellular Carcinoma

Radiology

ORIGINAL RESEARCH • GASTROINTESTINAL IMAGING

Contrast-enhanced US of High-Risk Indeterminate Focal Liver Observations Categorized as LR-4 or LR-M at CT/MRI

Andrej Lyshchik, MD, PhD • Cristina Kuon Yeng Escalante, MD • Tania Siu Xiao, MD • Fabio Piscaglia, MD, PhD • Yuko Kono, MD, PhD • Alexandra Medellin-Kowalewski, MD • Shuchi K. Rodgers, MD • Virginia Planz, MD • Aya Kamaya, MD • David T. Fetzer, MD • Annalisa Berzigotti, MD • Iuliana-Pompilia Radu, MD • Paul S. Sidhu, MD • Corinne E. Wessner, MS, RDMS • Kristen Bradigan, RN • John R. Eisenbrey, PhD • Flemming Forsberg, PhD • Stephanie R. Wilson, MD • for the CEUS LI-RADS Trial Group[1]

Results: Included were 109 participants (mean age, 64.3 years ± 8.3 [SD]; 68.8% [75 of 109] male participants) with 113 observations (≥10 mm) categorized as CT/MRI LR-4 (53.1%; 60 of 113) or LR-M (46.9%; 53 of 113). CEUS resulted in management recommendation changes in 33.6% (95% CI: 25, 43; 38 of 113) of observations; among these, 95% (95% CI: 82, 99; 36 of 38) were correct. A total of 30.1% (34 of 113) of CT/MRI LR-4 and LR-M observations were categorized at CEUS as LI-RADS category LR-5 (definite HCC), making biopsy unnecessary; 94% (32 of 34) of these categorizations were correct. Of CT/MRI LR-4 observations, 7% (four of 60) were categorized as CEUS LR-M; subsequent biopsy confirmed non-HCC malignancy in all participants. Clinical impact of CEUS was more substantial for observations 20 mm or larger (n = 68); CEUS helped appropriately categorize both LR-5 and LR-M lesions as HCC and non-HCC malignancies, respectively, and resulted in management recommendation changes in 40% (27 of 68) of observations with 100% accuracy.

Conclusion: CEUS resolved some high-risk indeterminate liver observations (categorized as LR-4 and LR-M at CT or MRI), with particularly high clinical impact for observations measuring at least 20 mm.

BMUS

Ultrasound in Early Detection of Hepatocellular Carcinoma

NHS
National Institute for Health and Clinical Excellence

SonoVue (sulphur hexafluoride microbubbles) – contrast agent for contrast-enhanced ultrasound imaging of the liver

Issued: August 2012

NICE diagnostics guidance 5
www.nice.org.uk/dg5

NICE has accredited the process used by the Centre for Health Technology Evaluation at NICE to produce diagnostics guidance. Accreditation is valid from October 2011 to September 2017, and applies to guidance produced using the processes described in NICE's 'Diagnostics Assessment Programme manual' (published December 2011). More information on accreditation can be viewed at www.evidence.nhs.uk.

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1 Recommendations

1.1 Contrast-enhanced ultrasound with SonoVue is recommended for characterising incidentally detected focal liver lesions in adults in whom an unenhanced ultrasound scan is inconclusive. An unenhanced ultrasound scan in which a focal liver lesion is detected, but not characterised, is defined as inconclusive.

1.2 Contrast-enhanced ultrasound with SonoVue is recommended for investigating potential liver metastases in adults:

- if contrast-enhanced computed tomography (CT) is not clinically appropriate, is not accessible or is not acceptable to the person, **and**
- in whom an unenhanced ultrasound scan is unsatisfactory and contrast is needed for further diagnosis.

1.3 Contrast-enhanced ultrasound with SonoVue is recommended for characterising focal liver lesions in adults whose cirrhosis is being monitored:

- if contrast-enhanced magnetic resonance imaging (MRI) is not clinically appropriate, is not accessible or is not acceptable to the person, **and**
- when unenhanced ultrasound scan is inconclusive.

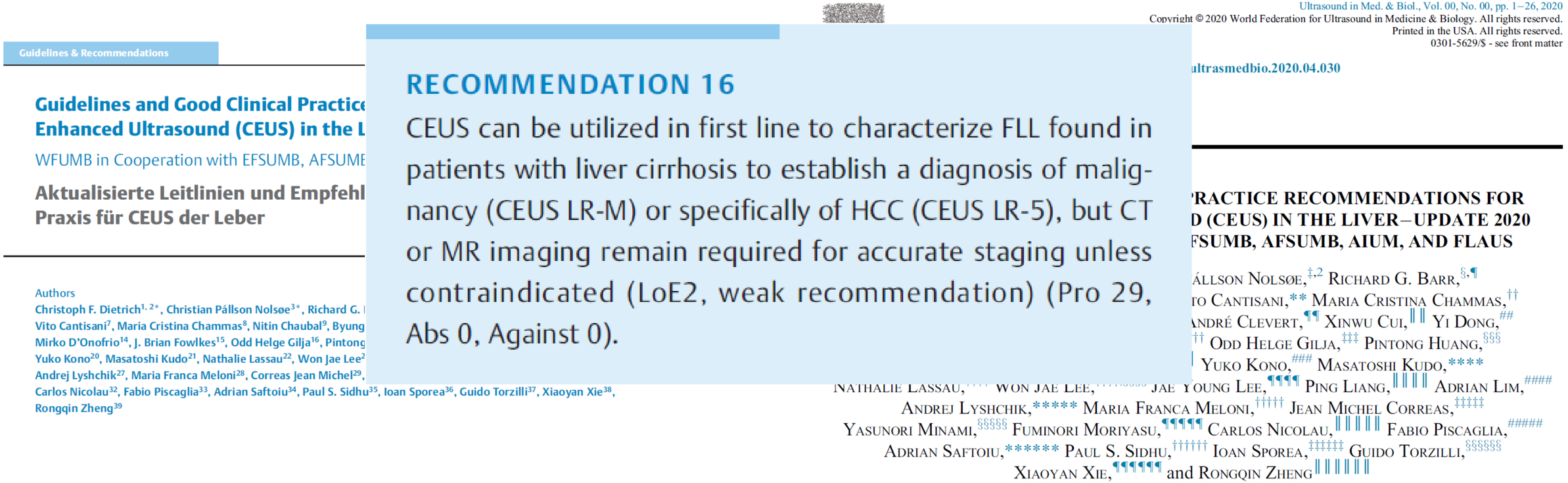
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

POST TRANSPLANT ASSESSMENT

Ultrasound in Early Detection of Hepatocellular Carcinoma

Addition of Contrast Enhanced Ultrasound:

EFSUMB GUIDELINES



Guidelines & Recommendations

Guidelines and Good Clinical Practice
Enhanced Ultrasound (CEUS) in the L

WFUMB in Cooperation with EFSUMB, AFSUME

Aktualisierte Leitlinien und Empfehl
Praxis für CEUS der Leber

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RECOMMENDATION 16

CEUS can be utilized in first line to characterize FLL found in patients with liver cirrhosis to establish a diagnosis of malignancy (CEUS LR-M) or specifically of HCC (CEUS LR-5), but CT or MR imaging remain required for accurate staging unless contraindicated (LoE2, weak recommendation) (Pro 29, Abs 0, Against 0).

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0301-5629/$ - see front matter

ultrasmedbio.2020.04.030

RACTICE RECOMMENDATIONS FOR
D (CEUS) IN THE LIVER–UPDATE 2020
FSUMB, AFSUMB, AIUM, AND FLAUS

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BMUS

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

Addition of Contrast Enhanced Ultrasound:

EFSUMB GUIDELINES

6. Liver Transplantation

6.4. Recommended Indications and Limitations

6.4.1. Indications

Before liver transplantation, CEUS is indicated to assess portal vein thrombosis and characterize focal liver lesions in cirrhosis. After liver transplantation, CEUS can be performed at the bedside or in the intensive care unit, avoiding most of the risks associated with CECT or angiography [10, 32, 63, 100, 154]. CEUS is indicated for:

- Confirmation of occlusion of the intrahepatic hepatic arteries, portal veins, hepatic veins or inferior vena cava (IVC) after an inconclusive Doppler evaluation of the liver vasculature. The extrahepatic arterial tree cannot always be studied in its entirety and complete patency cannot be confirmed with certainty without the addition of the finding of normal flow tracings from the intrahepatic arteries on Doppler US. In the late phase, the ultrasound can be switched to Doppler to exploit the remaining microbubbles to enhance the Doppler signals and investigate small vessels missed without contrast.
- Confirmation of the presence and assessment of the nature of fluid collections and, in case of recent hematomas, to search for active bleeding.
- Exclusion of perfusion defects when infarction is suspected.
- For monitoring the success of thrombolysis in the intensive care unit (ICU) after interventions for hepatic artery occlusion.

Guideline

Guidelines and Good Clinical Practice Recommendations for Contrast Enhanced Ultrasound (CEUS) in the Liver – Update 2012

A WFUMB-EFSUMB Initiative in Cooperation With Representatives of AFSUMB, AIUM, ASUM, FLAUS and ICUS

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Affiliations: Affiliation addresses are listed at the end of the article.

6.4.2. Limitations

- In the early postoperative period, wounds and surgical dressings or subcutaneous emphysema, may limit examination windows.
- In patients with split liver transplantation or after living donor liver transplantation, the examination may be more difficult because of the complex anatomy.
- Imaging the prehepatic portions of the hepatic artery and portal vein may be precluded by the surgical wound or intervening bowel gas.

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

Orthotopic Liver Transplantation

- hepatic artery ± iliac artery conduit
- portal vein
- IVC, end-to-end anastomoses
- common bile duct

‘Piggy-backing’ Transplantation

preservation of the donor IVC with end-to-side anastomoses with recipient IVC

‘Split’ Liver transplantation

Two recipients, donor liver is split into extended right lobe and left lateral segment

‘Segmental-reduction’ transplantation

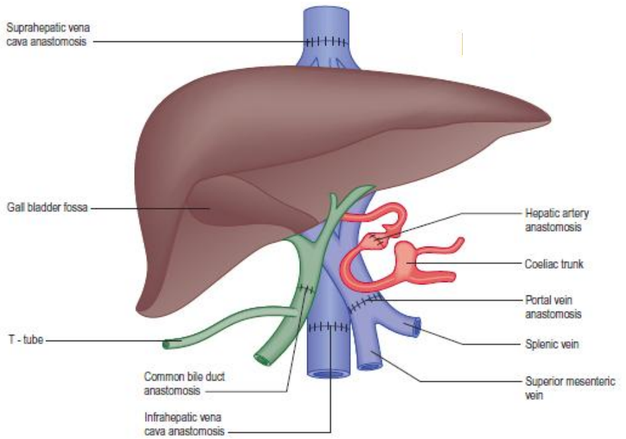
The donor liver is cut down to size to fit the patient

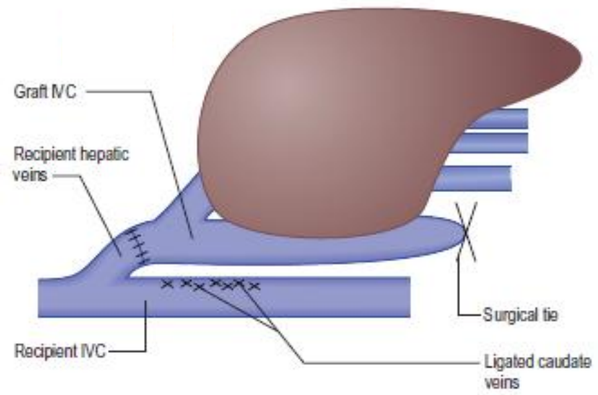
‘Auxiliary’ transplantation

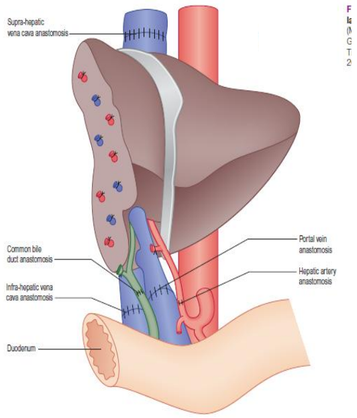
Part of the diseased liver is resected, and a reduced or split donor liver is positioned

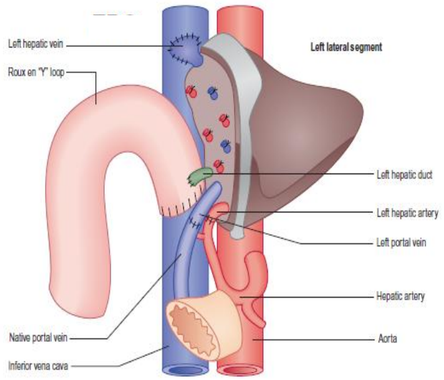
‘Living-related’ transplantation

Recipient liver replaced with a donor right lobe



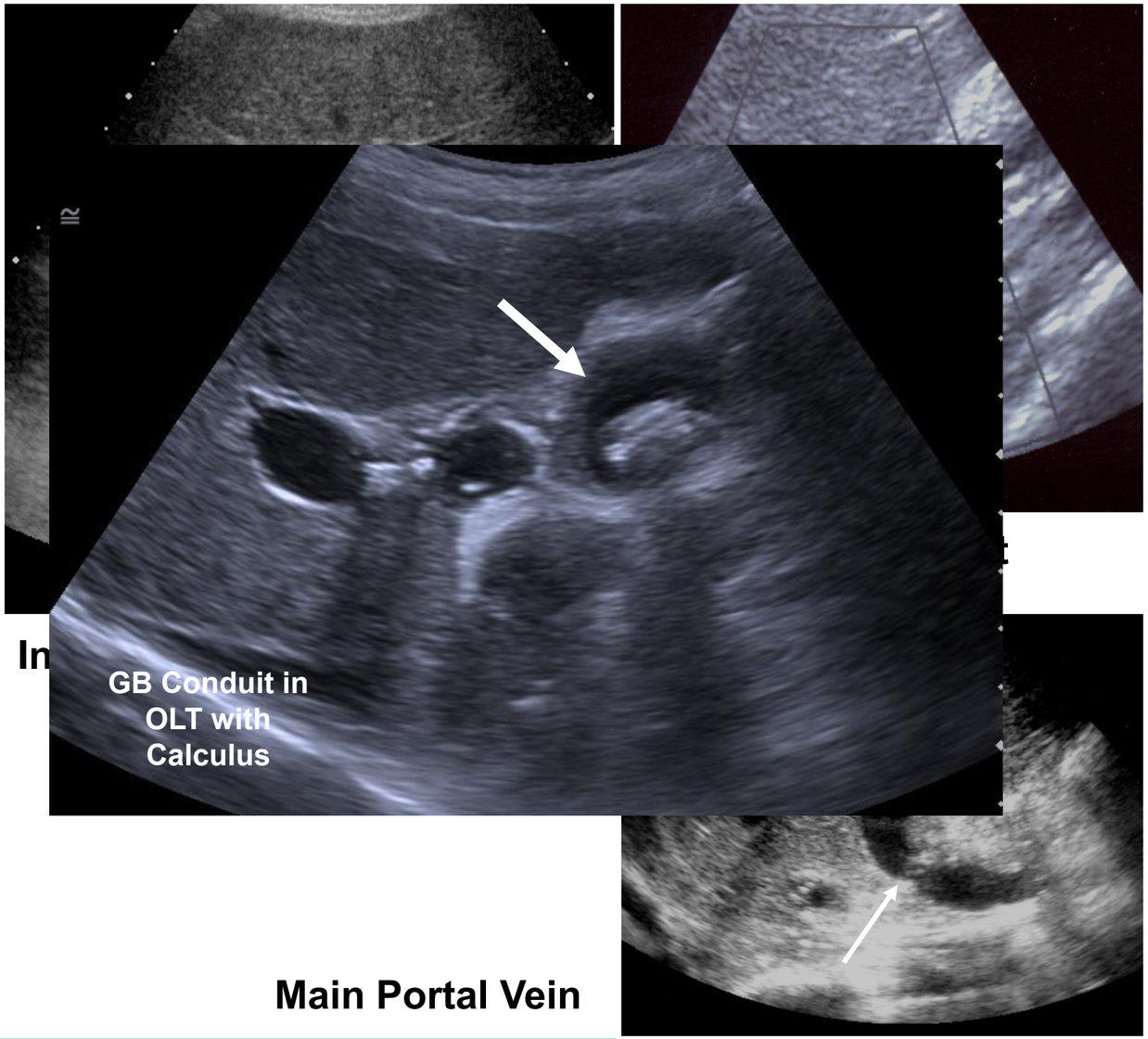


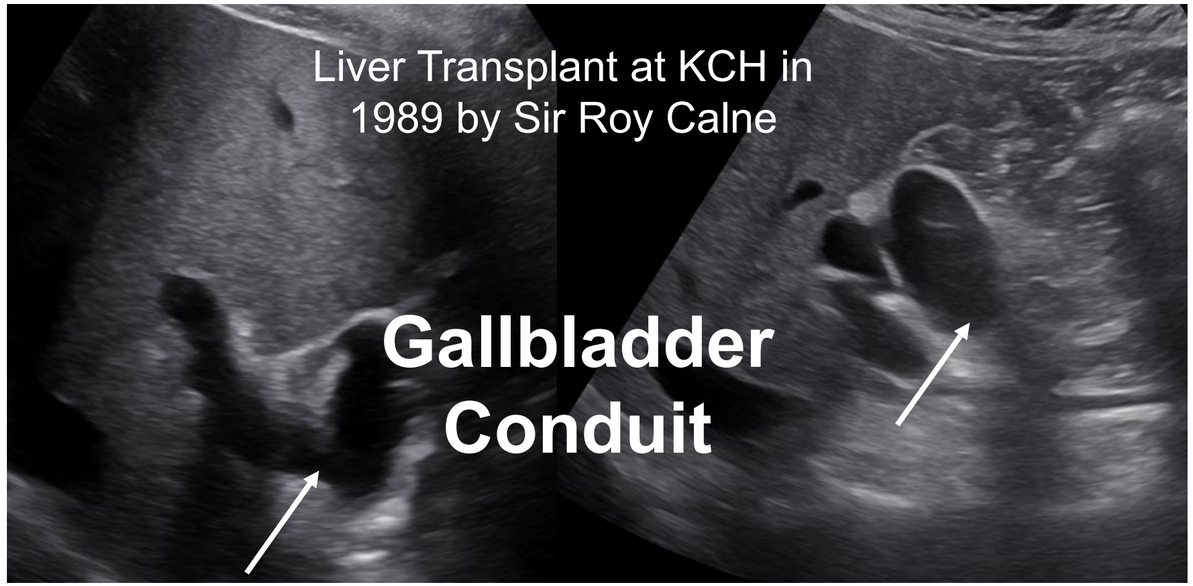




Bowles M, Rela M. Liver Transplantation: Surgical Techniques. In Ultrasound of Abdominal Transplantation. Ed. Sidhu PS, Baxter GM. Thieme New York 2002 Pp 69-75

