CEUS of the abdomen in 2017

Olivier Lucidarme
Pitié Salpêtrière – UPMC/Sorbonne University
Paris France

CARACTÉRISTIQUES DES MICROBULLES

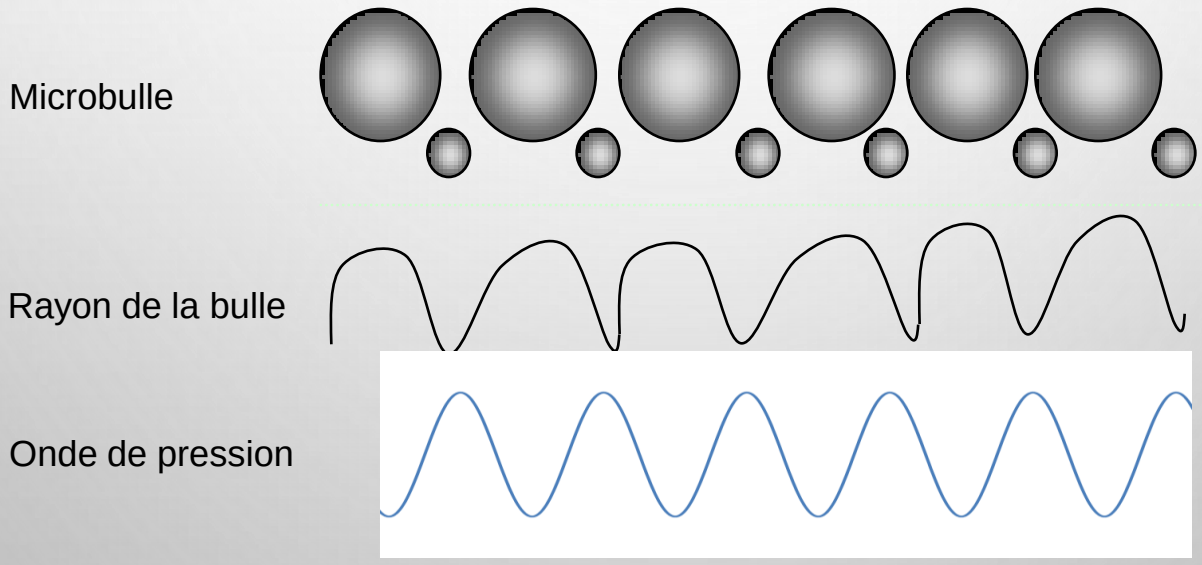
- Impératifs de taille
  - Capillaires pulmonaires : 7 μm (<15μm)
- Impératifs de stabilité (tension de surface)
  - Dissolution en fonction
    - Du diamètre initial
      - Une bulle d'air de 1 μm se dissout en 0,01 sec
      - Une bulle d'air de 10 μm se dissout en 1 sec

STABILITÉ DES MICROBULLES

- **La stabilité d'une microbulle peut être améliorée :**
  - En augmentant le diamètre de la bulle
  - En choisissant un gaz peu soluble
    - Perfluorocarbone, hexafluorure de souffre
  - En diminuant le coefficient de diffusion
    - Encapsulation

NON LINÉARITÉ LOCALE : LES MICROBULLES

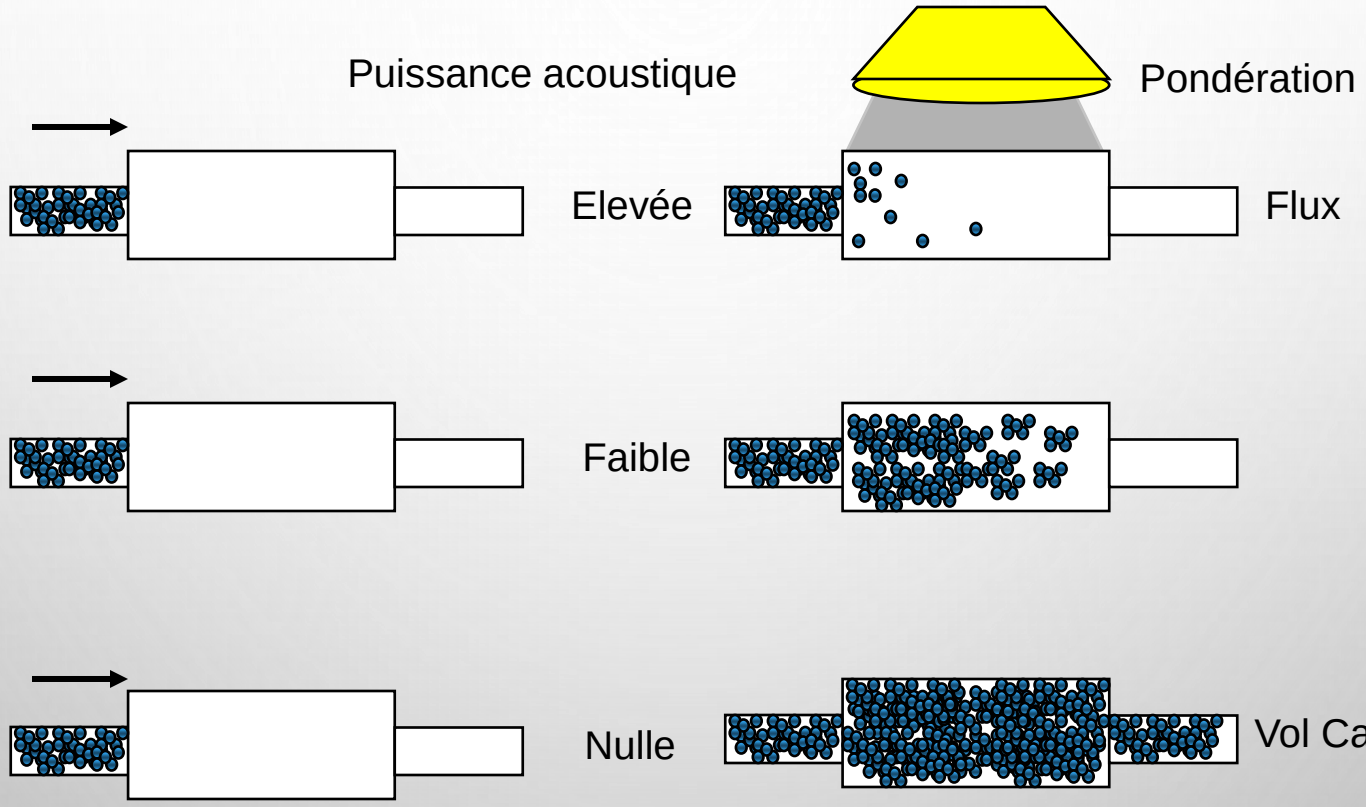
- **Puissance intermédiaire (> ~100 kPa,< ~ 1 MPa)**
  - **vibration non linéaire (rétrodiffusion à des fréquences harmoniques)**



NON LINÉARITÉ LOCALE : LES MICROBULLES

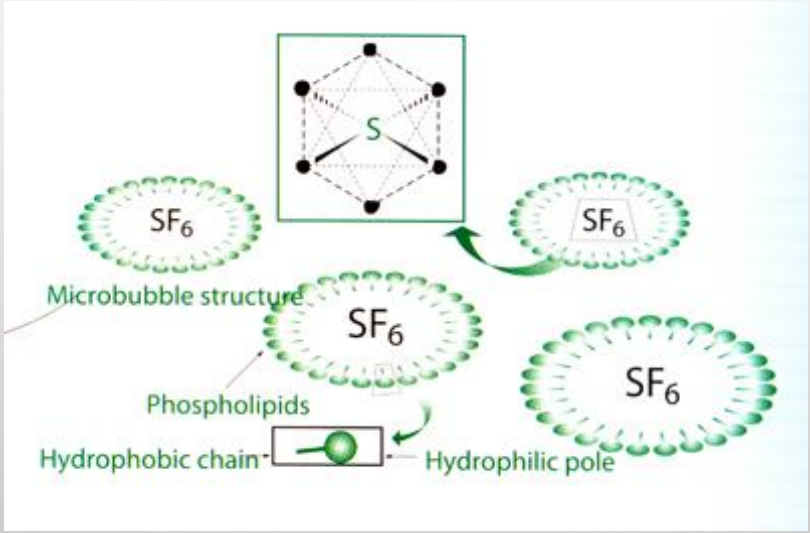
- **Très forte puissance acoustique (> 1 MPa)**
  - **destruction des microbulles (production d'un signal très intense et bref, très riche en fréquences harmoniques).**

LA DESTRUCTION DES BULLES



PRODUITS DE CONTRASTE

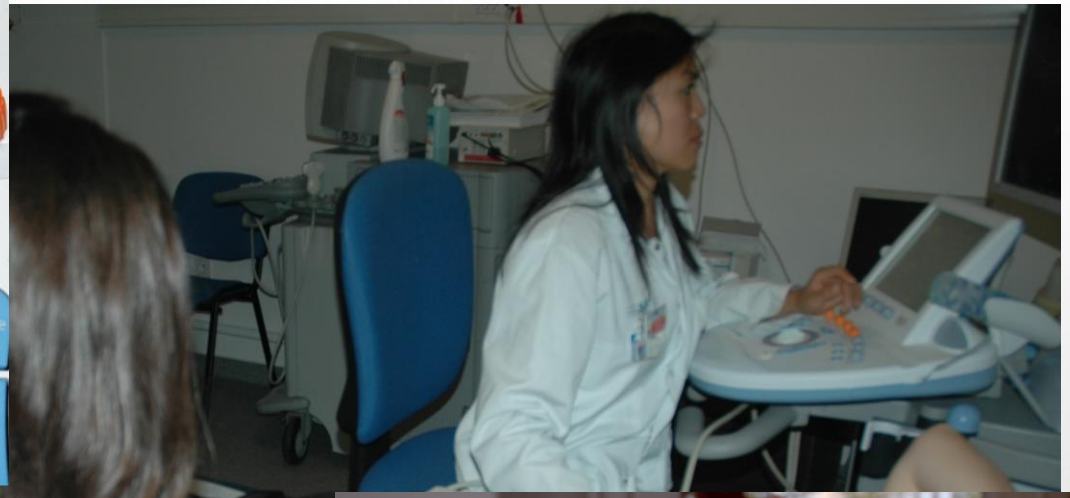
- Sonovue (Bracco)
  - Microbulles d'hexafluorure de souffre stabilisée par une enveloppe de phospholipide