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation





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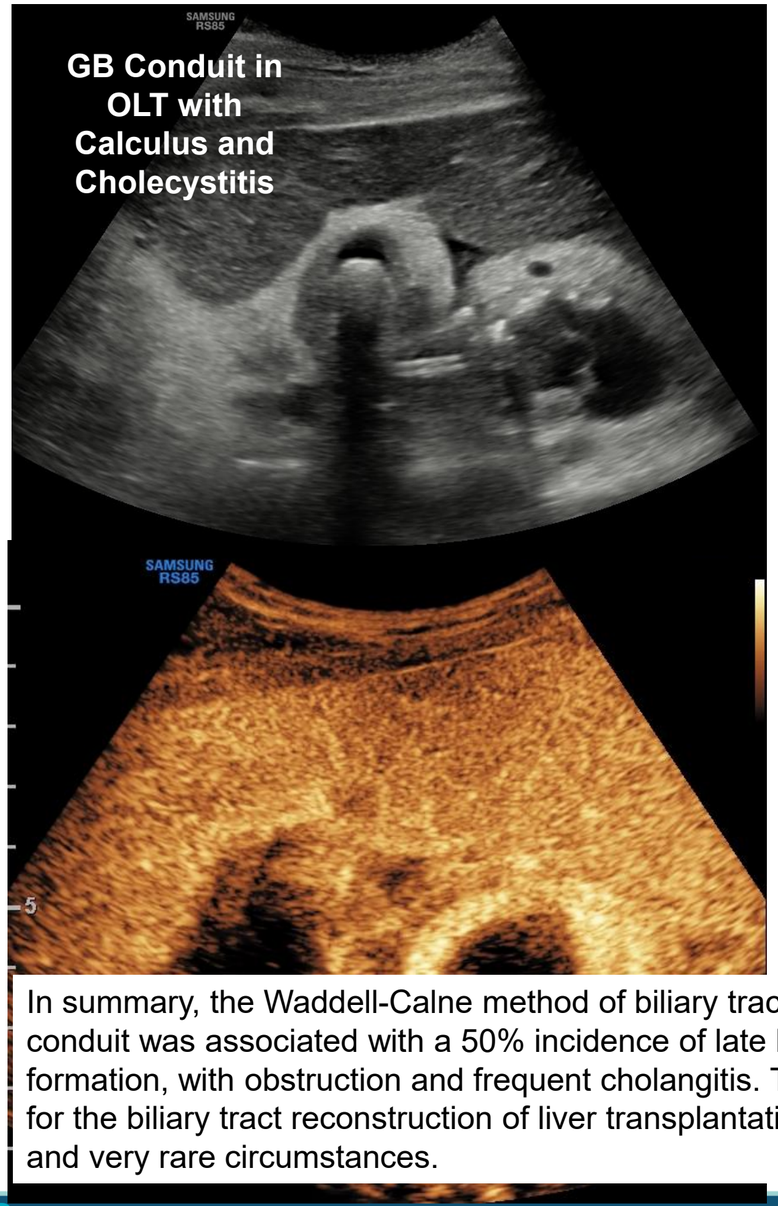
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation



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LATE COMPLICATIONS WITH GALLBLADDER CONDUIT BILIARY RECONSTRUCTION AFTER LIVER TRANSPLANTATION[1]

Glenn Halff, **Satoru Todo**, **Roberta Hall**, and **Thomas E. Starzl**[2]
The Department of Surgery, University of Pittsburgh Health Center, University of Pittsburgh, Pittsburgh, Pennsylvania

In summary, the Waddell-Calne method of biliary tract reconstruction using a gallbladder conduit was associated with a 50% incidence of late biliary tract sludge or stone formation, with obstruction and frequent cholangitis. This procedure should not be used for the biliary tract reconstruction of liver transplantation except under extremely specific and very rare circumstances.

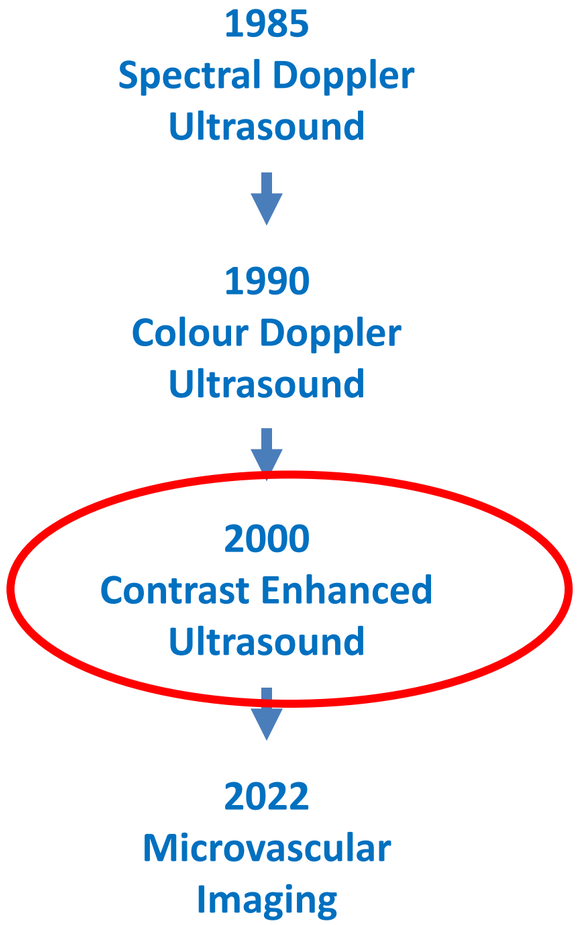
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Vascular

- Hepatic artery
- Hepatic veins and IVC
- Portal vein

Non-vascular

- Graft rejection
- Biliary tract
- Localised infection
- Miscellaneous



Vascular Complications

- Hepatic artery
  - Thrombosis
  - Stenosis
  - Pseudo aneurysm
- Portal Vein
  - Stenosis
  - Thrombosis
- Hepatic Veins and IVC
  - Stenosis

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

- Hepatic artery patency is crucial to viability of the transplant
- Hepatic artery thrombosis results in biliary ischemia as this is the sole blood supply to the intra-hepatic biliary epithelium
- Hepatic artery thrombosis requires urgent surgery; ischemia may be reversible
- Color Doppler US detection of patency is essential
- Hepatic artery not seen on ultrasound; *angiography* or CT
- Biliary necrosis requires re-transplantation

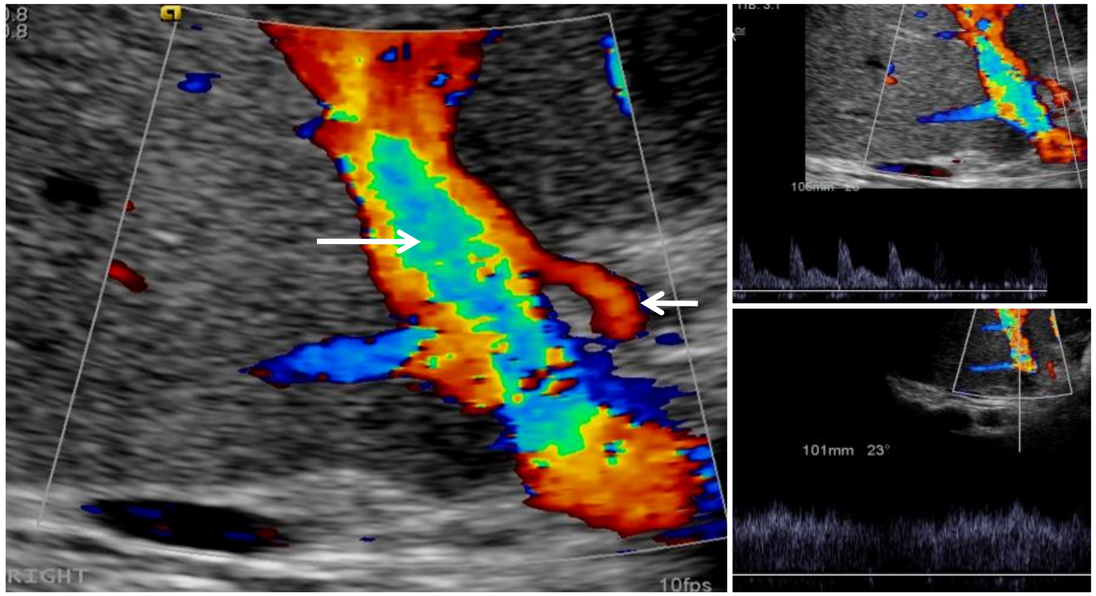
- Hepatic artery thrombosis
  - **7-12% adults**
  - **11-42% children**
- Infarction, sepsis, abscess, bile leak, strictures and liver failure
- Requires repeat liver transplantation if diagnosis is delayed

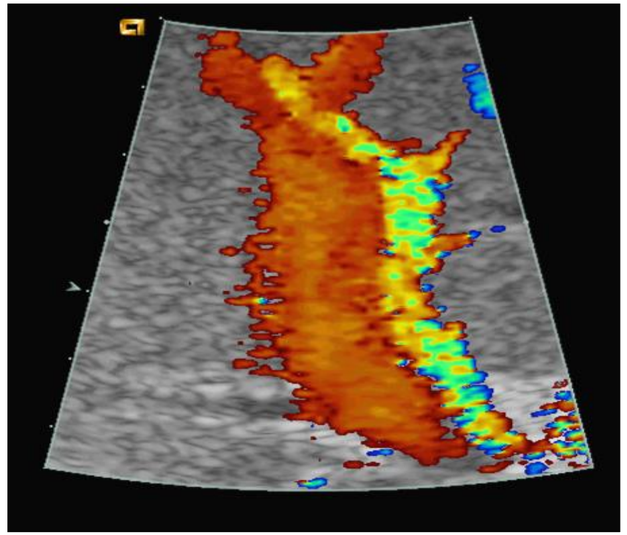
Tzakis AG, Gordon RD, Shaw BW, Iwatsuki S, Starzl TE. Clinical presentation of hepatic artery thrombosis after liver transplantation in the cyclosporine era. Transplantation 1985;40:667-671

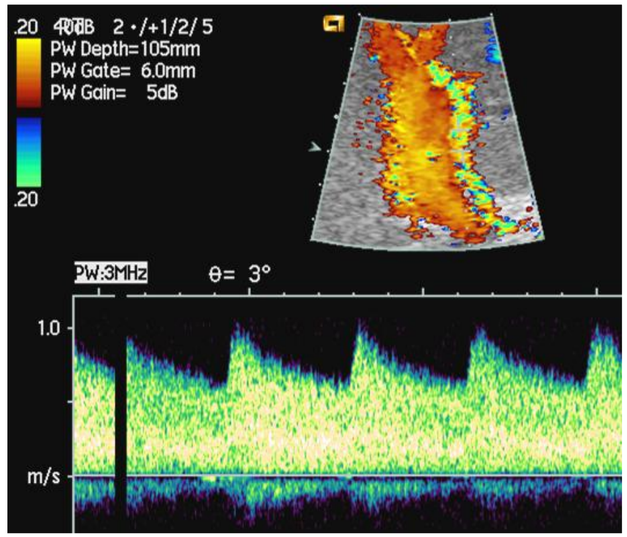
Valente JF, Alonso MH, Weber FL, Hanto DW. Late hepatic artery thrombosis in liver allograft recipients is associated with intra-hepatic biliary necrosis. Transplantation 1996;61:61-65

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

- High quality US machine with sensitive color and spectral Doppler capabilities
- CDUS at 24 hrs, day 4 and prior to discharge
- Normal hepatic artery; rapid systolic upstroke and continuous flow through diastole with an RI 0.5-0.7
- CDUS will visualise 96% of hepatic arteries







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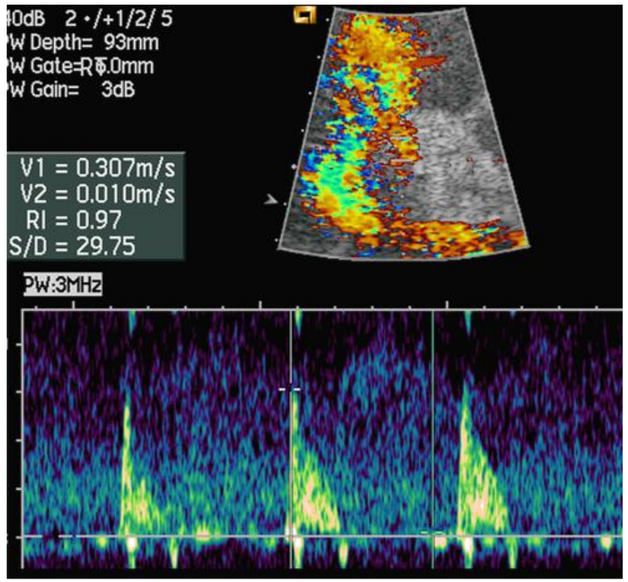
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

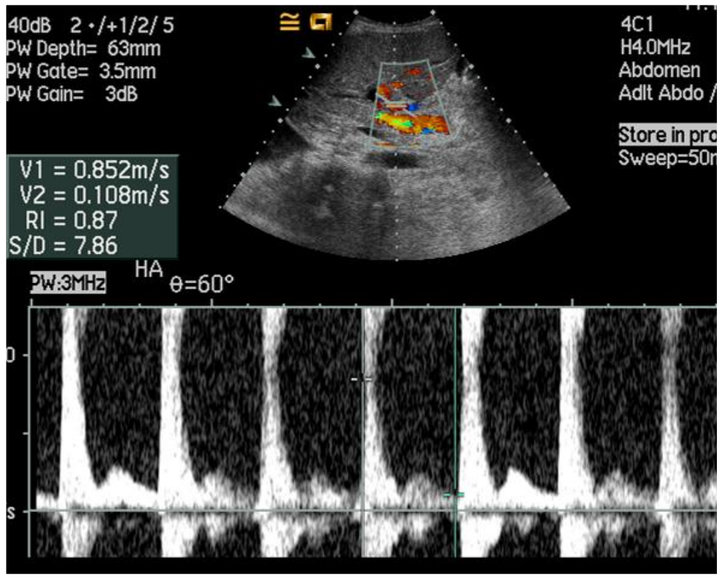
Hepatic Artery with High Resistance Index - False positive HAT