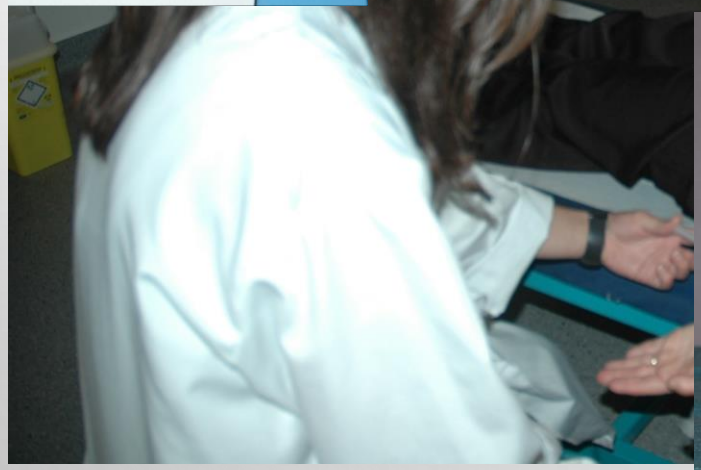


SONOVUE

- Flacon de 25 mg de poudre lyophilisée de phospolipides dans une atmosphère de gaz d'hexafluorure de souffre à 100% + 5 ml de Serum physiologique en seringue
- Stable 6 heures après reconstitution mais doit être utilisé immédiatement d'un point de vue microbiologique
- Conserve 2 ans à température ambiante


CEUS
Q/R
Fin
Exam
Patient
Mesure
Annot.





SONOVUE

- L’hexafluorure de souffre se dissout et est évacué par le poumon
  - Demi-vie : 12 min

EFFETS INDÉSIRABLES

- Céphalées
- Nausées
- Douleur au point d'injection
- Sensation de brûlure ou de paresthésies
- Modification transitoire de l'ECG, de la glycémie
- Vision floue, sensation de douleur au niveau des sinus
- **Allergie à l'hexafluorure de souffre**

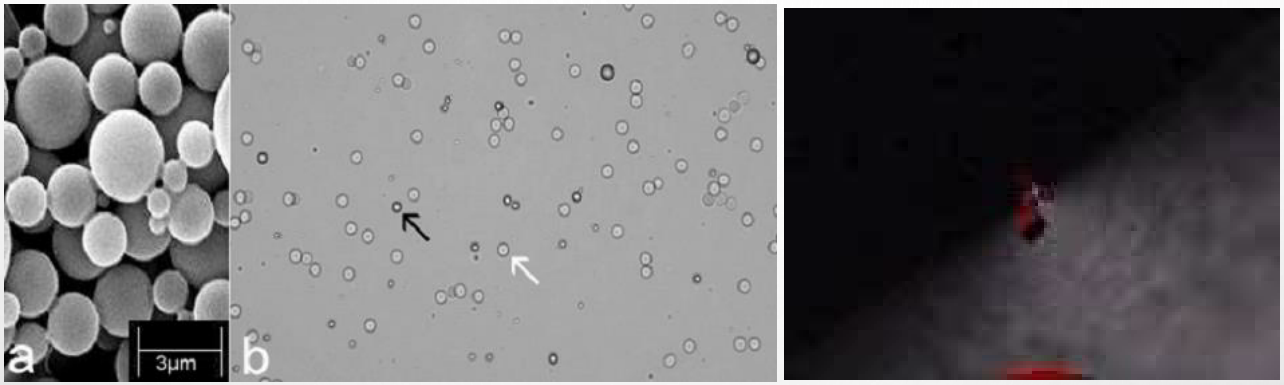
CONTRE INDICATIONS

- **Allergie à l'hexafluorure de souffre ou à un des composants**
- Syndrome de détresse respiratoire
- **Grossesse et allaitement**
- Insuffisance cardiaque aigue ou grave

PRIX (2010)

- **En ville (remboursé à 65%)**
  - 92,44 €
- **APHP**
  - 70 €

US CONTRAST AGENTS



- Microbubbles d’hexafluorure de souffre
- SonoVue®
- Diametre 3-7microns
- Blood pool agent

Guidelines and Good Clinical Practice Recommendations for Contrast Enhanced Ultrasound (CEUS) –

Ultrasound in Med. & Biol., Vol. 39, No. 2, pp. 187–210, 2013

0301-5629/$ - see front matter

ELSEVIER

http://dx.doi.org/10.1016/j.ultrasmedbio.2012.09.002

● *Guideline*

GUIDELINES AND GOOD CLINICA… …OMMENDATIONS FOR CONTRAST ENHANCED ULTRA… …THE LIVER – UPDATE 2012 A WFUMB-EFSUMB INITIATI… …ION WITH REPRESENTATIVES OF AFSU… …, FLAUS AND ICUS

MICHEL CLAUDON,[1,*] …H,[2,*] BYUNG IHN CHOI,[3] DAVID O. COSGROVE,[4] MASATOSHI KUD… …LSØE,[6] FABIO PISCAGLIA,[7] STEPHANIE R. WILSON,[8] RICHARD G. BARR… …HAMMAS,[10] NITIN G. CHAUBAL,[11] MIN-HUA CHEN,[12] DIRK ANDRE CLEVERT,… …MICHEL CORREAS,[14] HONG DING,[15] FLEMMING FORSBERG,[16] J. BRIAN FOWLKES,[17] ROBERT N. GIBSON,[18] BARRY B. GOLDBERG,[19] NATHALIE LASSAU,[20] EDWARD L. S. LEEN,[21] ROBERT F. MATTREY,[22] FUMINORI MORIYASU,[23] LUIGI SOLBIATI,[24] HANS-PETER WESKOTT,[25] and HUI-XIONG XU[26]

EBM A & B
(evidence based medicine oxford Criteria)

…C. Dietrich[9], …D. Lindsell[18], …, L. Thorelius[27],

…s 1

The Clin… (CE…

Piscaglia F. et coll. Ultraschall Med 2011; 32:1-27

Authors F. Piscaglia[1], C. Nolsøe[2], C. F. Dietrich[3], D. O. Cosgrove[4], O. H. Gilja[5], M. Bachmann Nielsen[6], T. Albrecht[7], L. Barozzi[8], M. Bertolotto[9], O. Catalano[10], M. Claudon[11], D. A. Clevert[12], J. M. Correas[13], M. D'Onofrio[14], F. M. Drudi[15], J. Eyding[16], M. Giovannini[17], M. Hocke[18], A. Ignee[19], E. M. Jung[20], A. S. Klauser[21], N. Lassau[22], E. Leen[23], G. Mathis[24], A. Saftoiu[25], G. Seidel[26], P. S. Sidhu[27], G. ter. Haar[28], D. Timmerman[29], H. P. Weskott[30]

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

Macrovascular system

- **Macro vessels indications:**
  - **Extracranial Carotids** (Recommendation level: B,3)
    - To improve the delineation of the endovascular borders in difficult cases
    - For distinguishing occlusion from tight sub-occlusive stenosis

*Clevert. Clin Hemorheol Microcirc 2008; 39: 121–132
*Pfister . Clin Hemorheol Microcirc 2009; 43: 119–128

Macrovascular system

- **Macro vessels indications:**
  - **Extracranial Carotids** (Recommendation level: B,3)
    - To improve the delineation of the endovascular borders in difficult cases
    - For distinguishing occlusion from tight sub-occlusive stenosis
  - **Aorta** (Recommendation level: A,1a)
    - To identify and follow-up endoleaks after AAA repair
    - CEUS > CT angiography*
    - Renal impairment.

Courtesy Dr Corinne Gautier CHU Lille

*Clevert. Clin Hemorheol Microcirc 2008; 39: 121–132
*Pfister . Clin Hemorheol Microcirc 2009; 43: 119–128

Macrovascular system

- **Macro vessels indications:**
  - **Extracranial Carotids** (Recommendation level: B,3)
    - To improve the delineation of the endovascular borders in difficult cases
    - For distinguishing occlusion from tight sub-occlusive stenosis
  - **Aorta** (Recommendation level: A,1a)
    - To identify and follow-up endoleaks after AAA repair
    - CEUS > CT angiography*
    - Renal impairment.
  - **Trans cranial Doppler** (Recommendation level: A,1b)
    - Diagnostic when unsatisfactory intracerebral information with non-enhanced transcranial colour duplex sonography.

*Clevert. Clin Hemorheol Microcirc 2008; 39: 121–132
*Pfister . Clin Hemorheol Microcirc 2009; 43: 119–128

Microvasculature

Liver / Kidney

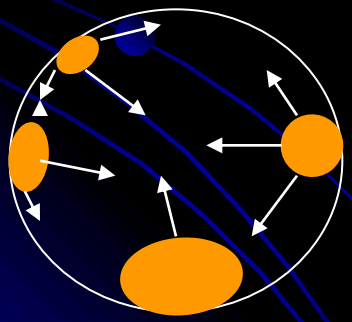
Interesting Feature #1 : TOLERANCE

- Extremely good tolerance in clinical practice
  - No nephrotoxicity,
  - No thyroid interaction
  - No need of Blood test before IV
- Rare anaphylactoïd reaction (≈ Gd chelates)
  - incidence < 0,002%
  - no cross allergy with Iodine contrast
- Do not use in case of pregnancy and Breast feeding (precaution)

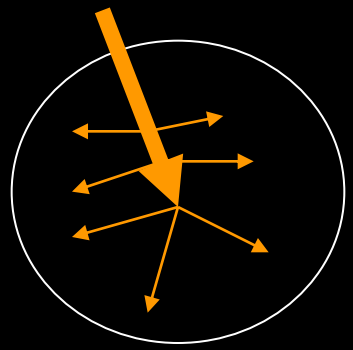
=> **Can be used when Iodine and Gadolinium cannot**

Interesting Feature #2

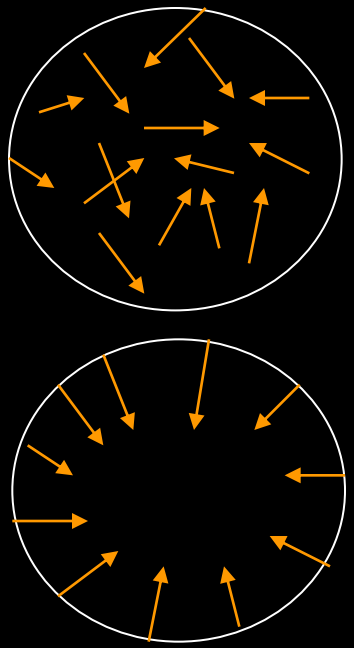
- **Early Phase**
  - Higher temporal resolution than CT or MRI



Hemangiomas



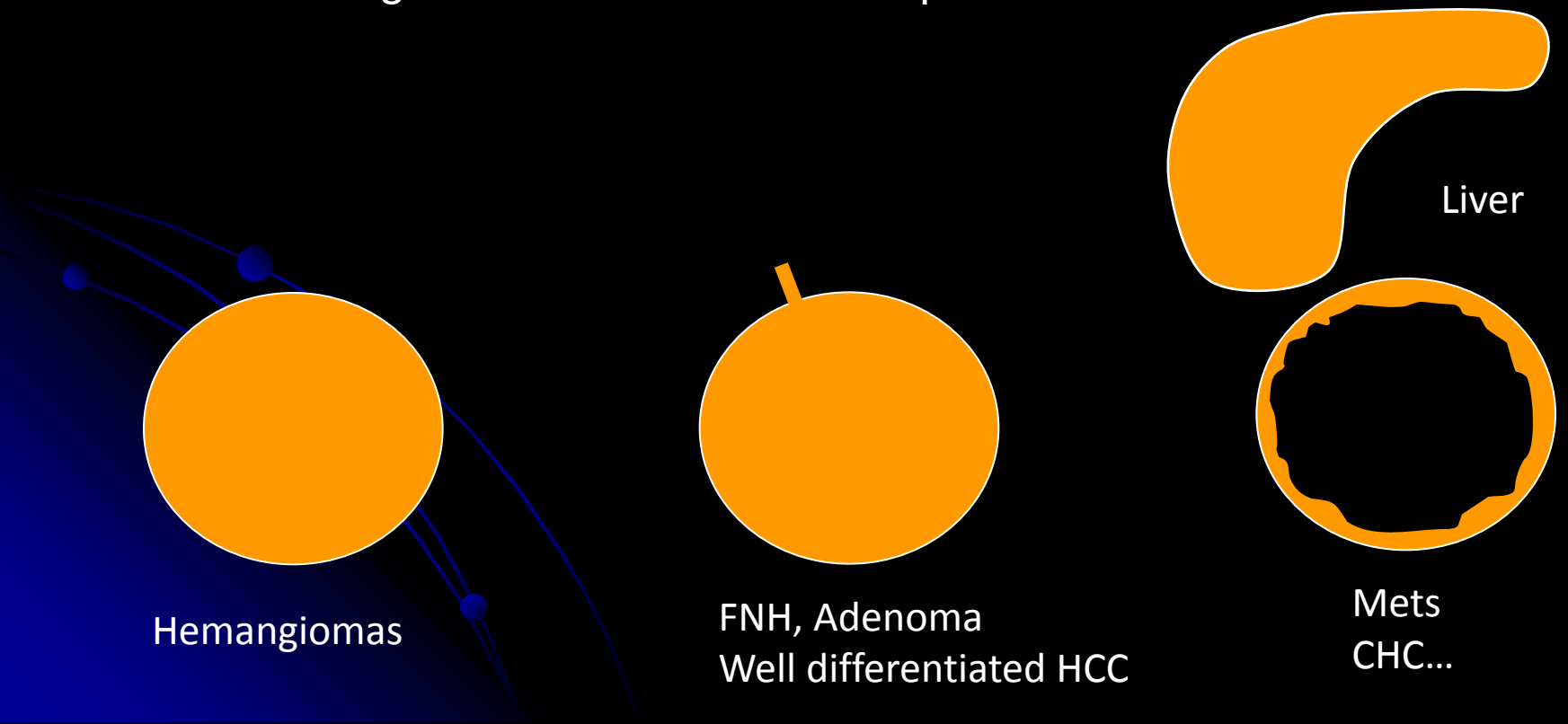
FNH



Adenoma
Mets
HCC…

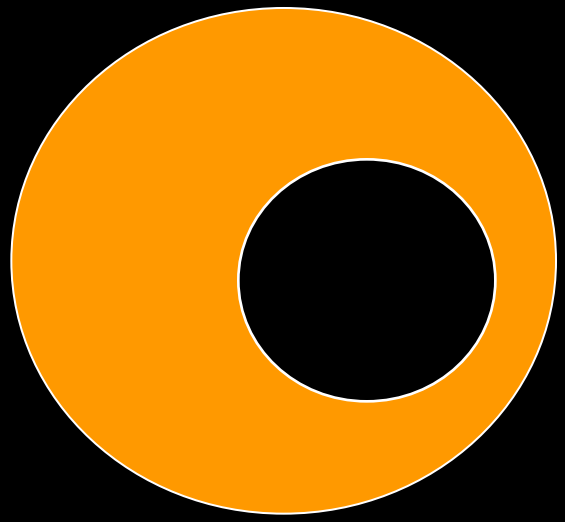
Interesting Feature #3

- **Late phase**
  - Iodine/gado : extravascular leaking ++ if tumoral vessels
  - Microbubbles :
    - Wash-out if tumoral vessels
    - Stagnation in the sinusoid capillaries or venous lakes

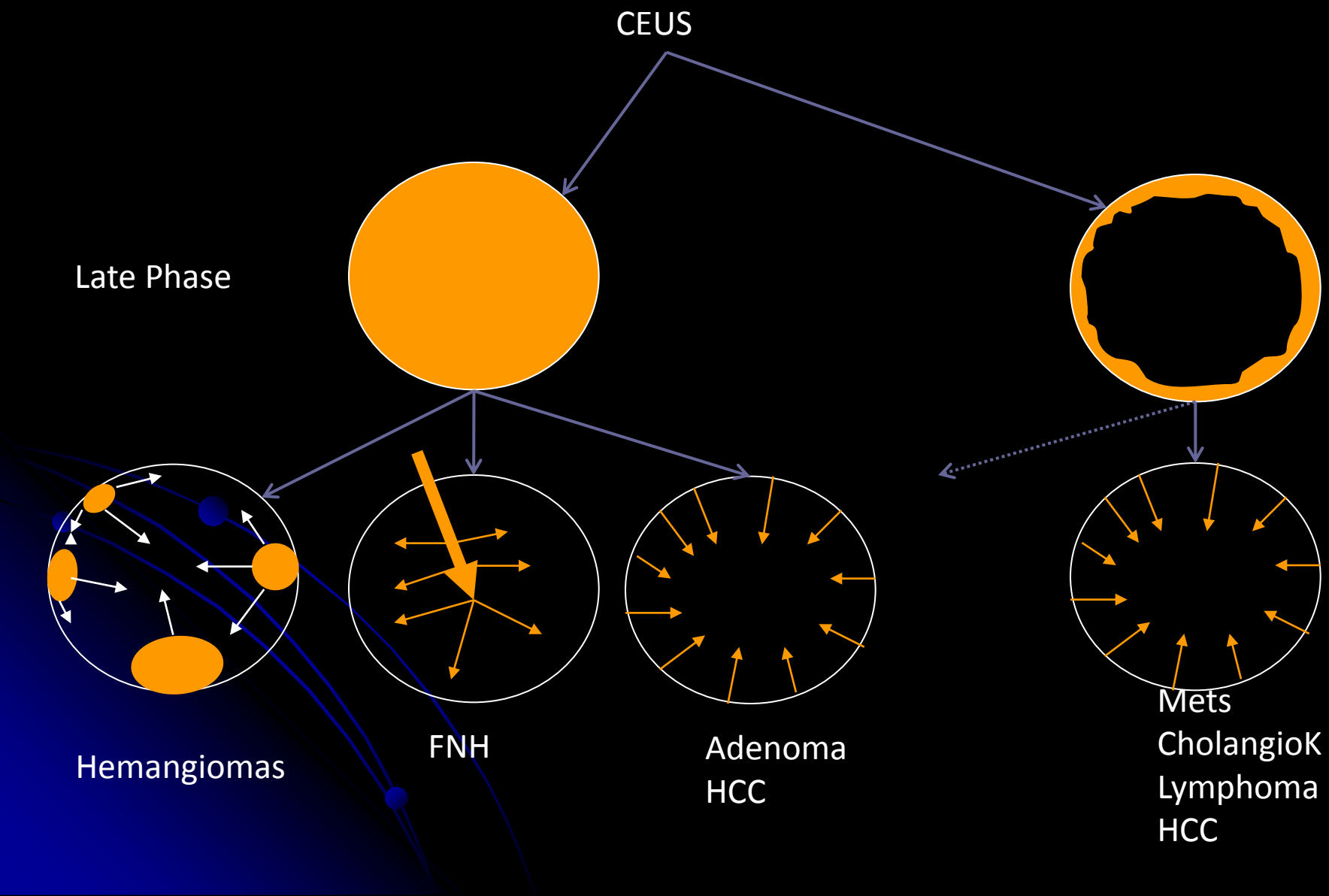


Interesting Feature #4

- **All Phases**
  - Higher sensitivity to low amount of circulating contrast
  - No enhancement means no (or almost no) circulating vessels