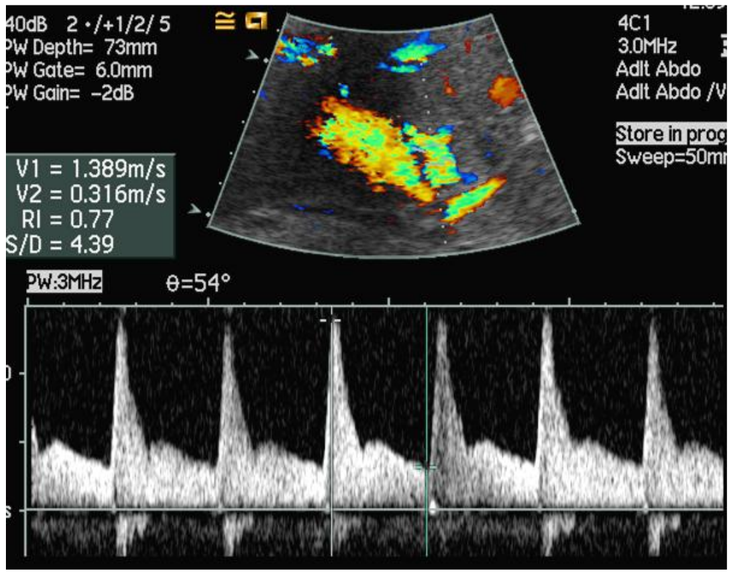
- Severe hepatic oedema
- Systemic hypotension
- High-grade hepatic artery stenosis



High Resistance Index Hepatic Artery Returning to Normal

- Normal evolution of changes as transplanted liver recovers

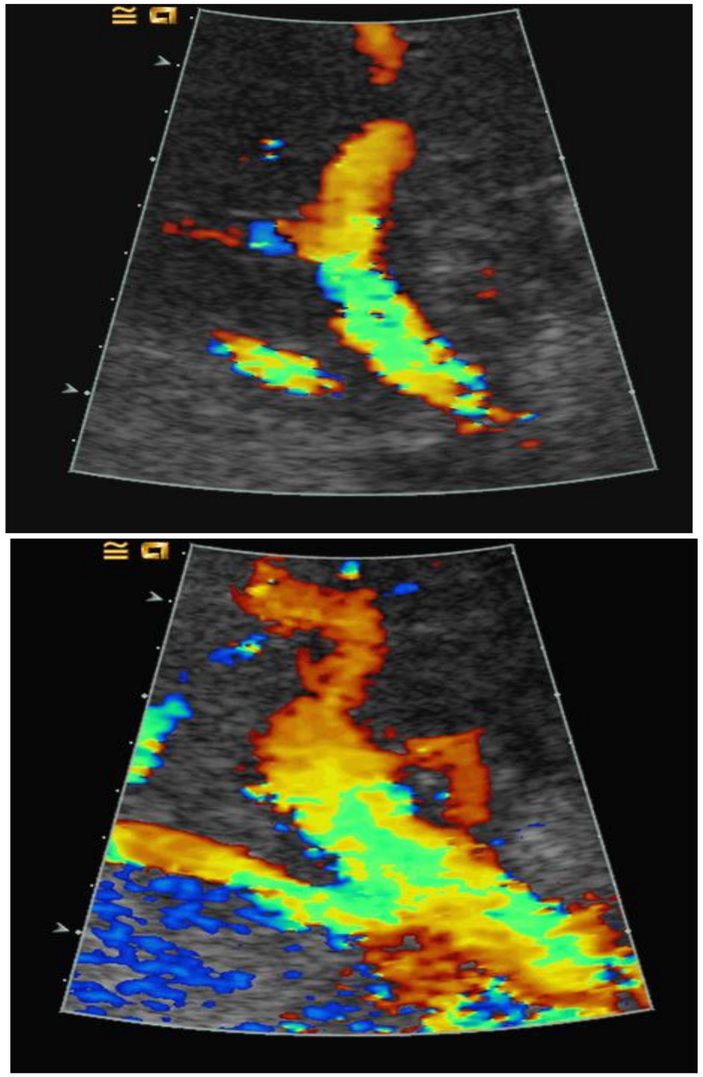




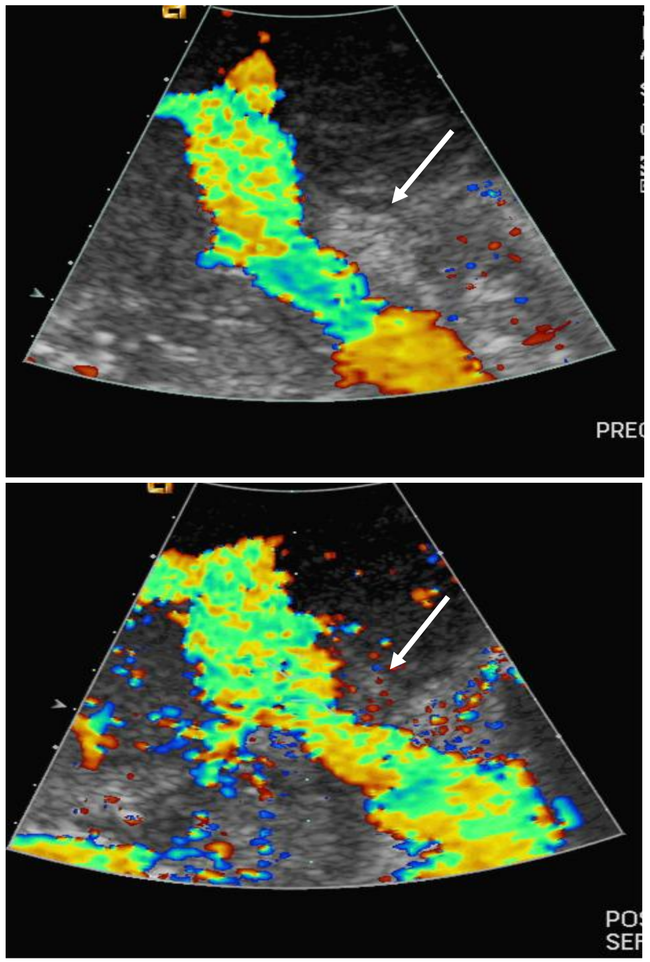
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

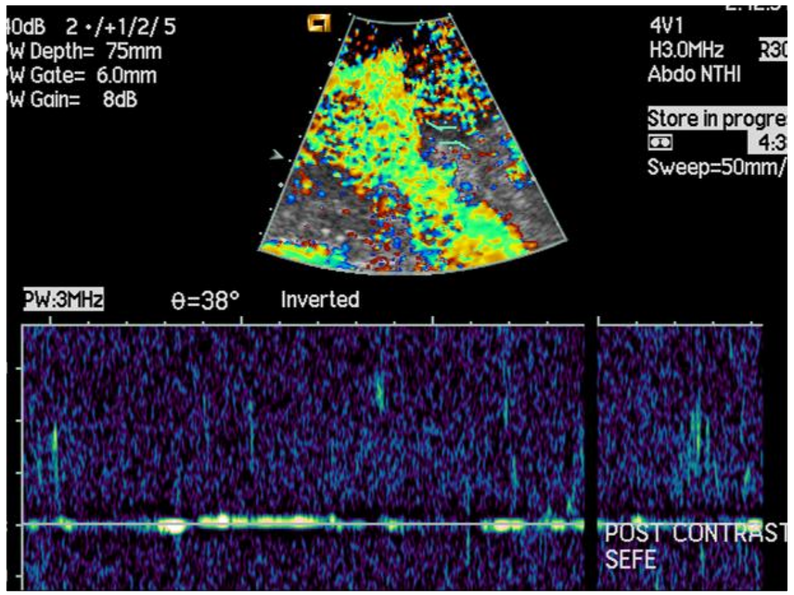
Liver Transplantation

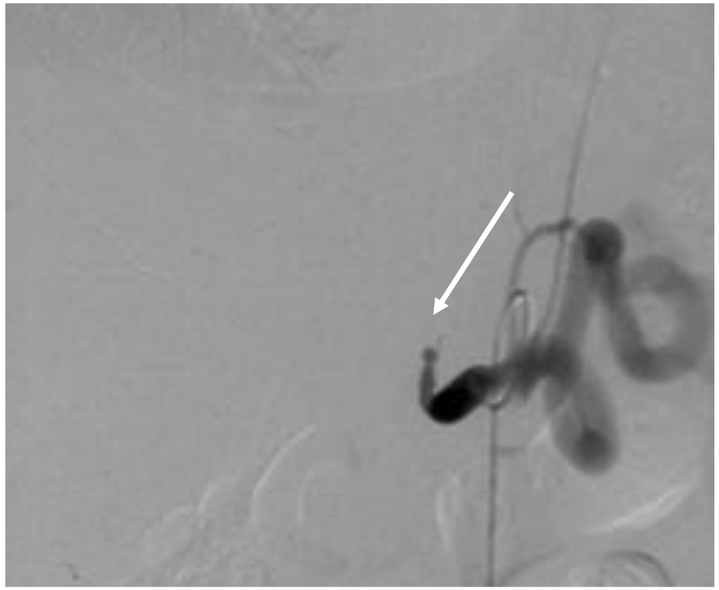
- CEUS in Hepatic Artery Thrombosis2-year study in 794 surveillance US
- HA flow seen in 759/794 (95.6%)
- 35 studies in 31 patients; microbubble contrast (Levovist)
- HA flow seen in 781/794 (98.4%)
- 13/35 (37.1%) HA still not seen
- One patient had patent HA on arteriography; high resistance



Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative





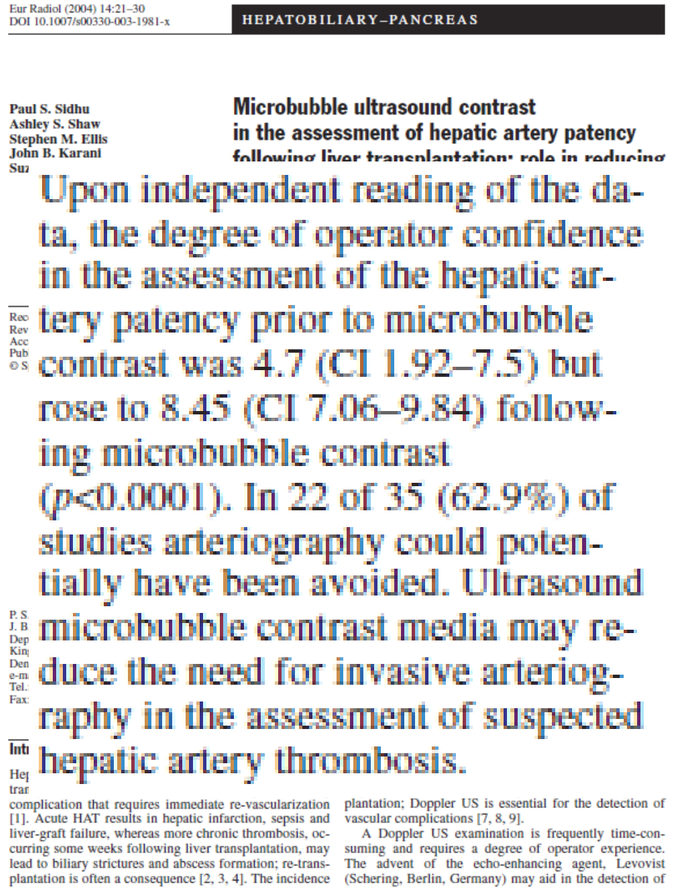


Sidhu PS, Shaw AS, Ellis SM, Karani JB, Ryan SM. Microbubble ultrasound contrast in the assessment of hepatic artery patency following liver transplantation: role in reducing frequency of hepatic artery arteriography Eur Rad 2004;10:1114-1126

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation

Why use CEUS on the ITU?

1. Quick and simple test for patency of the hepatic artery.
2. Mobile imaging – the observer attends the patient.
3. Transfer of intensive care patient to imaging
   - Whole team effort
   - Nursing and anesthetic time
   - Portering time
   - Morbidity associated with transfer
   - No delay in diagnosis for immediate treatment



Eur Radiol (2004) 14:21–30
DOI 10.1007/s00330-003-1981-x

HEPATOBILIARY–PANCREAS

Paul S. Sidhu
Ashley S. Shaw
Stephen M. Ellis
John B. Karani
Su

Microbubble ultrasound contrast in the assessment of hepatic artery patency following liver transplantation: role in reducing

Upon independent reading of the data, the degree of operator confidence in the assessment of the hepatic artery patency prior to microbubble contrast was 4.7 (CI 1.92–7.5) but rose to 8.45 (CI 7.06–9.84) following microbubble contrast ($p<0.0001$). In 22 of 35 (62.9%) of studies arteriography could potentially have been avoided. Ultrasound microbubble contrast media may reduce the need for invasive arteriography in the assessment of suspected hepatic artery thrombosis.

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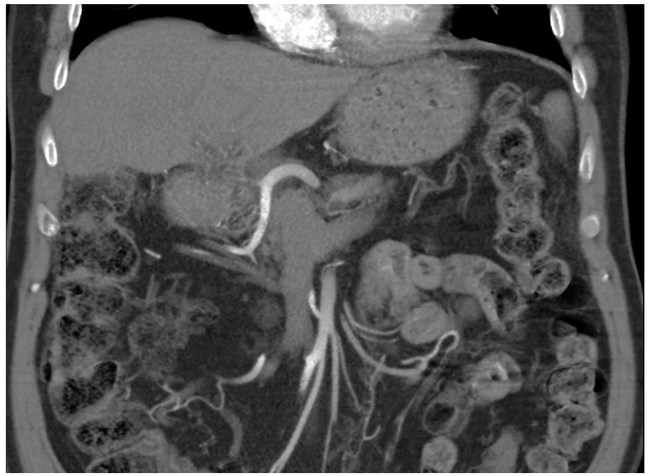
complication that requires immediate re-vascularization [1]. Acute HAT results in hepatic infarction, sepsis and liver-graft failure, whereas more chronic thrombosis, occurring some weeks following liver transplantation, may lead to biliary strictures and abscess formation; re-transplantation is often a consequence [2, 3, 4]. The incidence

plantation; Doppler US is essential for the detection of vascular complications [7, 8, 9].

A Doppler US examination is frequently time-consuming and requires a degree of operator experience. The advent of the echo-enhancing agent, Levovist (Schering, Berlin, Germany) may aid in the detection of

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative



CT of liver transplantation

Suzanne M. Ryan, MRCPI, FRCR and Paul S. Sidhu, MRCP, FRCR

Transplantation is an established treatment for end-stage liver disease, whatever the precipitating cause. Imaging of both the pre- and posttransplant patient is an important facet of patient management. Advances in immunosuppressive therapy, surgical techniques, perioperative care, and imaging have combined to improve the outcome of liver transplantation; 1-year survival is now >85%, with a quoted 5-year survival rate of 65% to 78%.[1] Graft survival relies on prompt diagnosis of complications. Although there is a reliance on ultrasound for assessing vascular and nonvascular complications, particularly in Europe, there is an important role for computed tomography (CT). CT imaging in the peri- and postoperative phase is used in the evaluation and diagnosis of vascular and biliary complications, focal collections (bile or infective), and hematomas, and for the assessment of the presence of pelvic fluid collections. Postoperative disease recurrence and posttransplant lymphoproliferative disease (PTLD) may be readily detected with CT.

Radiological assessment of the liver transplant

The candidate

evaluation of the transplant candidate is essential for appropriate patient selection.[2,4] Objectives of preoperative radiologic evaluation in the recipient include assessment of vessel anatomy and patency as well as exclusion of intra- and extrahepatic malignancy. Identification of cirrhosis, sequelae of portal hypertension, and quantification of the volume of the diseased liver may be performed. Further information available on CT that is useful to the transplant surgeon includes the status of the celiac artery, the presence of splenic artery aneurysms, and the position of any spontaneous portosystemic venous shunts.[3,4]

Shortage of cadaver donor livers has led to the institution of "live-related" donor transplantation. In the preoperative period, a CT of the donor assesses liver volume and vascular anatomy, excludes focal liver lesions, and identifies any unsuspected anomalies that would preclude surgery.

Hepatic parenchyma

The typical cirrhotic liver morphology shows hypertrophy of the caudate lobe (segment 1 according to the Couinaud classification) and the left lateral liver segments (segments 2 and 3), with atrophy of the remaining liver (Figure 1). The presence of congestive splenomegaly, ascites, and portosystemic collaterals allows for the documentation of portal hypertension.[4,5]

Hepatocellular carcinoma

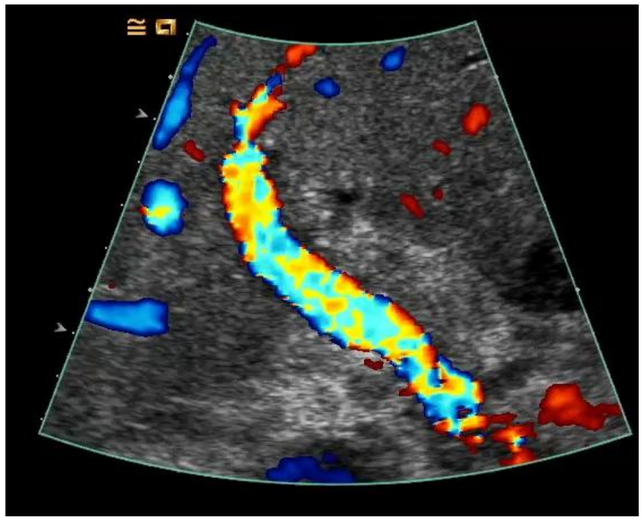
Most candidates for liver transplant will have cirrhosis and, with it, a greater risk of an associated hepatocellular carcinoma (HCC). Screening for HCC should be performed preoperatively.[2] However, the presence of HCC does not preclude transplantation, and in some instances, transplantation is curative.[6,7] The presence of lesions ≥5 cm in diameter, the presence of ≥3 lesions (the "Milan criteria") or evidence of extra-hepatic spread are accepted contraindications to transplantation.[6] Hepatocellular carcinomas are best visualized on arterial-phase images, where they appear as avidly enhancing nodules that become hypodense on the portal-venous phase (Figure 2).