Liver Tumours

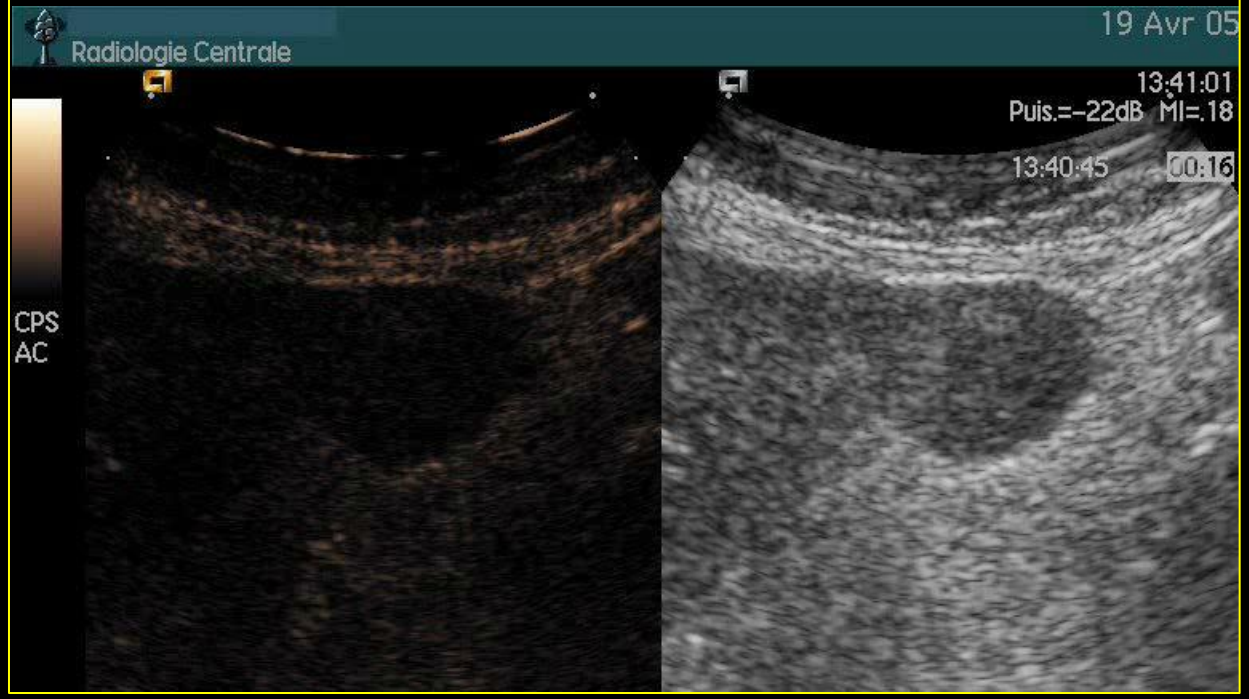


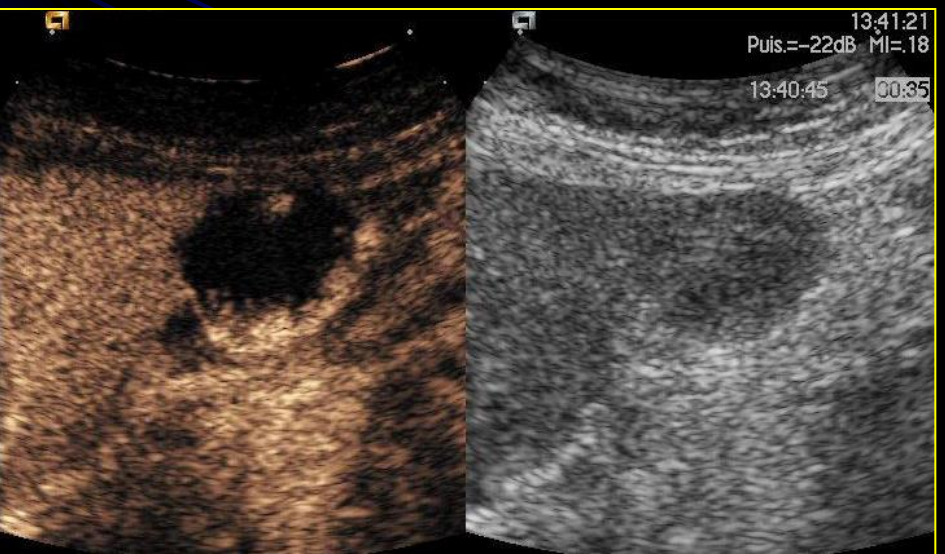
Microvasculature

Liver / Kidney

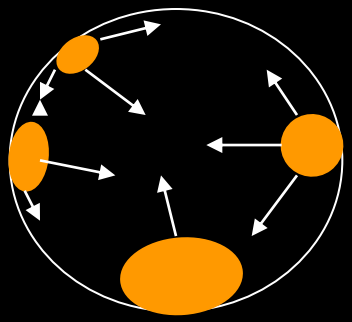
FLL in healthy liver


SEGT III
Puis.=0dB
MI=1.9
----1----
Dist = 2.80cm
----2----
Dist = 2.60cm
----3----
Dist = 3.72cm