Larger lesions tend to have a typical mosaic enhancement pattern and may show a peripheral capsule.[3] Portal vein (PV) and hepatic vein involvement from tumor extension is also characteristic. The preoperative detection of a cholangiocarcinoma is an absolute contraindication to liver transplantation. The rate of recurrence is reported to be as high as 44%.[8]

Liver volume

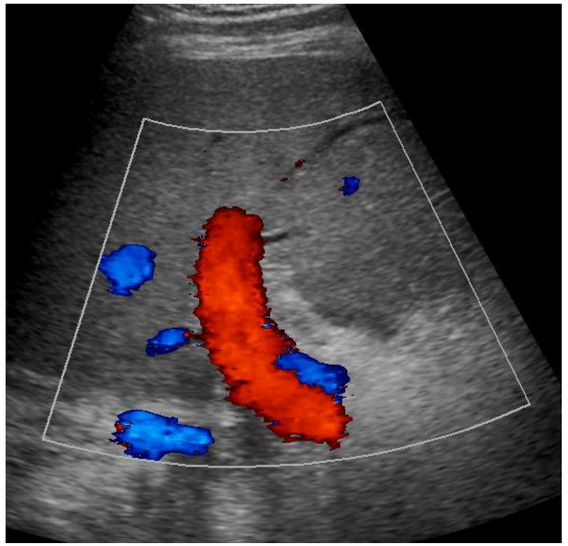
Assessment of the liver volume is important in live-related donors, both to ensure that adequate liver volumes remain in the donor and that an adequate volume of liver is transplanted into the recipient; liver graft size is one of the major factors that determines a successful outcome. A graft that is too large for the recipient is associated with a risk of graft compression, which leads to poor vascular perfusion. Conversely, a liver graft that is too small for the recipient may cause postopera-

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation



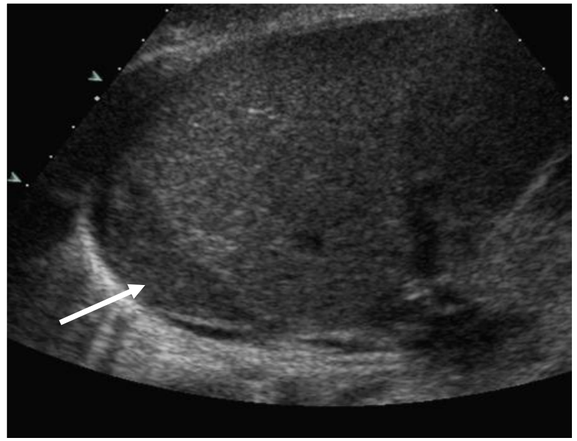
Occlusion at level of coeliac axis – unequivocal imaging

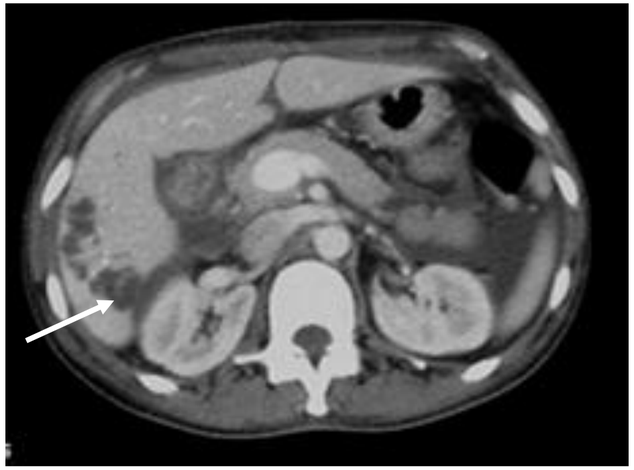
ITU bedside images showing arrival of contrast in portal vein without any hepatic artery enhancement



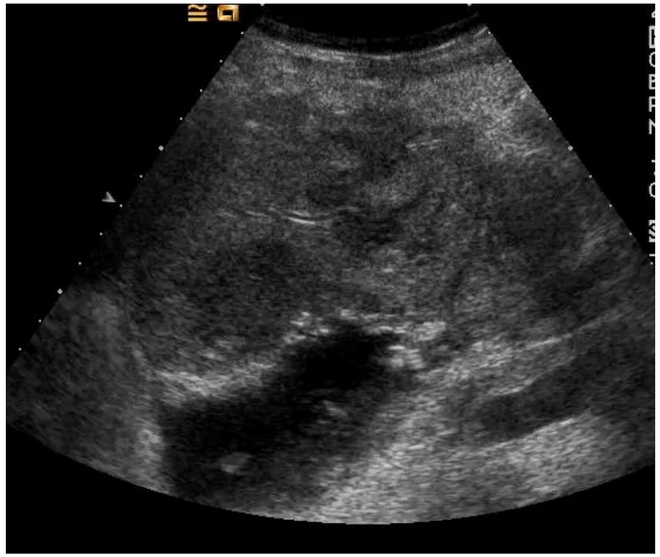
Sidhu PS, Shaw AS, Ellis SM, Karani JB, Ryan SM. Microbubble ultrasound contrast in the assessment of hepatic artery patency following liver transplantation: role in reducing frequency of hepatic artery arteriography Eur Rad 2004;10:1114-1126

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative





Infarction Post Liver Transplantation



Eur Radiol Suppl (2004) 14[Suppl 8]:P96–P103
DOI 10.1007/s10406-004-0082-5

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Microbubble contrast-enhanced ultrasound in liver transplantation

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Abstract The use of liver transplantation for treatment of end-stage liver disease is now commonplace. The accurate assessment of the pre-transplant candidate and long-term follow-up of the posttransplant patient is vital in ensuring that the limited resource of donor livers is appropriately used. Ultrasound is accepted as playing an important role in this process. The advent of microbubble contrast enhanced ultrasound provides new opportunities in terms of improving diagnostic accuracy and obviating more invasive investigations with their associated patient morbidity and mortality. We present the current and developing applications of microbubble contrast-enhanced ultrasound in the field of liver transplantation.

Keywords Ultrasound · Liver transplant · Microbubble contrast

Introduction

Liver transplantation is the definitive treatment for end-stage liver disease resulting from a variety of causes. Improvements in surgical technique, immuno-suppression and peri-operative care mean that an increased number of patients with chronic liver disease, acute liver failure, malignant and metabolic disorders are eligible for transplantation [1-3]. Of those patients that are transplanted, the likelihood of success continues to improve, with 1-year survival now in excess of 85% [4]. Selection of suitable candidates requires a multifaceted approach. Radiology plays an important role in providing information regarding the liver parenchyma and vasculature [5]. Furthermore, postoperatively accurate visualization of the liver is vital in the follow-up of the transplanted organ. The employment of colour Doppler techniques has enhanced the detection of vascular complications [6-8]. Augmentation of colour Doppler ultrasound with microbubble contrast has proved useful in both pre- and post-operative assessment of hepatic vasculature, possibly delaying or obviating the need for more invasive investigations [9].

We review the current applications of microbubble ultrasound contrast utilizing both colour Doppler and a variety of contrast-specific imaging modes pre- and post-liver transplantation.

Pretransplant

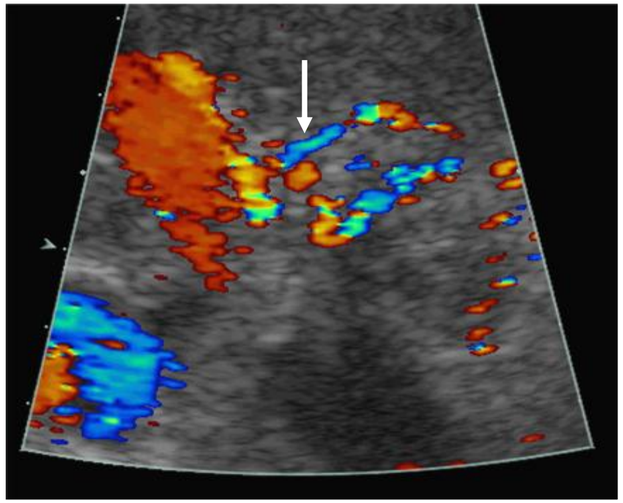
Vascular patency

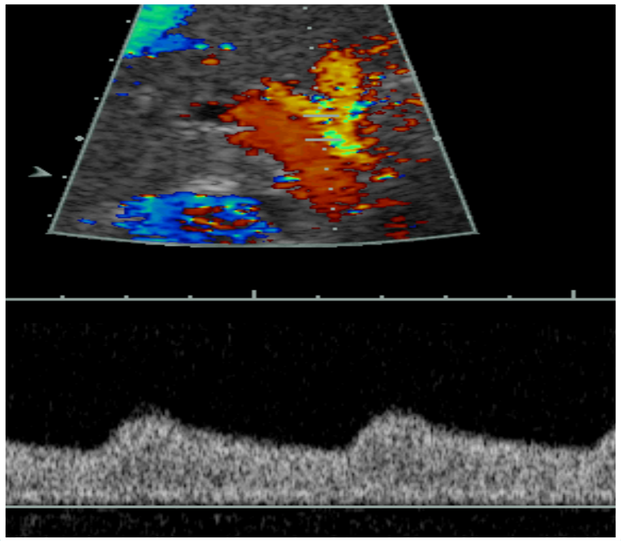
Portal and superior mesenteric veins

The presence of portal vein (PV) thrombosis requires modification of surgical technique at the time of transplantation, for example the construction of a venous conduit from the patent superior mesenteric vein (SMV) to the donor graft [10]. Thrombosis of the PV is known to occur in 5–10% of patients with end-stage cirrhosis [11]. The attenuating nature of cirrhotic liver parenchyma together with the not infrequent large volume of ascites makes standard Doppler ultrasound assessment of the PV in such patients problematic. More difficult still is visualization of the SMV because of overlying bowel gas [12]. Microbubble contrast-enhanced Doppler ultrasound may be utilized in these scenarios to improve confidence in demonstrating PV patency [13], improving visualization of the vessel in up to 94% of patients (Fig. 1) [12].

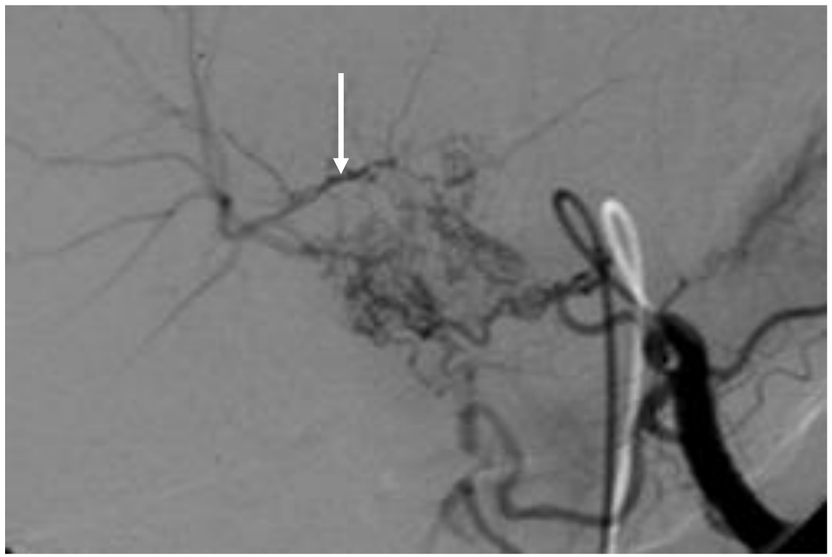
Sidhu PS, Shaw AS, Ellis SM, Karani JB, Ryan SM. Microbubble ultrasound contrast in the assessment of hepatic artery patency following liver transplantation: role in reducing frequency of hepatic artery arteriography Eur Rad 2004;10:1114-1126

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative





Hepatic Artery Thrombosis: Collaterals on Ultrasound and Angiography



Eur. Radiol. 10, 1114–1126 (2000) © Springer-Verlag 2000

European Radiology

Pictorial review

Clinical use of Levovist, an ultrasound contrast agent, in the imaging of liver transplantation: assessment of the pre- and post-transplant patient

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Abstract. Colour Doppler US is well established for imaging of hepatic vessels in the assessment of pre- and post-liver transplant patients. Unfortunately, a full colour Doppler US examination of the portal or hepatic venous and hepatic arterial systems is frequently precluded by technical factors. Ultrasound contrast agents are useful in enhancing vascular Doppler signal and play an important role in liver transplantation assessment. A series of patients with vascular problems illustrates the role of US contrast in the pre-transplant candidate, where portal vein patency and direction of flow is assessed, presence of portal vein thrombus is confirmed and cavernous transformation demonstrated. Occlusion of hepatic veins in Budd-Chiari syndrome is confidently confirmed. Following liver transplantation, US contrast allows a comprehensive assessment of hepatic artery thrombosis, hepatic artery stenosis and pseudoaneurysm formation. The need for further imaging is reduced or confidently deferred in many instances. Ultrasound contrast agents play an important role in the liver transplant candidate.

Key words: Liver – Transplantation – US contrast – Complications

Introduction

Liver transplantation is the treatment of choice in patients with acute or chronic liver failure, when no other therapy is suitable. Improvements in surgical techniques, immunosuppressive drug therapy and tissue typing have combined to improve the success of liver transplantation [1, 2]. The success of liver transplantation has led to increased demand for accurate imaging evaluation in the pre- and post-operative period where detailed assessment of the vascular supply of the liver is crucial. Ultrasound is generally regarded as the primary screening technique for the detection of vascular abnormalities following transplantation. The use of colour Doppler US has improved the detection of vascular complications [3, 4, 5].

The advent of the echo-enhancing agent Levovist (Schering, Berlin, Germany) has introduced the potential for further improvement in the detection of vascular abnormalities. Levovist is a suspension of monosaccharide microparticles (galactose in sterile water stabilized with palmitic acid). The microbubbles measure 2–8 µm in mean diameter, can traverse the pulmonary capillary bed and are non-toxic and biodegradable. Levovist is administered intravenously as a bolus injection with echo enhancement lasting for between 4 and 6 min [3, 6, 7].

Following liver transplantation, an increase in the detection rate of vascular abnormalities may reduce the need for more invasive investigation and may thus reduce morbidity. We illustrate the value of Levovist in pre- and post-liver transplantation.

Pre-transplant

Portal and superior mesenteric veins

Patients being considered for liver transplantation undergo clinical assessment that involves surgical, radiological and psychosocial evaluation. Radiological assessment is used to confirm vascular patency, anatomical appearance, the presence or absence of porto-systemic collaterals and the identification of intra-hepatic malignancy [8].

The US examination of the potential transplant recipient is used to assess vascular patency; 5–10% of patients with end-stage cirrhosis have portal vein (PV) thrombosis [9]. Thrombus within the PV, although not an absolute contra-indication to transplantation, requires surgical modification. A venous conduit may be constructed from the patent superior mesenteric vein

Correspondence to: P.S. Sidhu

Sidhu PS, Marshall MM, Ryan SM, Ellis SM. Clinical use of Levovist, an ultrasound contrast agent, in the imaging of liver transplantation: assessment of the pre and post transplant patient. European Radiology 2000;10:1114-1126.