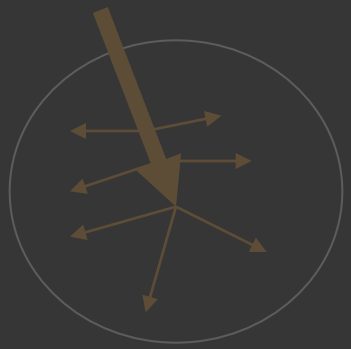

Radiologie Centrale
19 Avr 05
13:41:01
Puis.=-22dB MI=.18
13:40:45
00:16
CPS
AC


13:41:21
Puis.=-22dB MI=.18
13:40:45
00:35

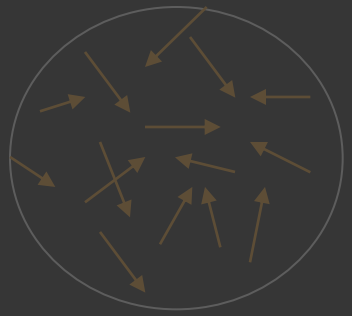

13:44:02
Puis.=-24dB MI=.15
13:40:45
03:16
03:23

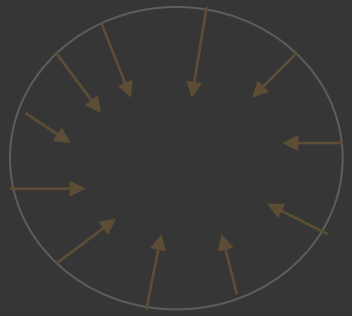


Hemangioma



HNF

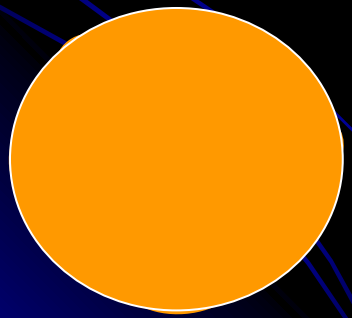




Adénomes
Meta
CHC…

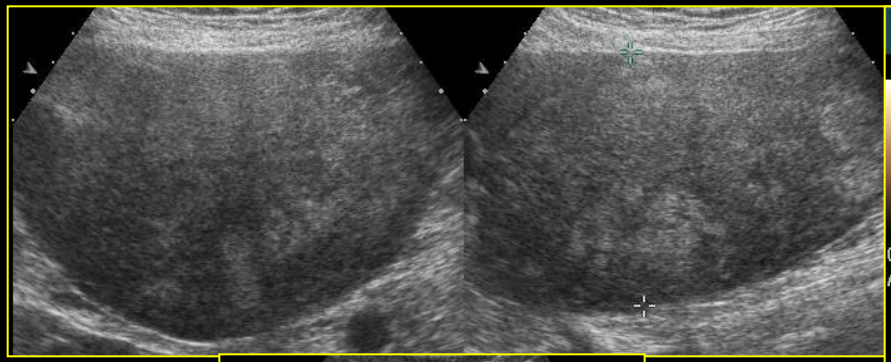
HNF, adénomes
CHC

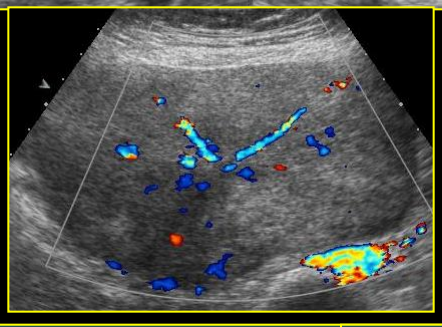
Meta
CHC…



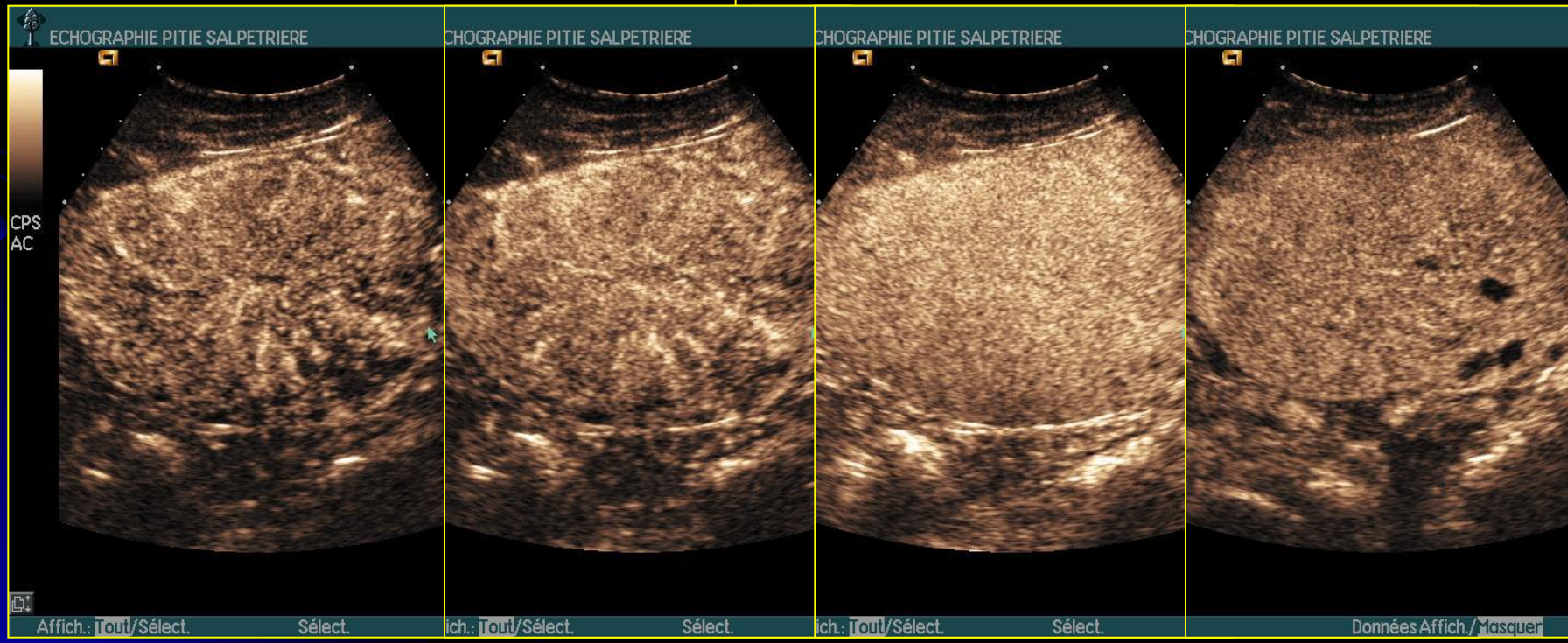
Hemangioma

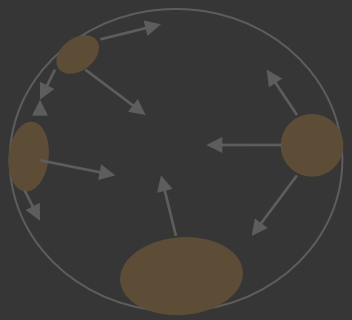

14 Nov 06
ECHOGRAPHIE PITIE SALPETRIERE
15:28:14
Puis.=-22dB MI=.17
00:15
CPS
AC
Sortir
Désactiver Horloge



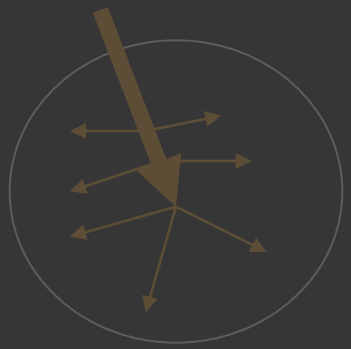



ECHOGRAPHIE PITIE SALPETRIERE
CHOGRAPHIE PITIE SALPETRIERE
CPS
AC

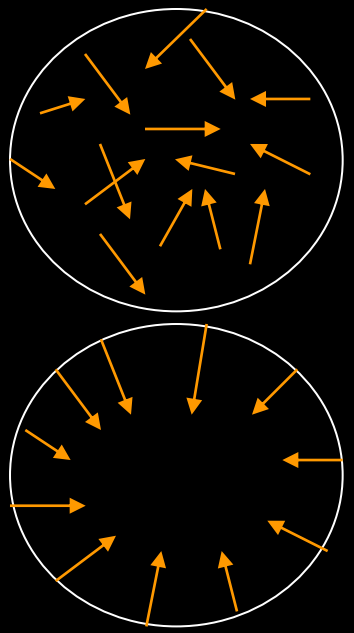

ECHOGRAPHIE PITIE SALPETRIERE
CHOGRAPHIE PITIE SALPETRIERE
CHOGRAPHIE PITIE SALPETRIERE
CHOGRAPHIE PITIE SALPETRIERE
CPS
AC
Affich.: Tout/Sélect. Sélect.
ich.: Tout/Sélect. Sélect.
ich.: Tout/Sélect. Sélect.
Données Affich./Masquer



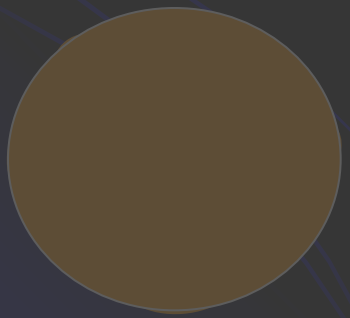
Angiomes



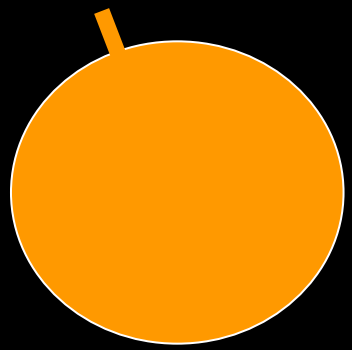
FNH



Adénomes
Meta
CHC…

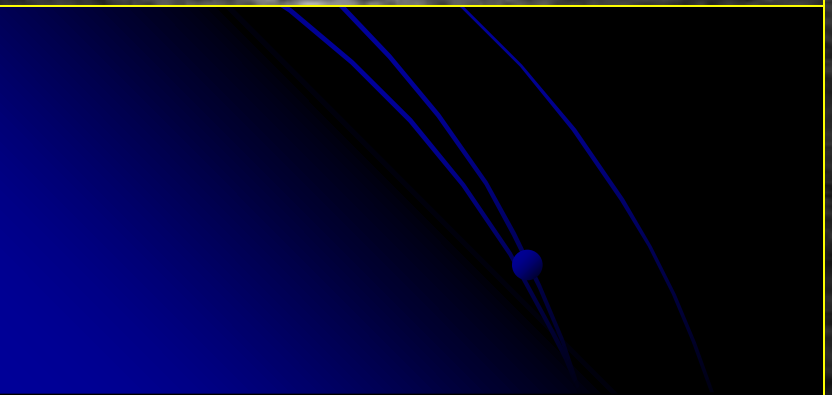
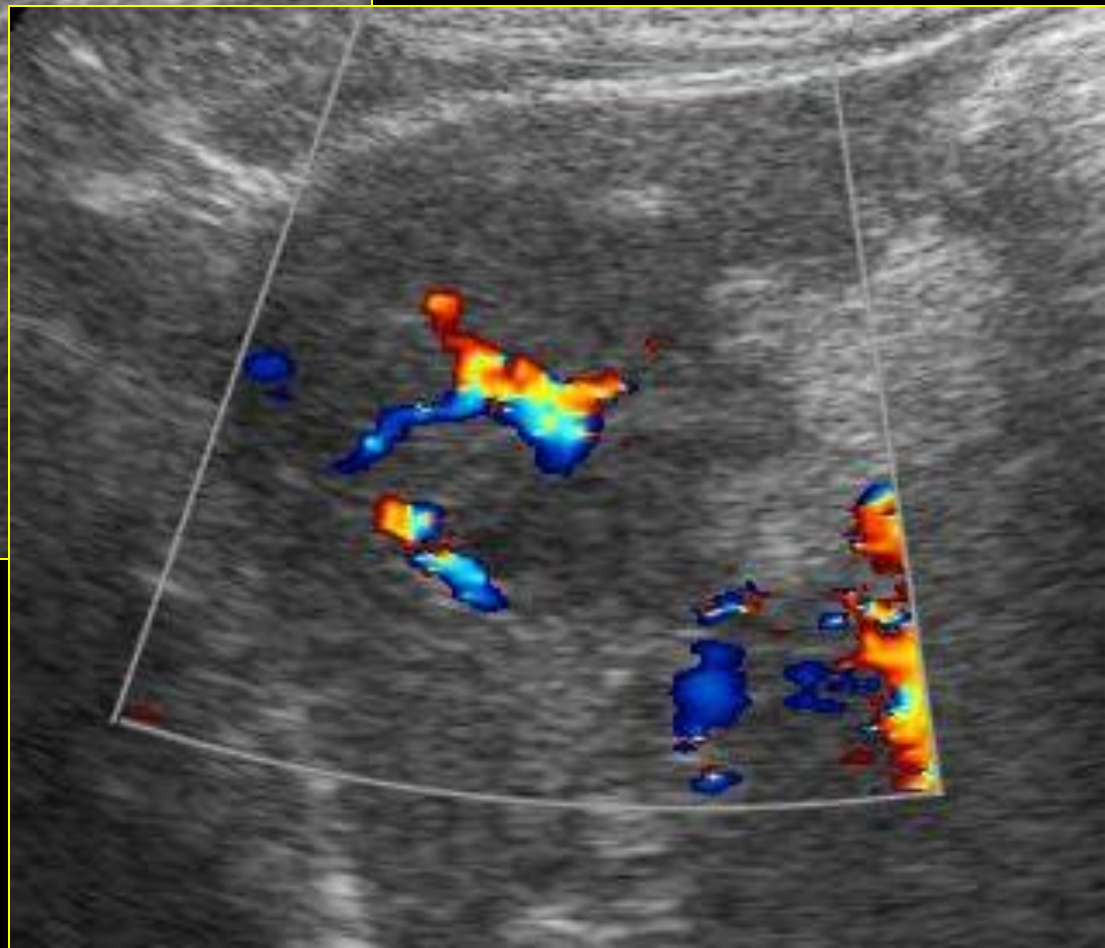