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Indirect evidence of hepatic artery stenosis

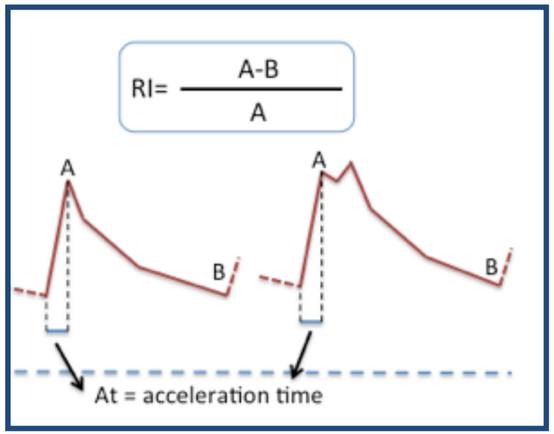
Tardus Parvus Waveform

- Systolic Acceleration Time (>100msec)

  Time from end diastole to first systolic peak

- Resistance Index (RI <0.5)

$$\frac{\text{Peak Systole - End Diastole}}{\text{Peak Systole}}$$



Direct Evidence of hepatic artery stenosis

Difficult to detect site of hepatic artery stenosis directly to identify peak systolic velocity of >2-3 m/sec;

- obesity
- bowel gas
- tortuosity of vessel
- post-surgical dressings and drains

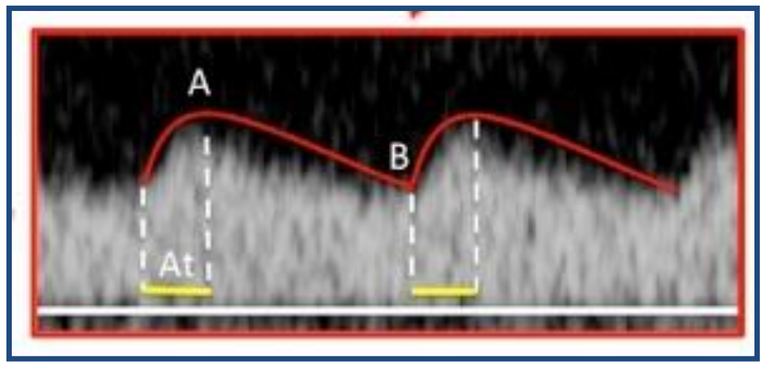
Abbasoglu O, Levy MF, Vodapally MS et al. Hepatic artery stenosis after liver transplantation; incidence, presentation , treatment and long term outcome. Transplantation 1997;27:250-255

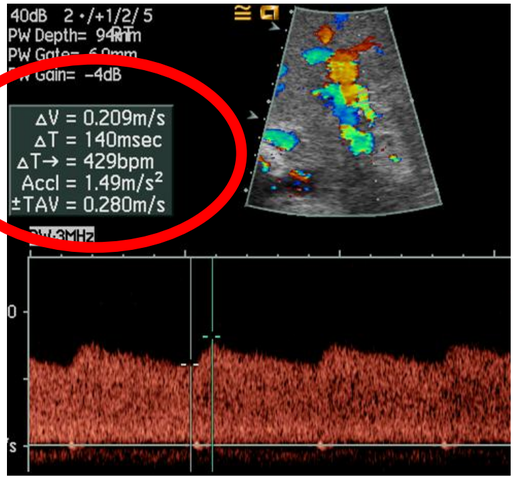
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

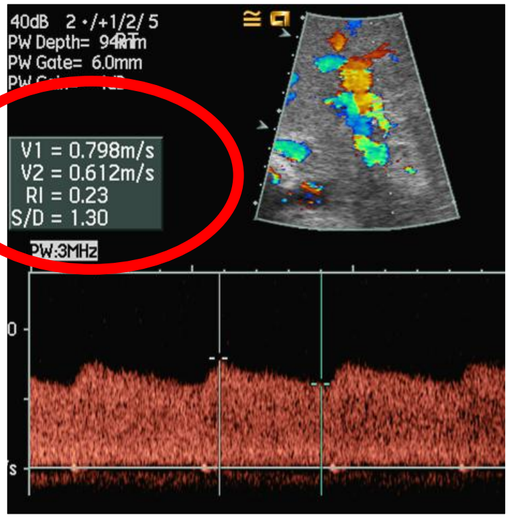
Tardus Parvus is non-specific

Similar pattern

- Aorto-coeliac atherosclerotic disease
- Arterio-venous fistula
- Arterio-biliary fistula formation
- Long standing thrombosis





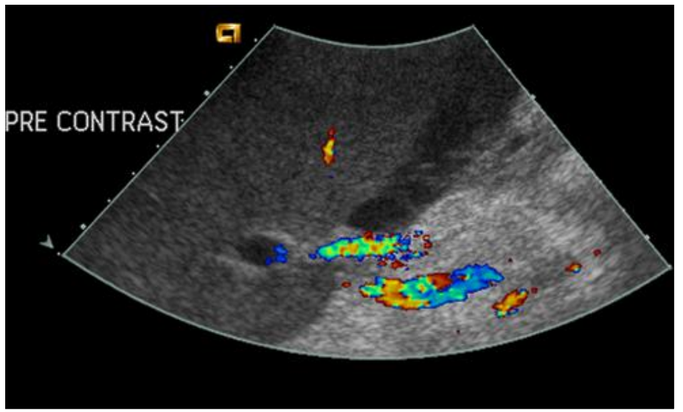


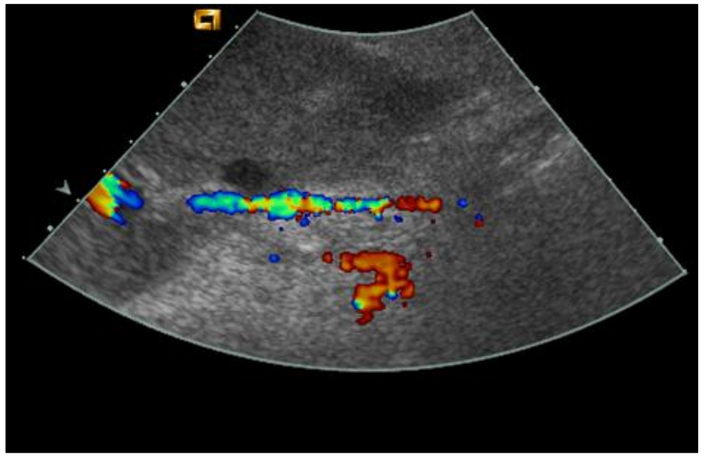
Sidhu PS, Ellis SM, Karani JB, Ryan SM. Hepatic artery stenosis following liver transplantation: significance of the tardus parvus waveform and the role of microbubble contrast media in the detection of a focal stenosis Clin Radiol 2002;57:789-799

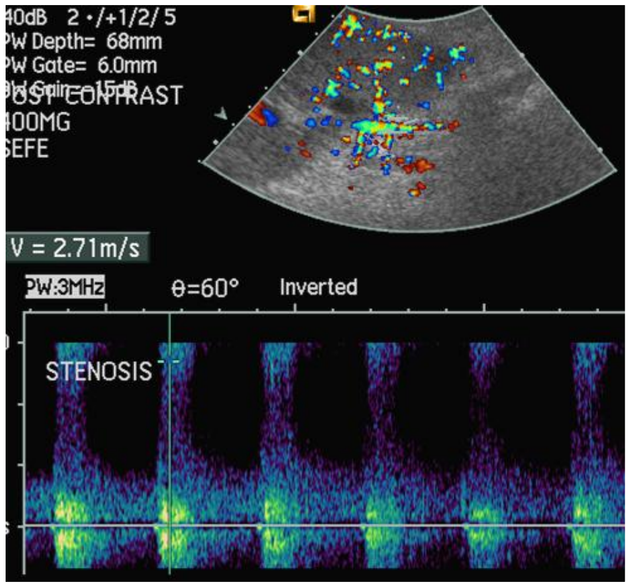
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

CEUS in Hepatic Artery Stenosis

- 2038 US examinations in 529 liver transplants
- 16 patients identified with a tardus parvus waveform (SAT >0.08secs and RI <0.50)
- Median SAT 0.18secs and RI 0.47
- Following microbubble contrast PSV elevation seen in 14/16 in the hepatic artery; median 2.15 m/sec
- Arteriography confirmed 8/10 stenosis; 2/10 with occlusion
- 6 patients with no arteriography; 4 resolved on US, 2 re-transplantation
- Tardus parvus is an excellent screening test for HAS







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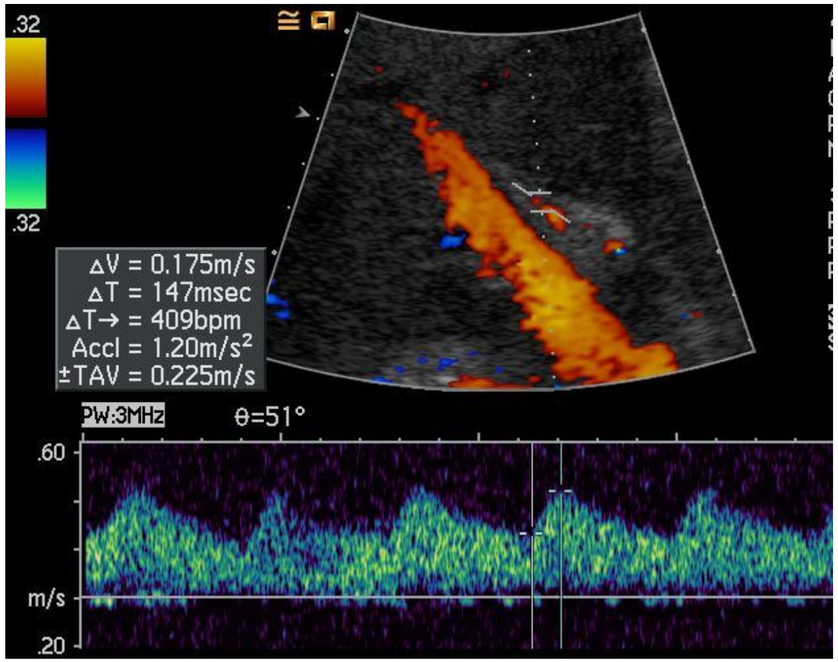
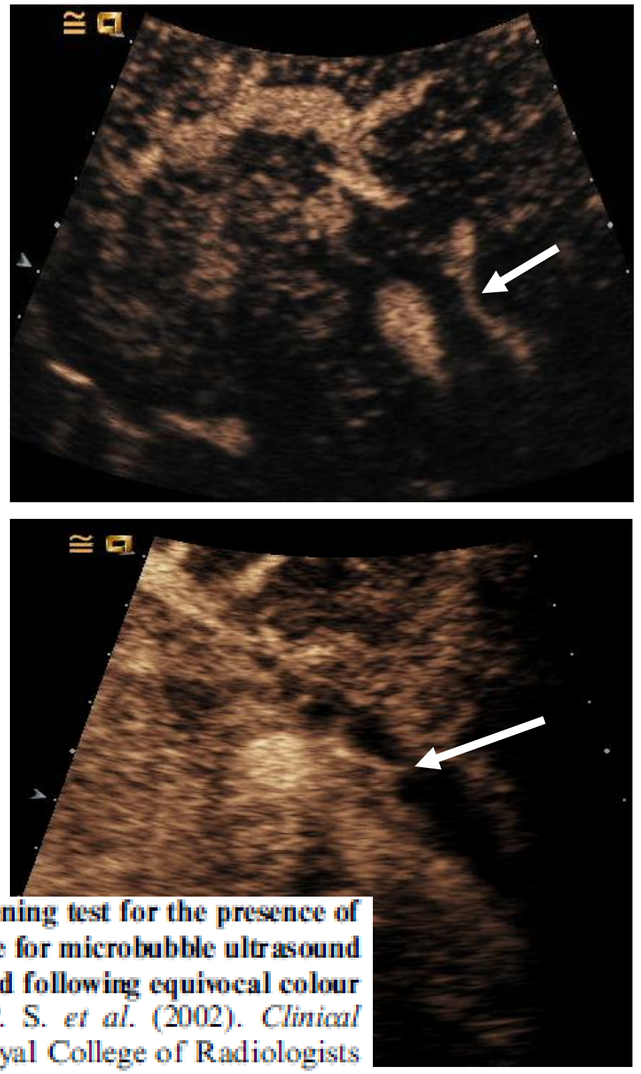
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

CEUS in Hepatic Artery Stenosis





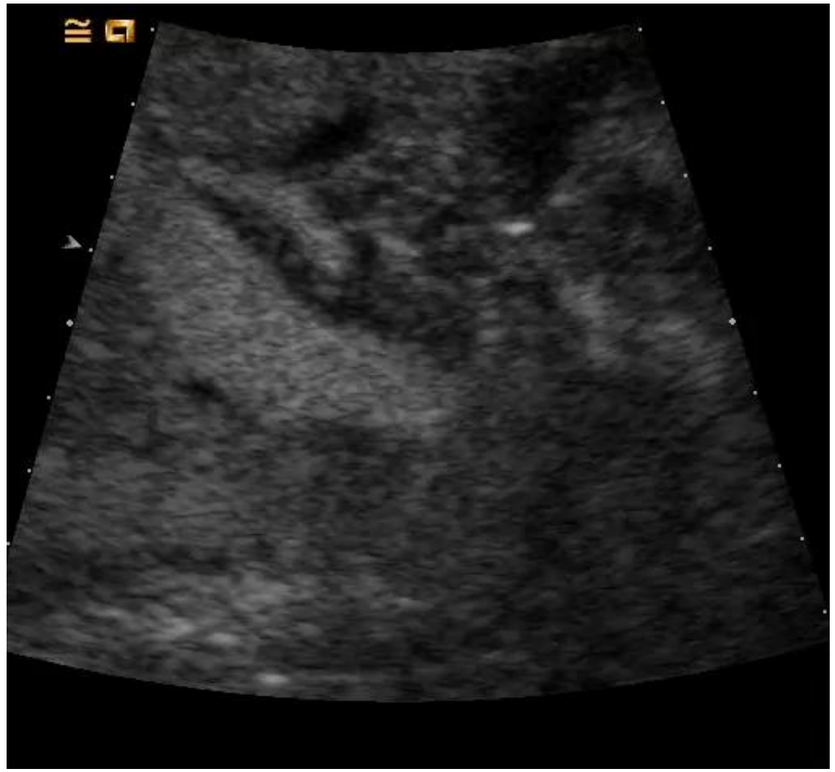
CONCLUSION: The tardus parvus waveform pattern is an excellent screening test for the presence of post-liver transplantation hepatic artery stenosis. There is only a limited role for microbubble ultrasound contrast agent in the presence of a tardus parvus waveform. It could be used following equivocal colour Doppler ultrasound, but arteriography will still be necessary. Sidhu, P. S. *et al.* (2002). *Clinical Radiology* **57**, 789–799.

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Tardus Parvus is non-specific

- Similar pattern
  - Aorto-coeliac atherosclerotic disease
  - Arterio-venous fistula
  - Arterio-biliary fistula formation
  - Long standing thrombosis

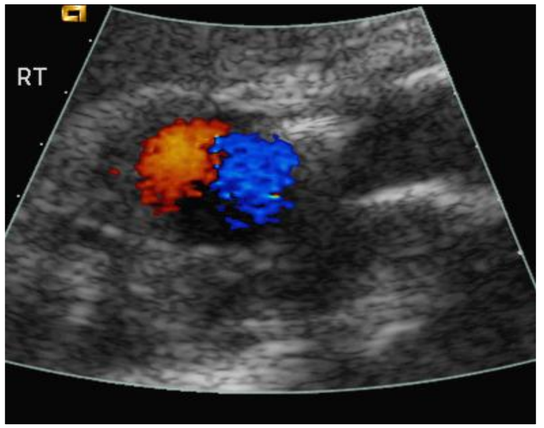
Artery kinking ?