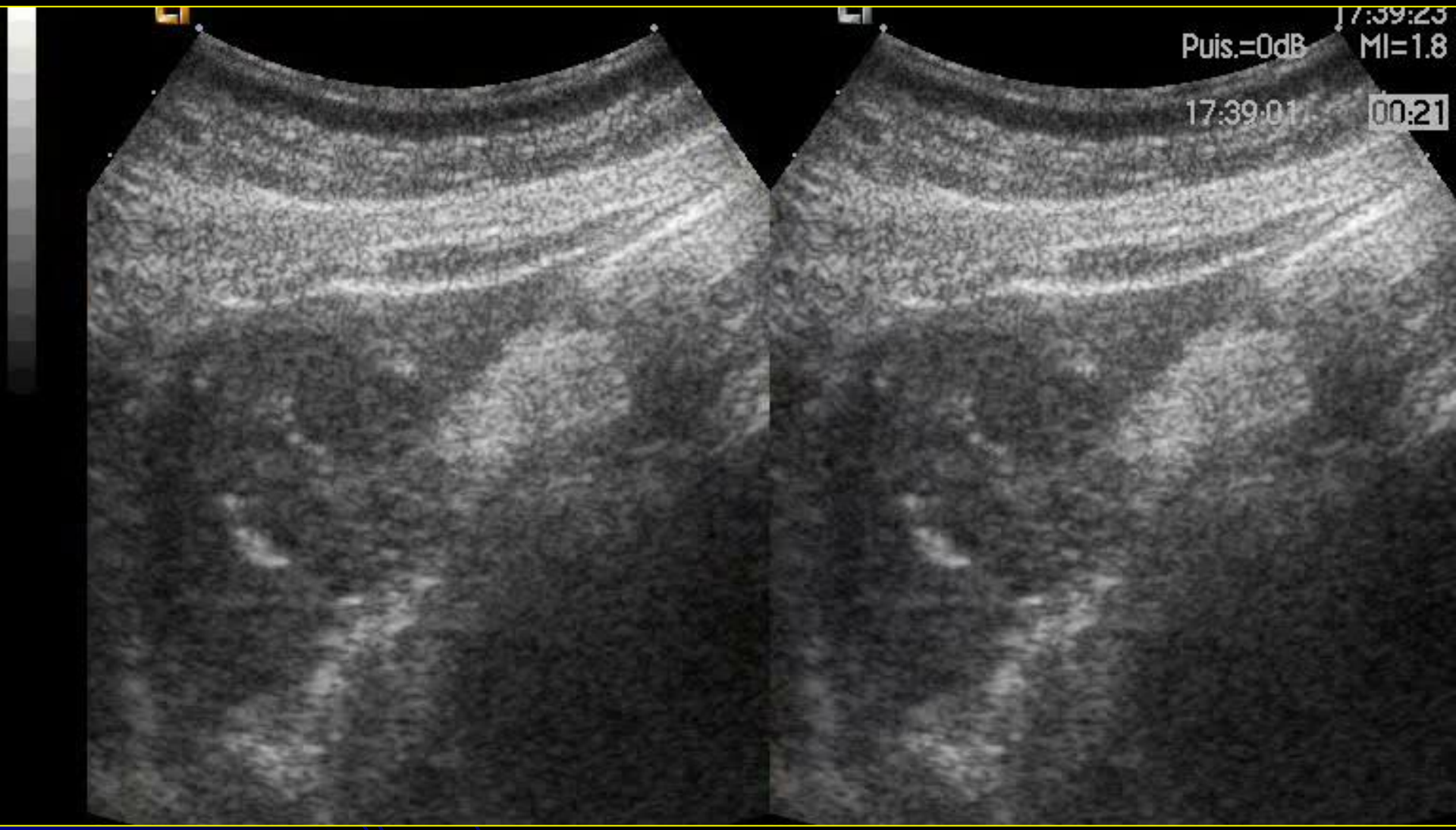
Angiomes

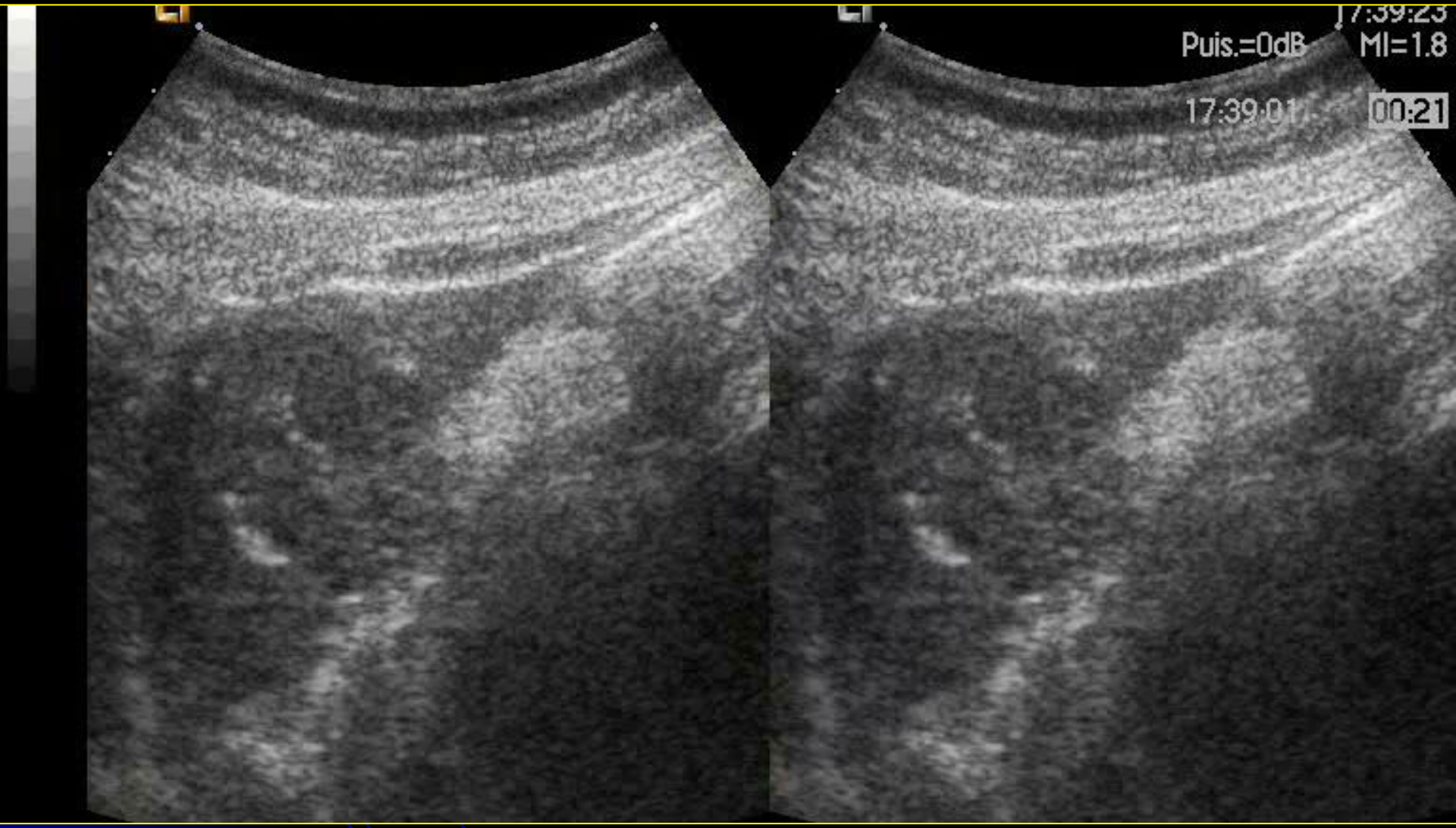


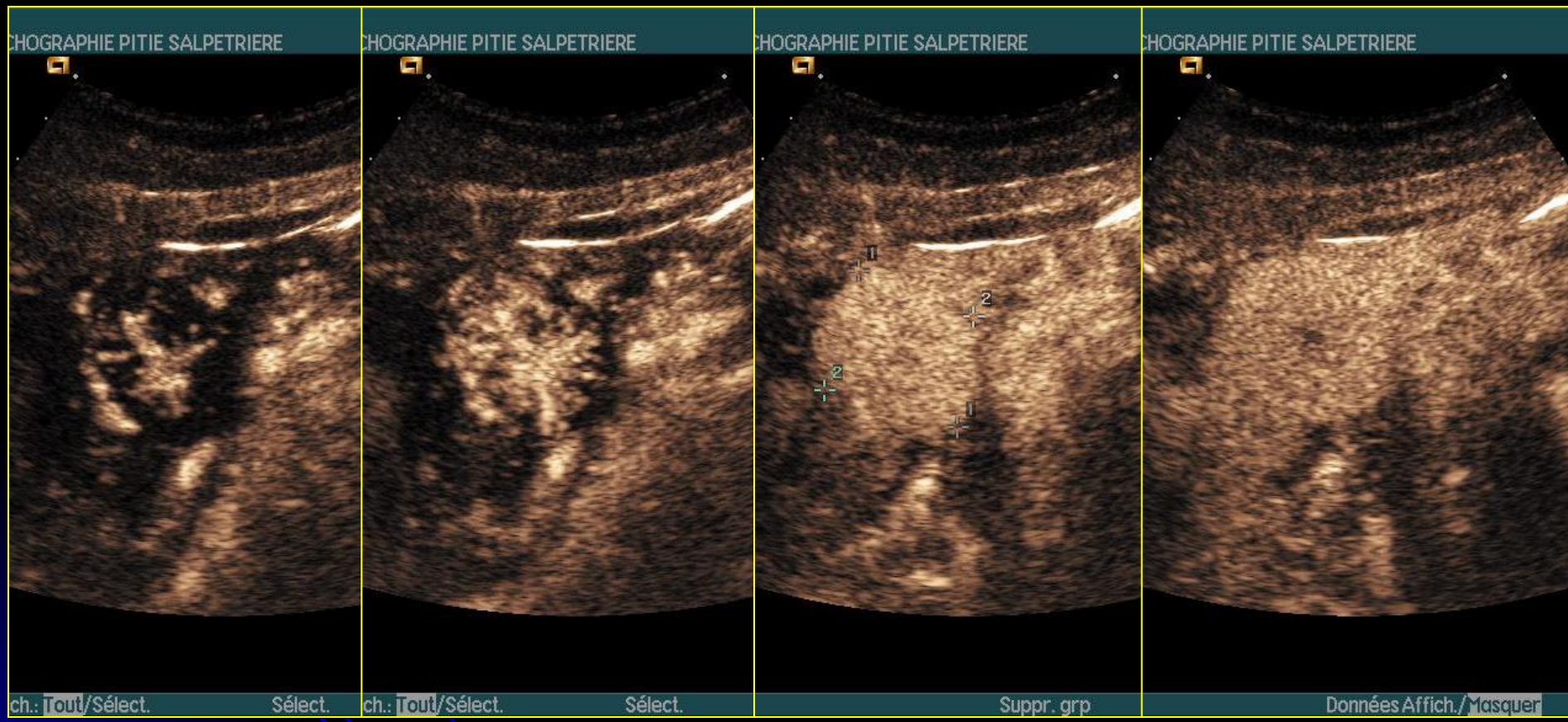
FNH, adenomas
HC

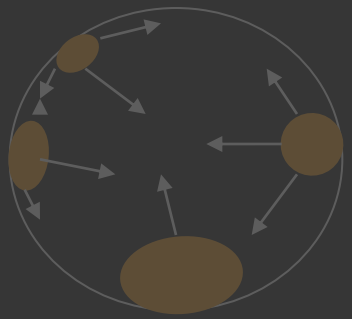
Meta
CHC…


1
2
1



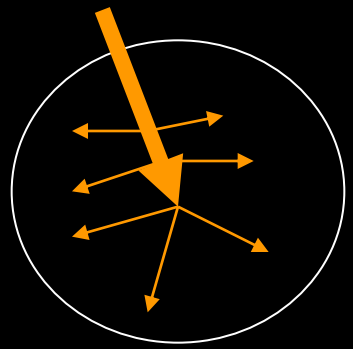

Puis.=0dB
MI=1.8
17:39:01
00:21


Puis.=0dB
MI=1.8
17:39:01
00:21

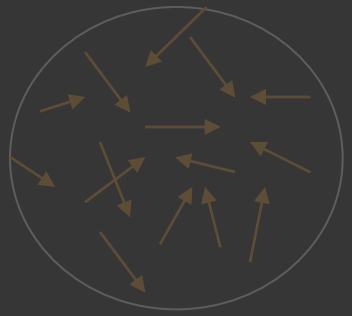

CHOGRAPHIE PITIE SALPETRIERE
ch.: Tout/Sélect. Sélect.
CHOGRAPHIE PITIE SALPETRIERE
ch.: Tout/Sélect. Sélect.
CHOGRAPHIE PITIE SALPETRIERE
1
2
2
1
Suppr. grp
CHOGRAPHIE PITIE SALPETRIERE
Données Affich./Masquer