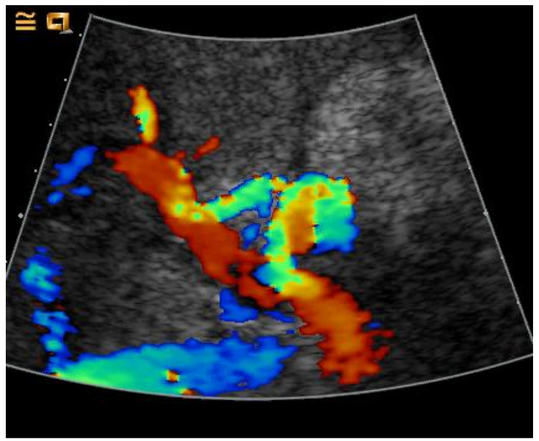


Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Hepatic Artery Pseudo aneurysm

- Intra-hepatic
  - Biopsy related when peripheral within the liver parenchyma
- Extra-hepatic
  - Bowel perforation and sepsis
  - Biliary leak
  - Fungal sepsis
  - Arterial damage





Incidence of 1% following 1327 liver transplants

13 hepatic artery pseudo aneurysms
- 9 anastomotic
- 4 intrahepatic

Mortality of 69%

Coil embolization
- 3 intra-hepatic and 3 extra-hepatic
- 5 required re-transplantation

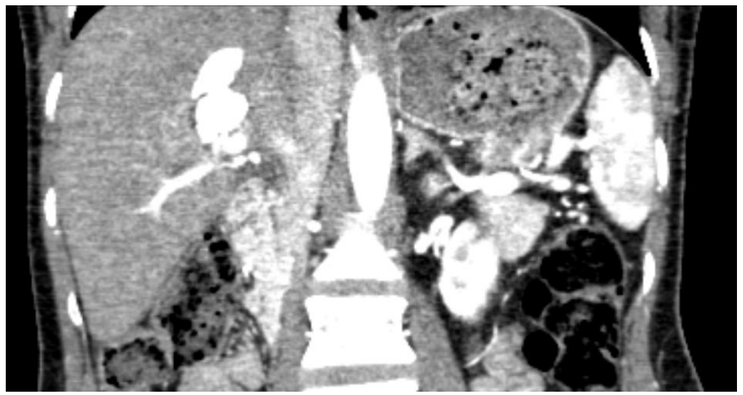
Marshall MM, Muiesan P, Srinivasan P, Kane P, Rela M, Heaton ND, Karani JB, Sidhu PS. Hepatic artery pseudoaneurysms following liver transplantation: Incidence, presenting features and management. Clinical Radiology 2001;56:579-587

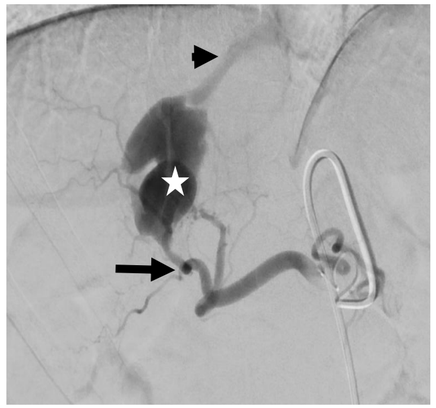
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

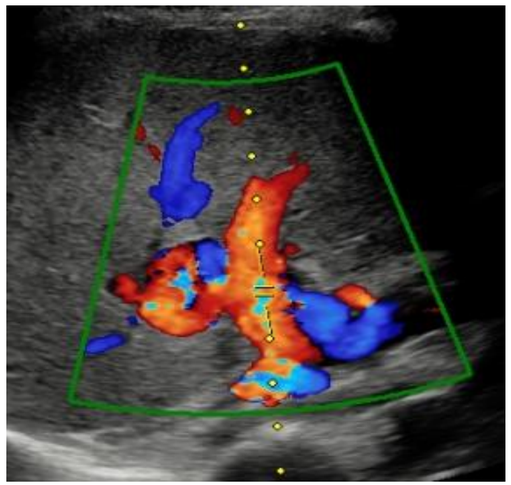
Hepatic Artery Pseudo aneurysm

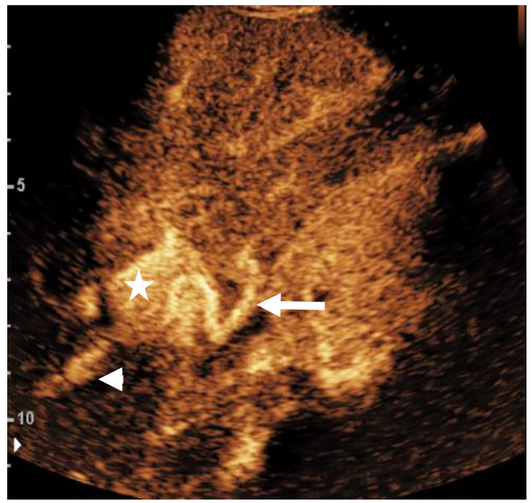
Intra-hepatic

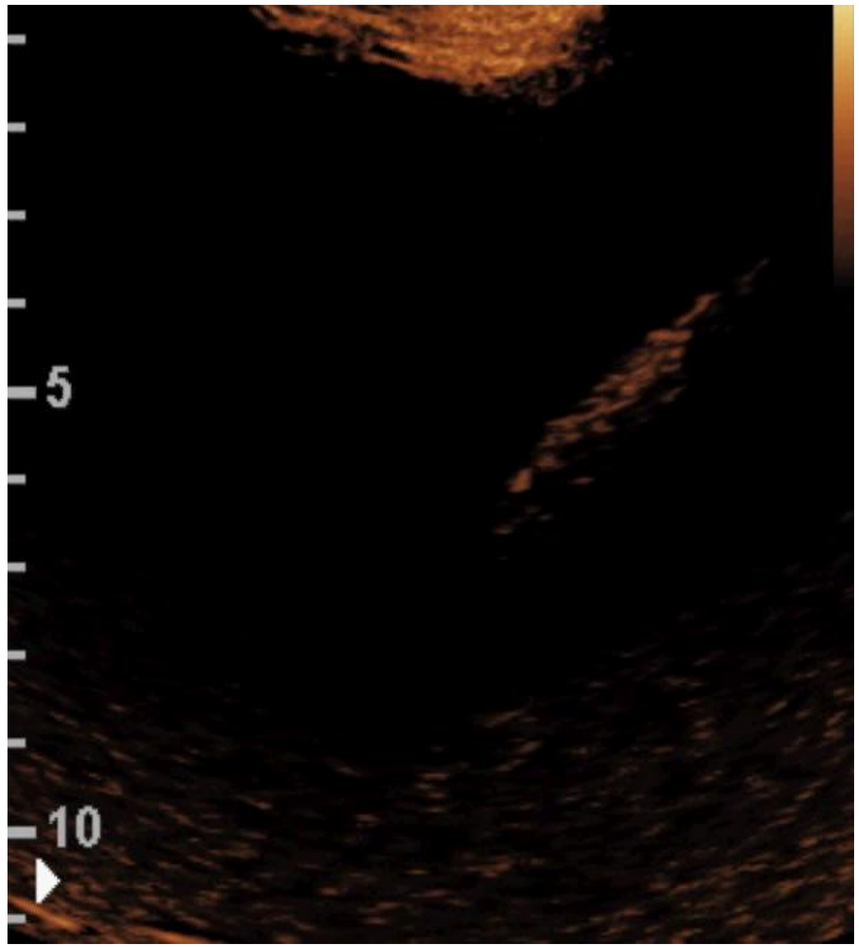
Biopsy related when peripheral within the liver parenchyma



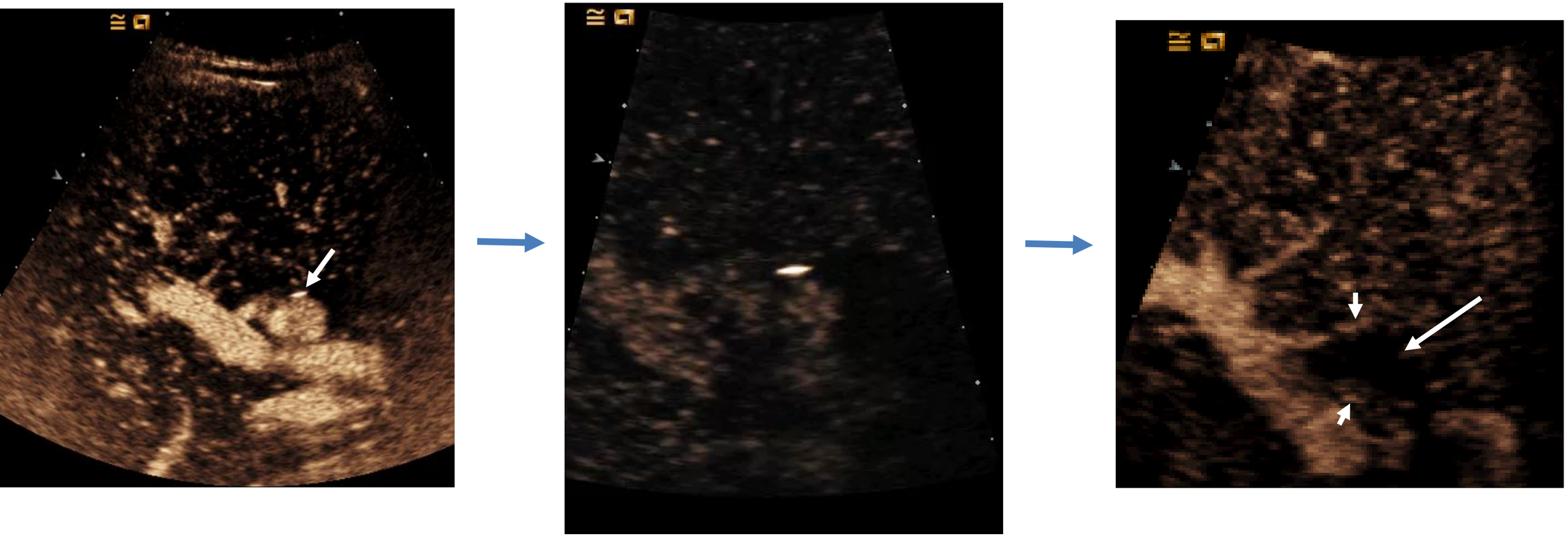








Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative



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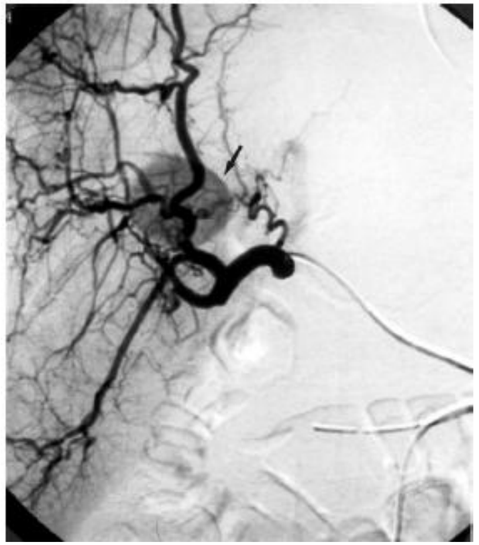

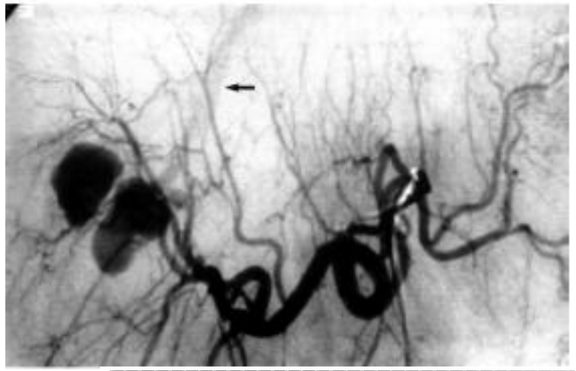

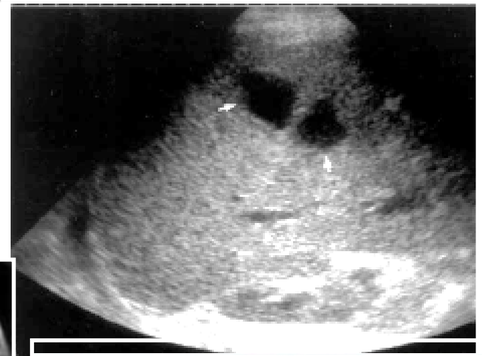

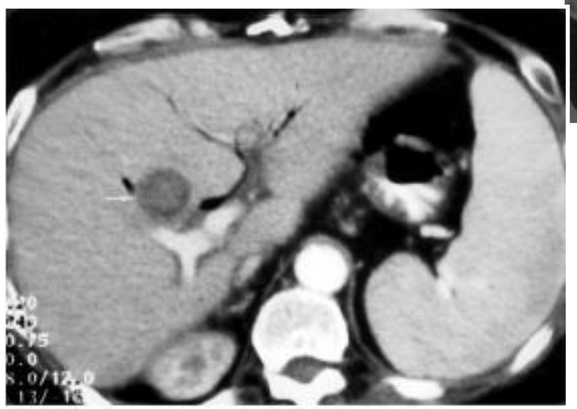

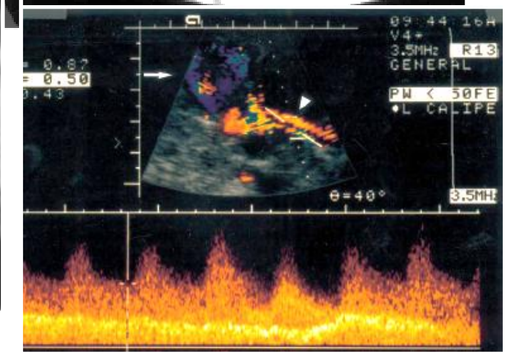

Clinical Radiology (2001) **56**: 579–587
doi:10.1053/crad.2001.0650, available online at http://www.idealibrary.com on IDEAL®

Hepatic Artery Pseudoaneurysms Following Liver Transplantation: Incidence, Presenting Features and Management

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**Department of Radiology, King's College Hospital, London, U.K. and †Department of Liver Transplant Surgical Service, King's College Hospital, London, U.K.*

Received: 6 March 2000 Revised: 20 September 2000 Accepted: 28 September 2000

AIM: Hepatic artery pseudoaneurysm (PA) is an uncommon complication of liver transplantation. We report a series of 13 patients, the largest published review including outcome. The presenting features, risk factors and role of radiology in the diagnosis and management of this frequently fatal complication are discussed. Marshall, M. *et al. Clinical Radiology* (2001). **56**, 579–587

Key words: aneurysm, hepatic artery, transplantation, complications.

INTRODUCTION

Hepatic artery pseudoaneurysms (PAs) are a rare, life-threatening complication of liver transplantation with

Aetiological factors and outcome are considered for intrahepatic and extrahepatic PA separately.

associated abnormality in graft perfusion. Arteriography should be performed in all suspected cases of PA irrespective of other imaging findings and is the examination of choice to define the arterial anatomy and plan further treatment. Embolization is the treatment of choice in biopsy related intrahepatic pseudoaneurysms. In both surviving patients with extrahepatic PA, embolization, used as a temporary measure for control of acute haemorrhage, facilitated successful re-transplantation.

Marshall MM, Muiesan P, Srinivasan P, Kane P, Rela M, Heaton ND, Karani JB, Sidhu PS. Hepatic artery pseudoaneurysms following liver transplantation: Incidence, presenting features and management. Clinical Radiology 2001;56:579-587

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

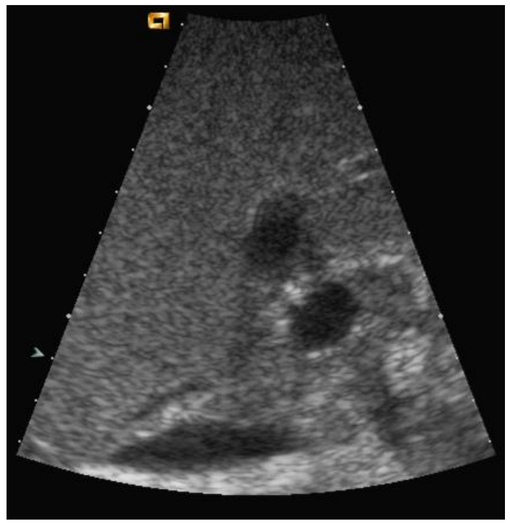
Portal Vein

Risk factors that predispose to PV complications

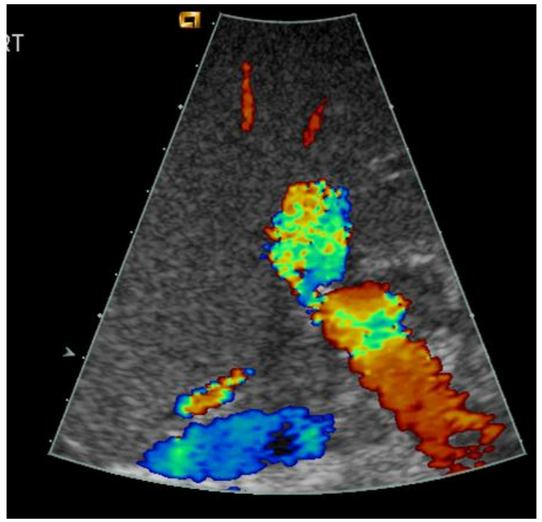
- Hypercoagulable states
- Decreased portal vein inflow
- Porto-systemic shunts
- Prior splenectomy
- Twisting/kinking of the vascular conduit
- Tension in the portal vein graft

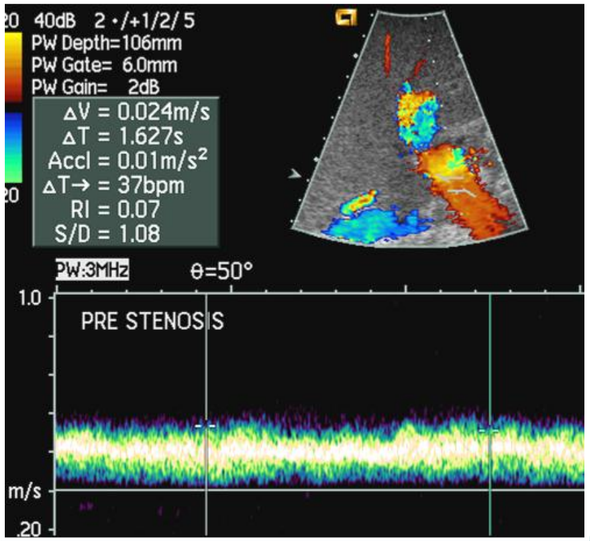
- **Portal vein stenosis**
  - 0.6 – 1.2 %, an absolute velocity of >1.0 m/sec or a 2-fold increase in velocity across a narrowing is suspicious
- **Portal vein thrombosis**
  - 2.0 – 7.0%, no flow is present with echogenic solid material within the portal vein
- **Portal vein ligation**
  - Criggler-Najar syndrome, an iatrogenic manoeurve to increase flow to the auxiliary liver graft
- **Redundant portal vein**
  - Misalignment or excessive vessel length

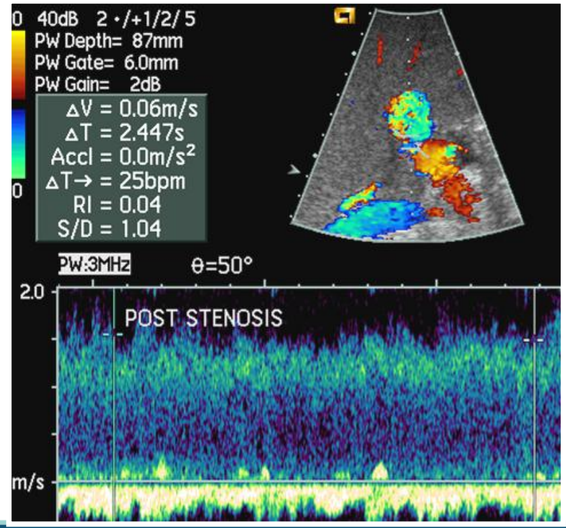
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative



Portal Vein Stenosis







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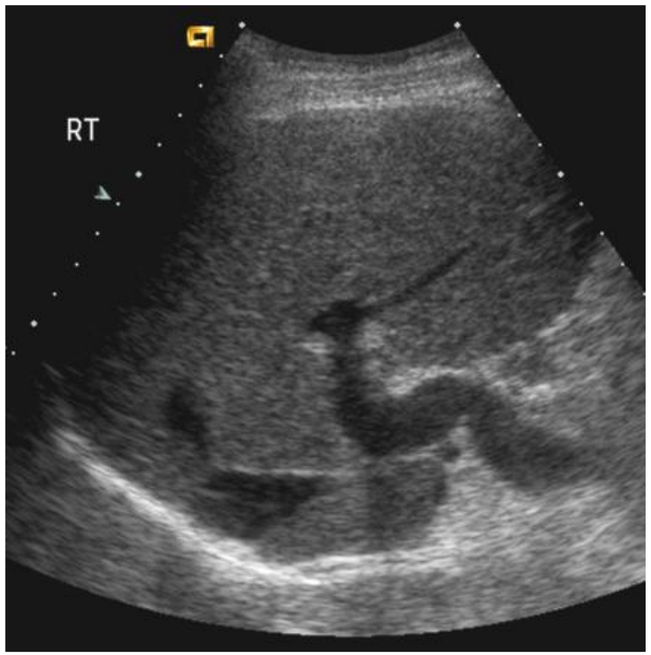
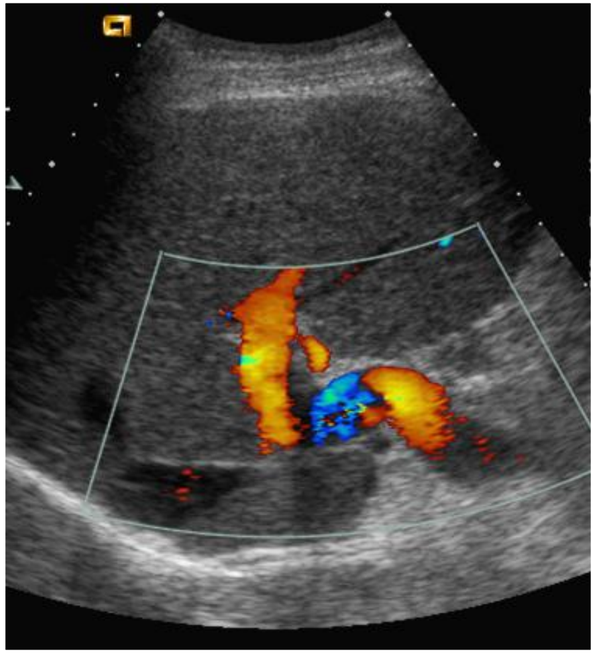
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Redundant
Portal Vein





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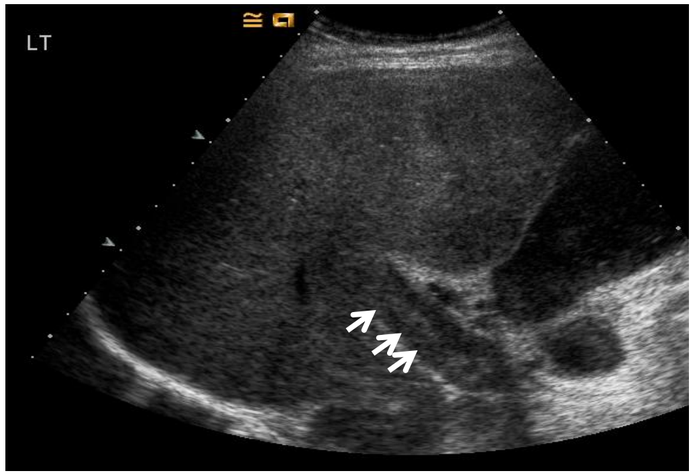
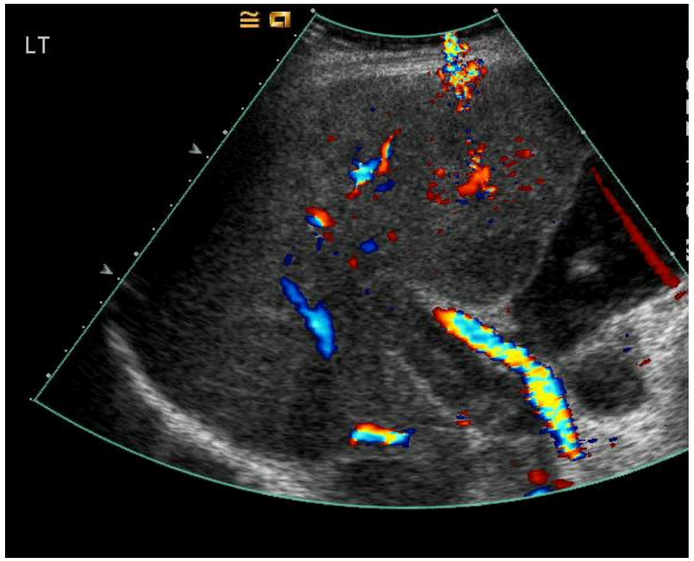
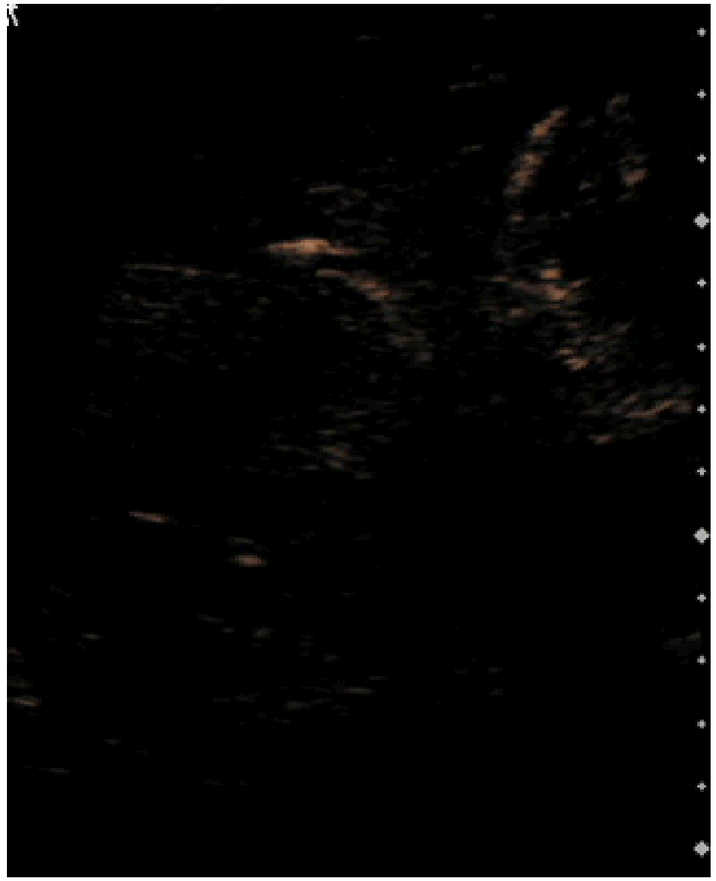
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative





Portal Vein Thrombus



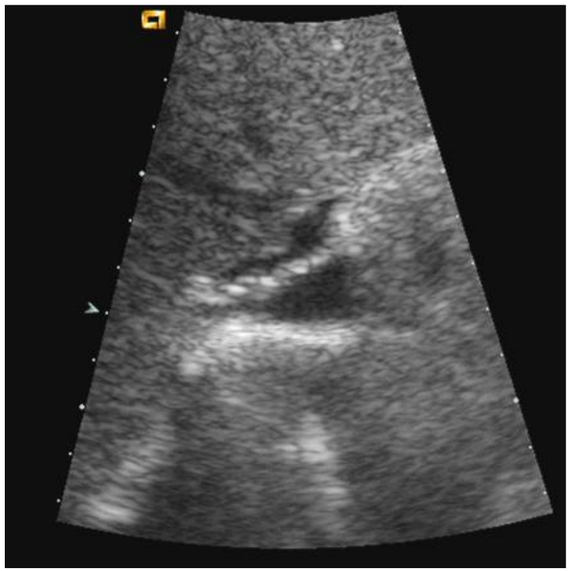
Risk factors that predispose to PV complications

- Hypercoagulable states
- Decreased portal vein inflow
- Porto-systemic shunts
- Prior splenectomy
- Twisting/kinking of the vascular conduit
- Tension in the portal vein graft

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Inferior Vena Cava and Hepatic Veins stenosis

- Rare complication either at the supra-hepatic or infra-hepatic IVC anastomosis

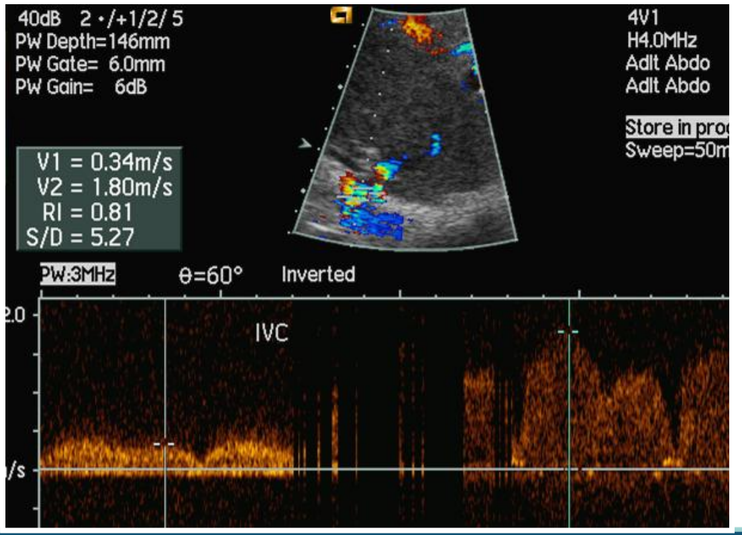


Hepatic vein stenosis

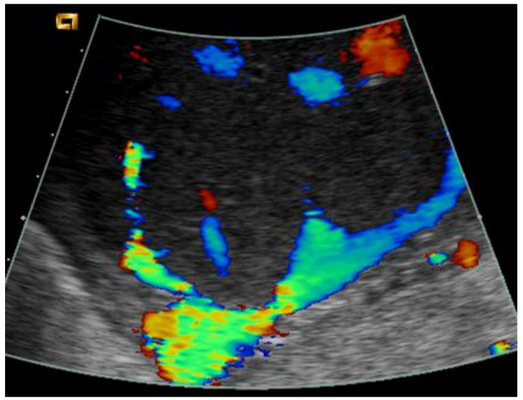
- Usually comprised in ‘piggy-back’ procedures

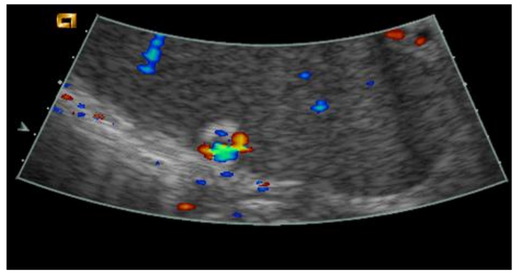
Hepatic vein thrombosis

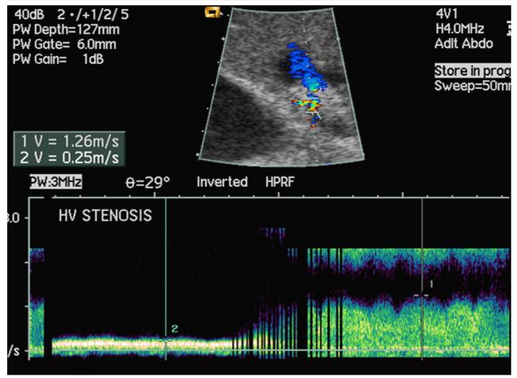
- Rare, <1% of patients, usually with Budd-Chiari syndrome



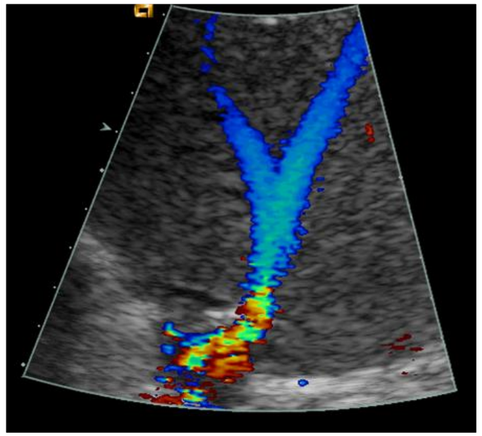
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative