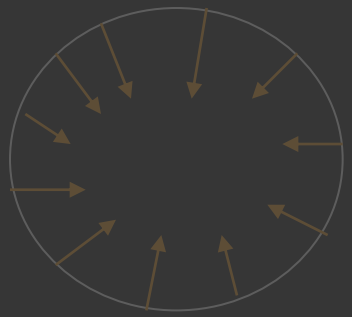


Angiomes

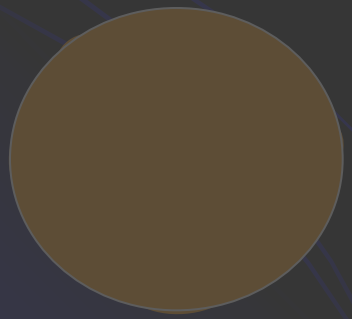


FNH

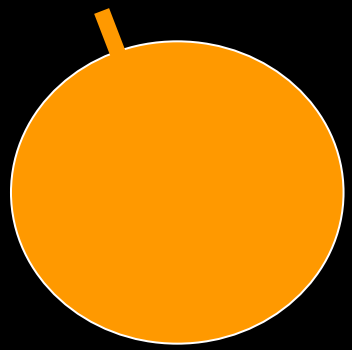




Adénomes
Meta
CHC…

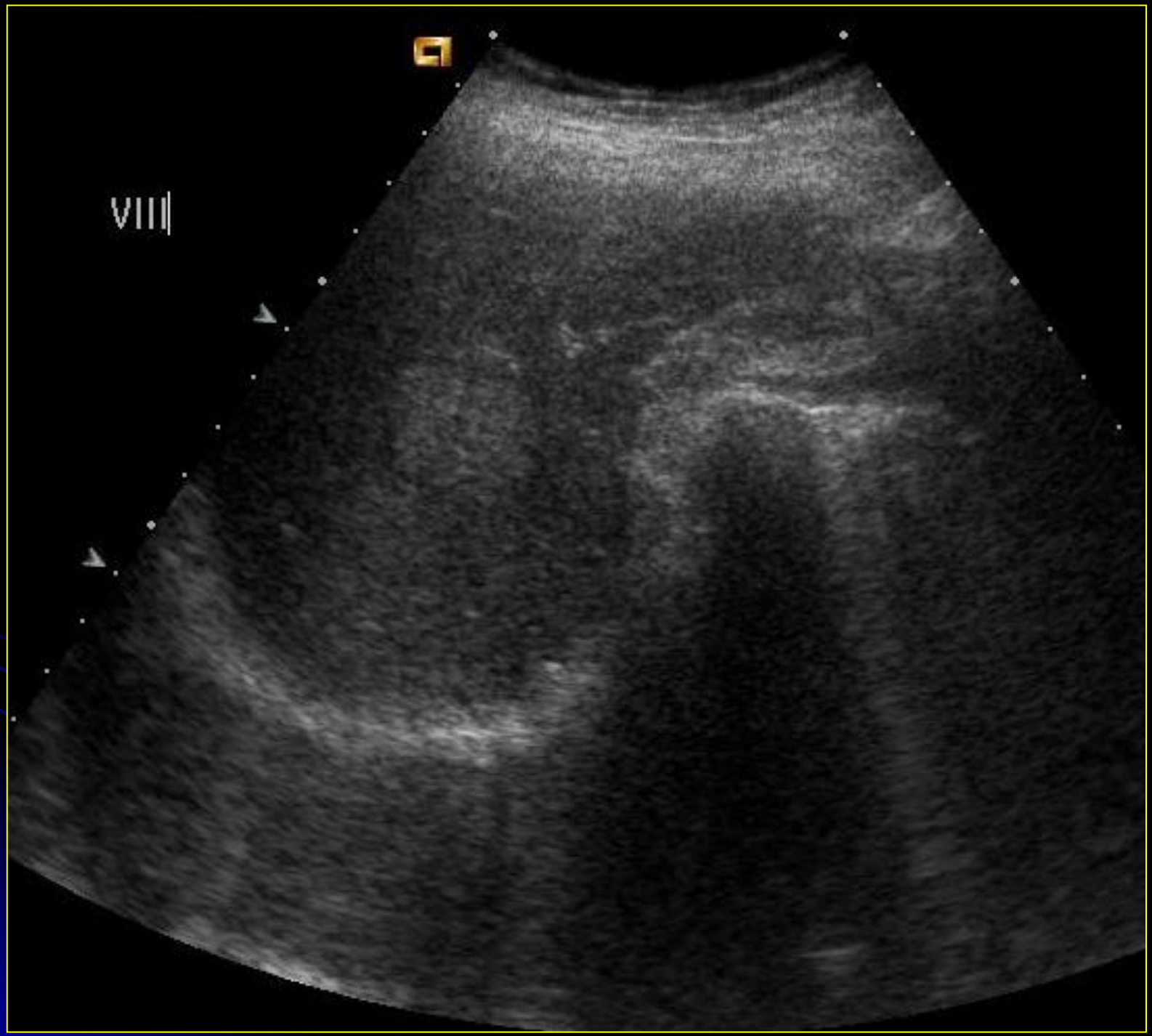


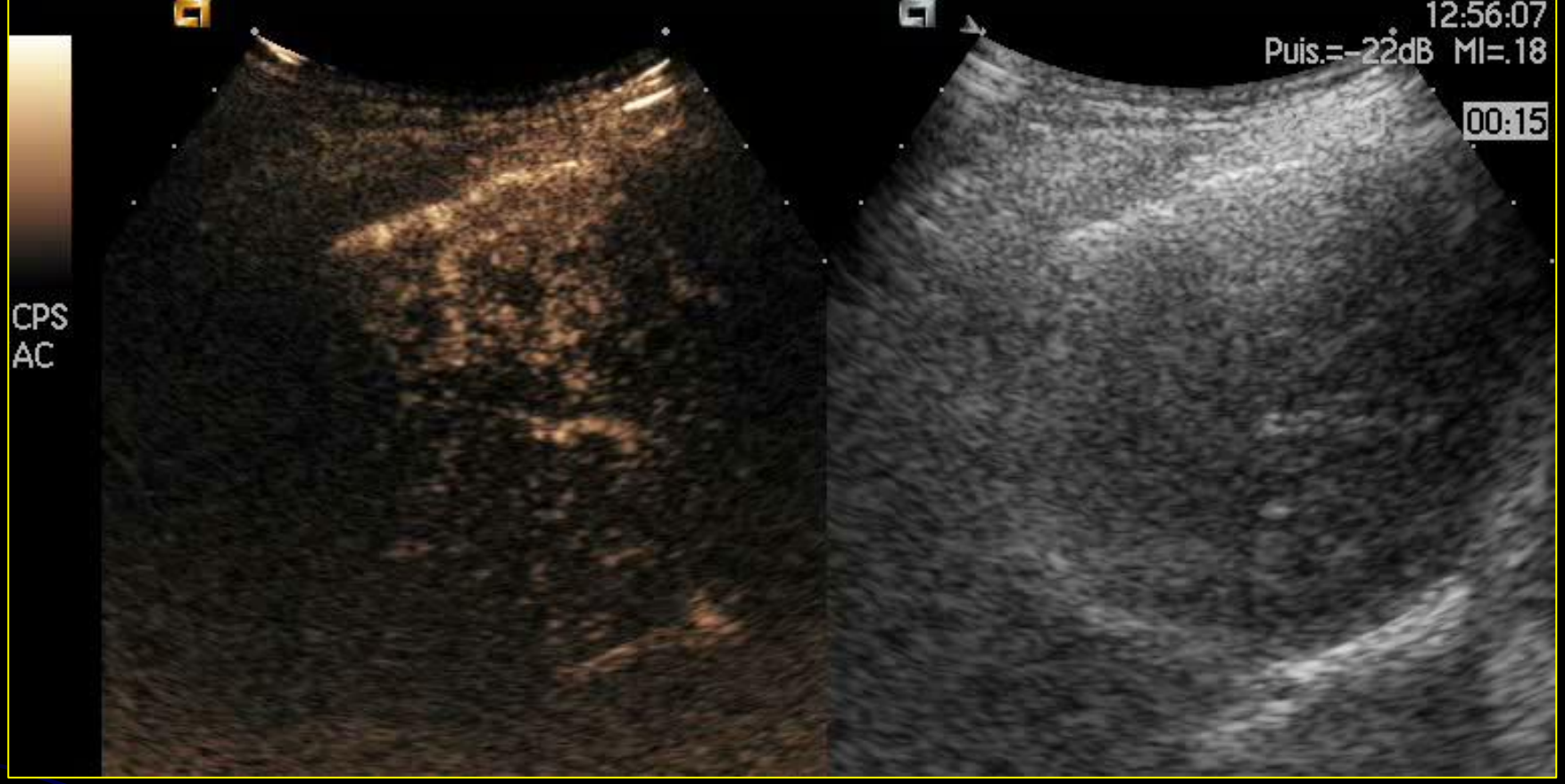
Angiomes

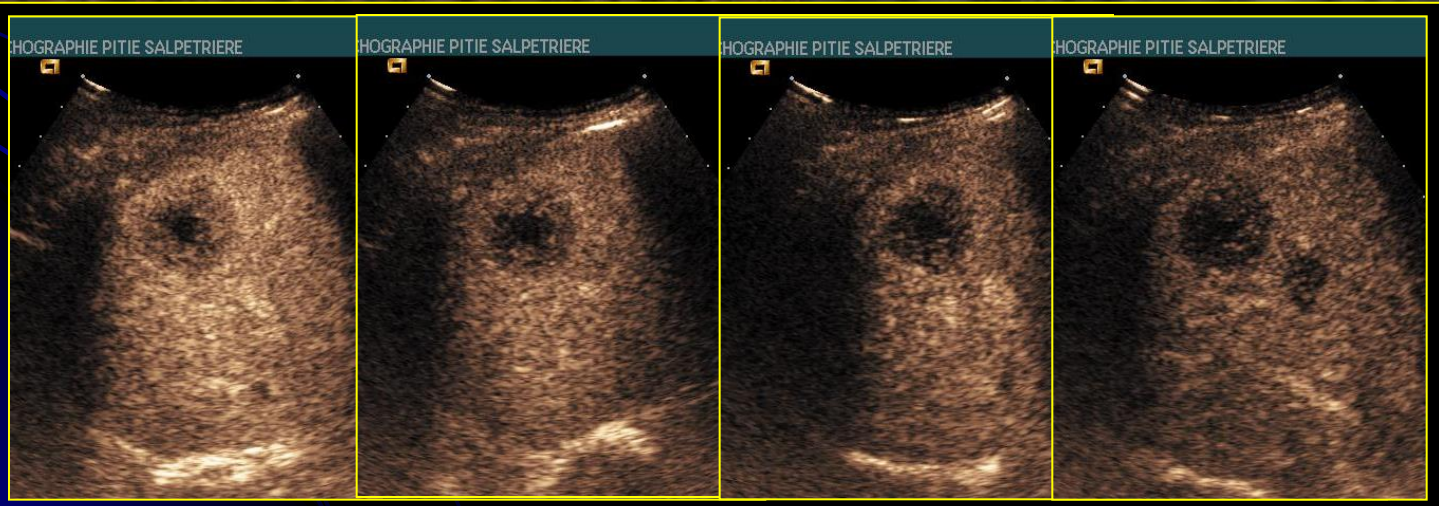


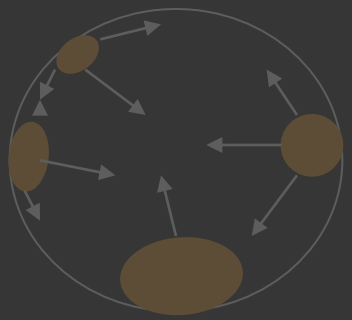
FNH, adenomas
HC

Meta
CHC…

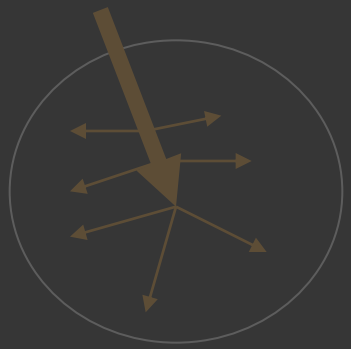

VIII


CPS
AC
12:56:07
Puis.=-22dB MI=.18
00:15

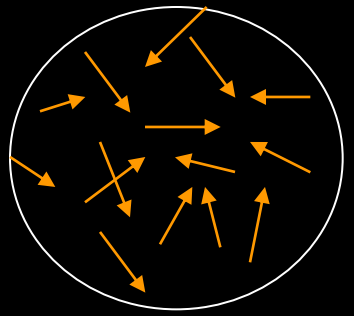

HOGRAPHIE PITIE SALPETRIERE
HOGRAPHIE PITIE SALPETRIERE
HOGRAPHIE PITIE SALPETRIERE
HOGRAPHIE PITIE SALPETRIERE

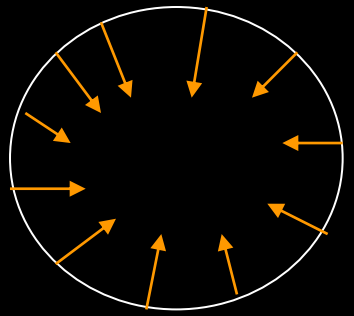


Angiomes

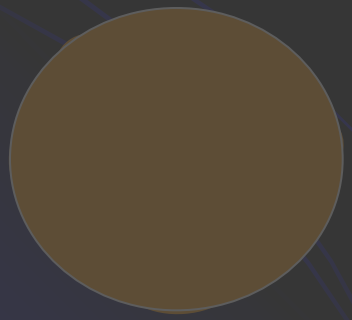


HNF





Adenomes
Mets
HCC…



Angiomes

HNF, adénomes
CHC

Mets
HCC…

Literature (Healthy Liver)

- **Percentage of correct diagnosis**
  - US without contrast : 38[3]-65%[1]
  - With contrast : 81[3]-92%[1]
  - FNH 112/134 = 83,5%[2]
  - Hemangiomas 113/132 = 85%[2]
  - Adenomas 2/19 = 10,5%[2]
  - Métastases 105/127 = 82,6%[2]
- Differenciation benign/Malignant
  - Accuracy(490/562) : 87,1[2]- 92[3]%

[1]Albrecht T. Eur Radiol. 2004 Oct;14 Suppl 8:P25-33

[2] Tranquart F. J Radiol 2009, 90: 123-138

[3] Trillaud H, World J Gastroenterol 2009; 15:3748-3756

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

Guidelines and Good Clinical Practice Recommendations for Contrast Enhanced Ultrasound (CEUS) – Update 2008

Claudon M. et coll. Ultraschall Med 2008; 29:28-44