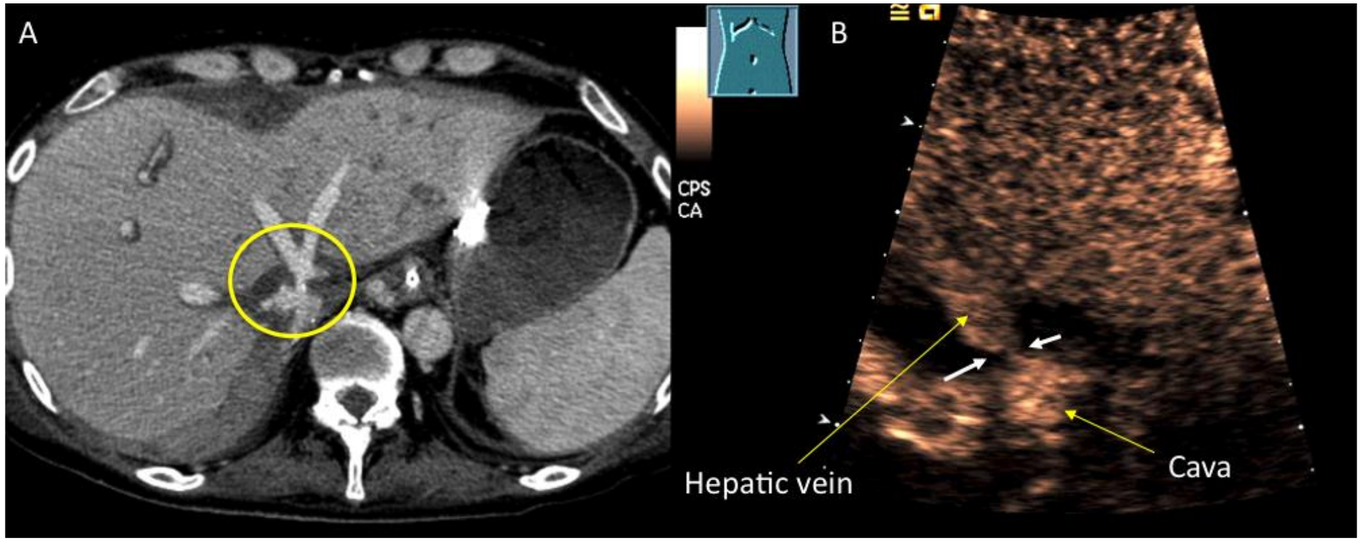


IVC Stenosis



‘Piggyback’ Transplant

HV/IVC Stenosis

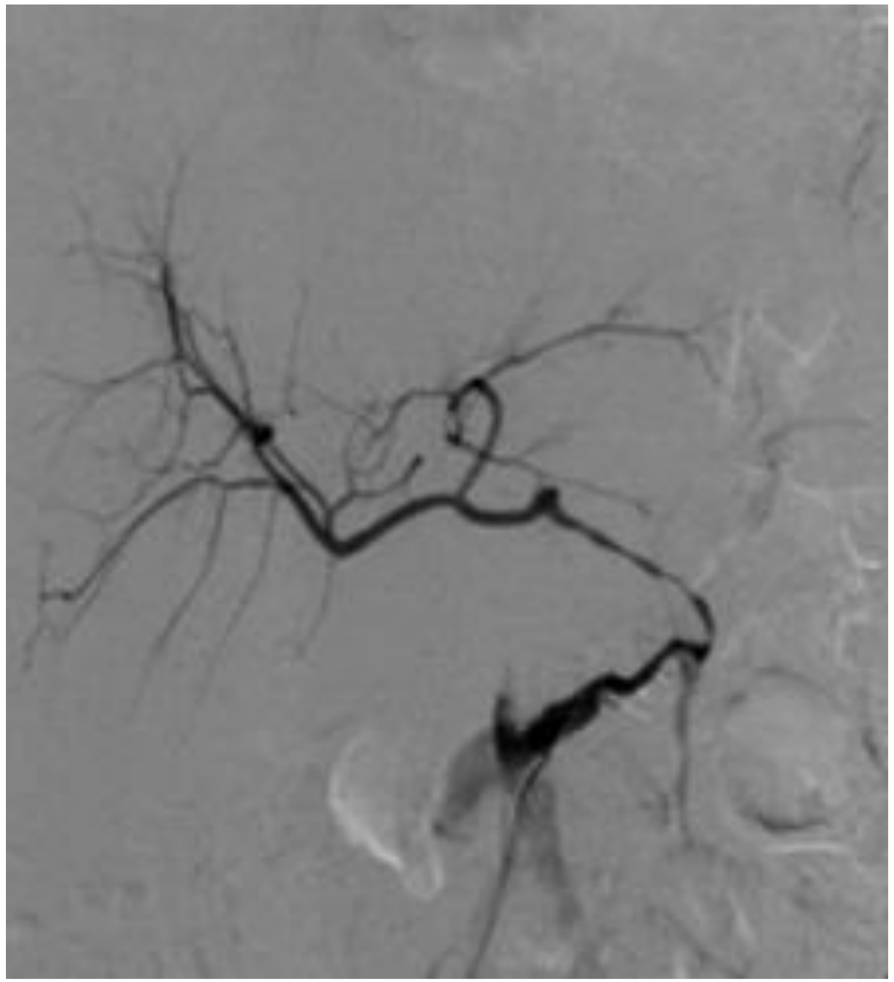


Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Non-Vascular complications

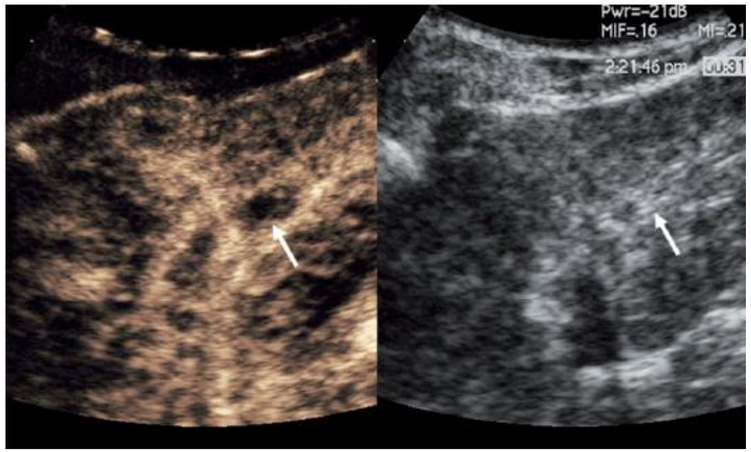
Graft Rejection

- Common serious complication (30%)
- Non-anastomotic vascular stenosis
- No correlation with RI in the HA
- No correlation with HV profile
- No reliable non-invasive diagnostic test
- US excludes other causes prior to biopsy



Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

- Biliary tract
  - Biliary obstruction
    - Anastomotic, early and late
    - Non-anastomotic, poorer prognosis
  - Bile leakage
    - Secondary to anastomotic complications
  - Generalised bile duct changes
    - Recurrent sclerosing cholangitis
    - Biliary sludge and stones



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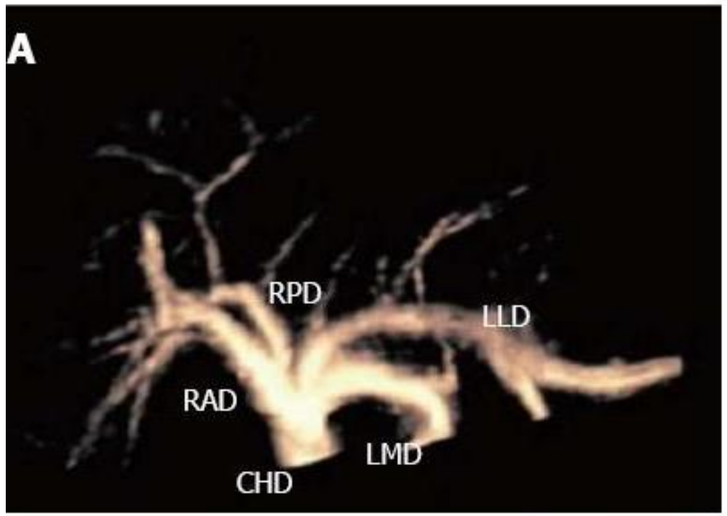
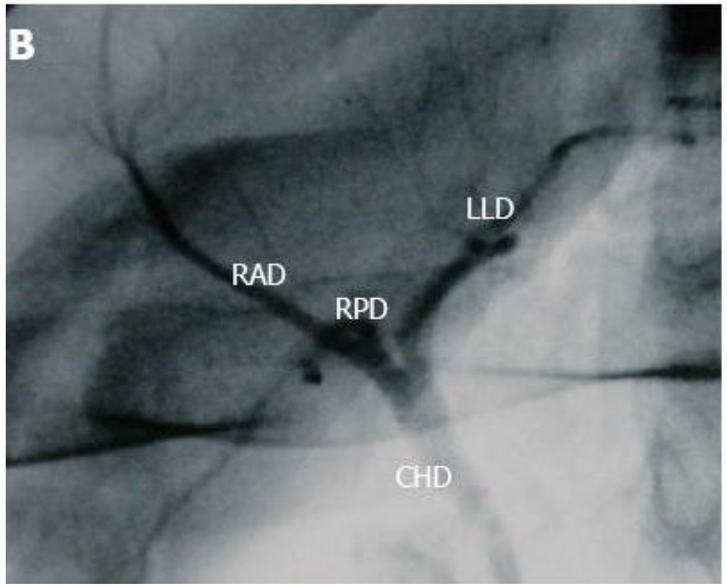
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative





Endocavitary contrast enhanced ultrasound (CEUS): a novel problem solving technique

G. T. Yusuf[1] · C. Fang[1] · D. Y. Huang[1] · M. E. Sellars[1] · A. Deganello[1] · P. S. Sidhu[1]

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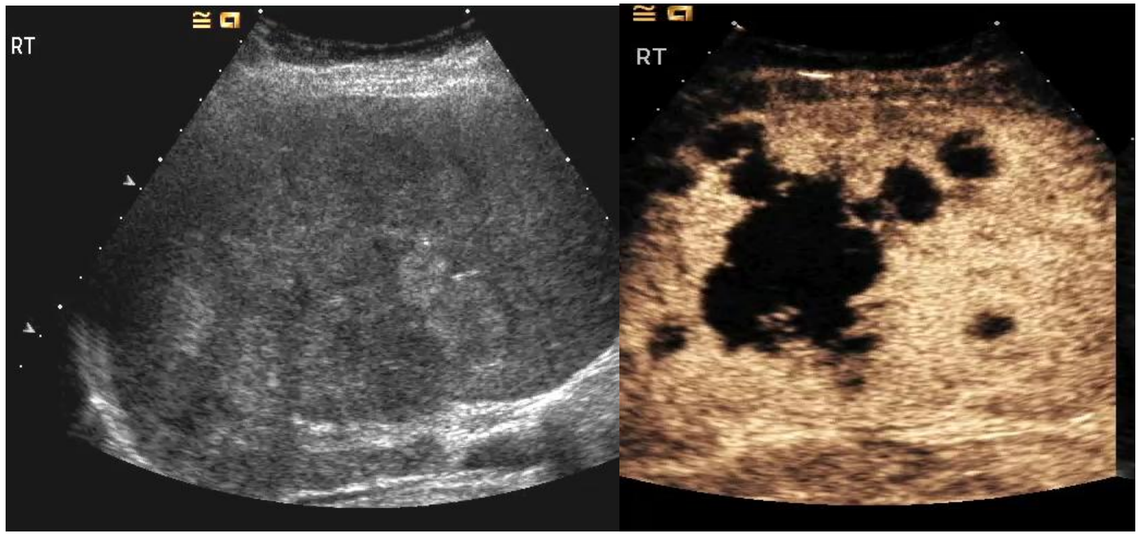
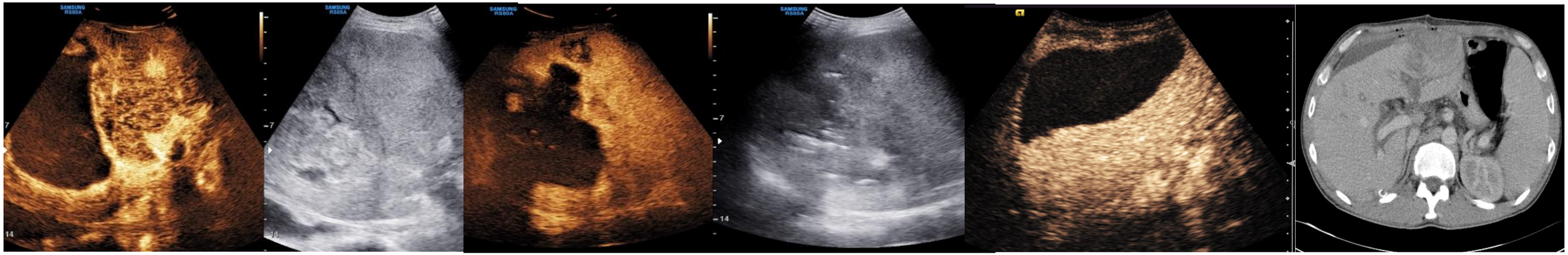
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Miscellaneous

- Intra-hepatic abscess/Abdominal
- Post-Transplant Lymphoproliferative Disorder
- Recurrent malignancy
- Pancreatitis
- Adrenal Infarction
- Collections





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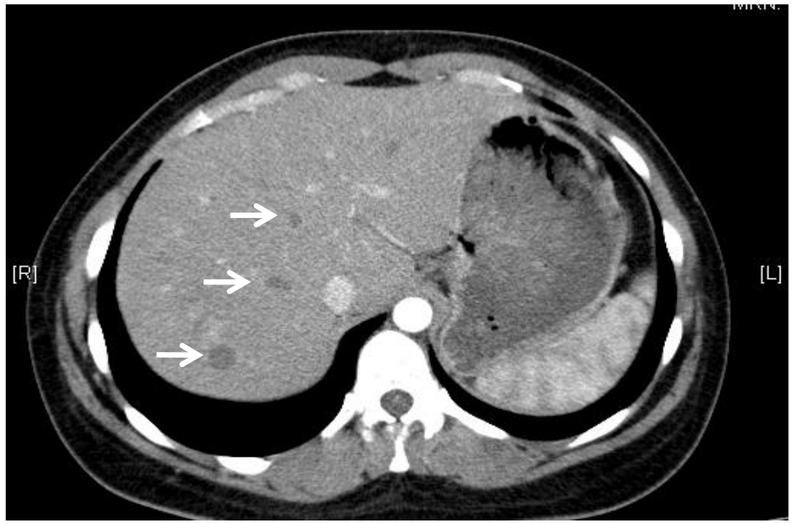
Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Post-Transplant Lymphoproliferative Disorder

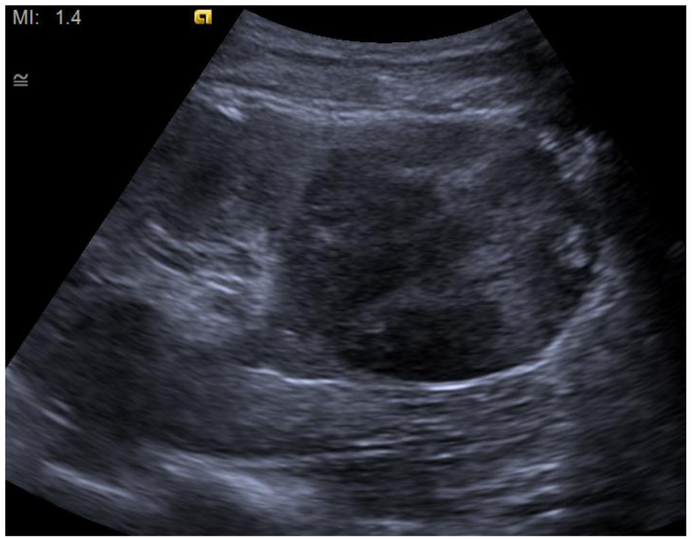
- Three distinct patterns;
  - Localised areas of low reflectivity with increase in vascularity
  - Diffuse involvement resulting in hepatomegaly
  - Disease at the porta-hepatis arising in the biliary tree
- Gastrointestinal tract involvement occurs in 30%
- Splenic involvement occurs in 28%
- Lymph node involvement occurs in 20%

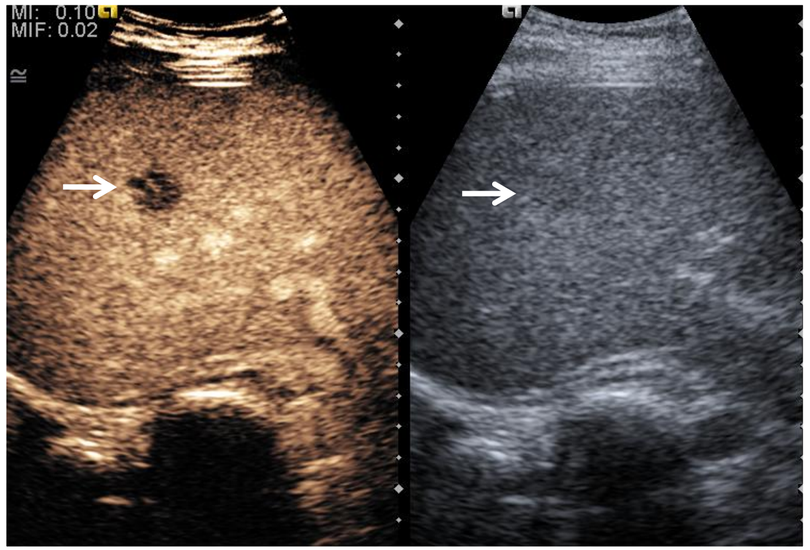
- Due to B-cell proliferation
- Clinically; infectious mononucleosis-like syndrome to overt lymphoma
- Associated with the Epstein-Barr virus
  - 2.9 – 18.9% children
  - 2.0 – 10% adults
- Mirror appearances seen in AIDS associated lymphomas

Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative



- Diagnosis involves biopsy and histological supported by imaging
- Treatment depends on PTLD type and severity
- Reduction of immunosuppression often effective in early lesions
- Chemotherapy for aggressive or refractory cases
- Monitoring for graft rejection when immunosuppression reduced





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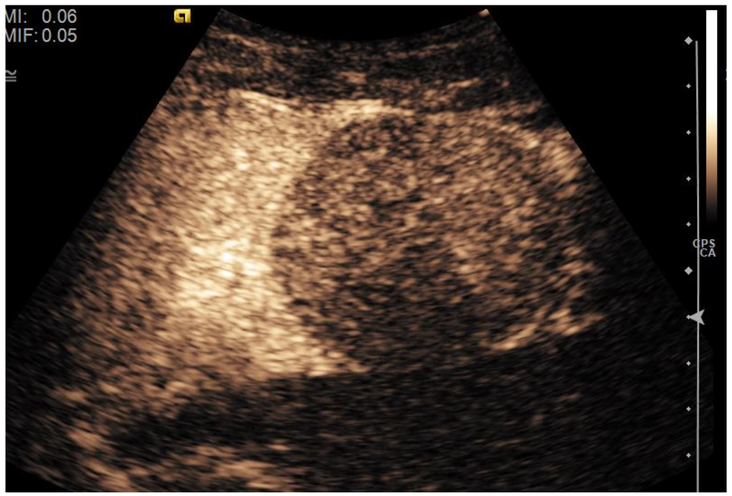
Brief Report

DOI: 10.5582/irdr.2024.01032

The value of contrast-enhance ultrasound in the diagnosis of hepatic post-transplant lymphoproliferative disease: Four case reports

Xingqi Lu[1,2], Jingtong Yu[1,2], Litao Ruan[1], Kazushi Numata[3], Dong Zhang[4], Feiqian Wang[1,*]



Contrast Enhanced Ultrasound (CEUS) in Liver Transplantation: Complications Post-Operative

Summary

- Ultrasound is the ideal imaging modality in the immediate post transplant patient
- Addition of colour Doppler allows for excellent investigation of the hepatic artery, portal vein and hepatic veins
- Complications are identified early to allow for prompt management
- Addition of CEUS aids the ultrasound examination, often as a problem-solving tool
- This may obviate the need for further imaging
- Both intravascular and intra cavitary CEUS is useful in many clinical scenarios


Thank You