EFSUMB study group M. Claudon[1], D. Cosgrove[2], T. Albrecht[3], L. Bolondi[4], M. Bosio[5], F. Calliada[6], J.-M. Correas[7], K. Darge[8], C. Dietrich[9], M. D'Onofrio[10], D. H. Evans[11], C. Filice[12], L. Greiner[13], K. Jäger[14], N. de. Jong[15], E. Leen[16], R. Lencioni[17], D. Lindsell[18], A. Martegani[19], S. Meairs[20], C. Nolsøe[21], F. Piscaglia[22], P. Ricci[23], G. Seidel[24], B. Skjoldbye[25], L. Solbiati[26], L. Thorelius[27], F. Tranquart[28], H. P. Weskott[29], T. Whittingham[30]

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

Both: CEUS is recommended for characterizing incidentally detected focal liver lesions in adults in whom an unenhanced ultrasound scan is inconclusive or lesions with inconclusive MRI/CT

=> immediate answer if typical enhancement patterns for:

Hemangioma, typical FNH and metastases

EFSUMB Recommendations

- **In case of focal liver lesion**
- If the quality of the images is good:
  - Injection of microbubbles may be done at the same time => immediate answer if:
    - Hemangioma, typical FNH
    - If non hypoechoic at the late phase (not a met)
    - If hypoechoic at the late phase
      - Met in oncologic context
      - benign lesions are possible
- Specificity and sensitivity are markedly reduced in attenuating livers and for deep-sited lesions

Claudon M, Ultraschall Med. 2008 Feb;29(1):28-44

FLL in chronic liver disease

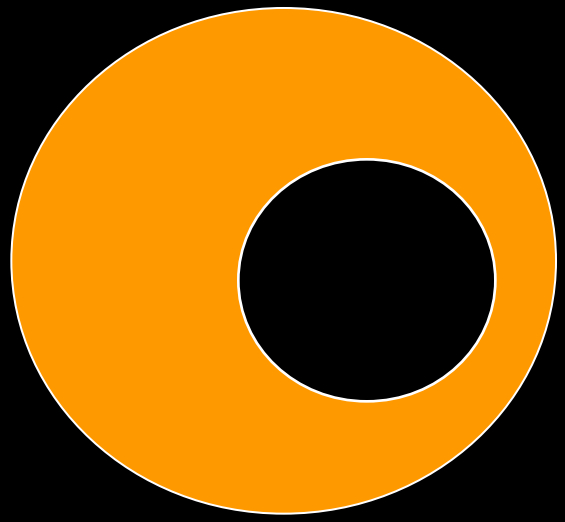
- See specific presentation

Microvasculature

Liver / Kidney

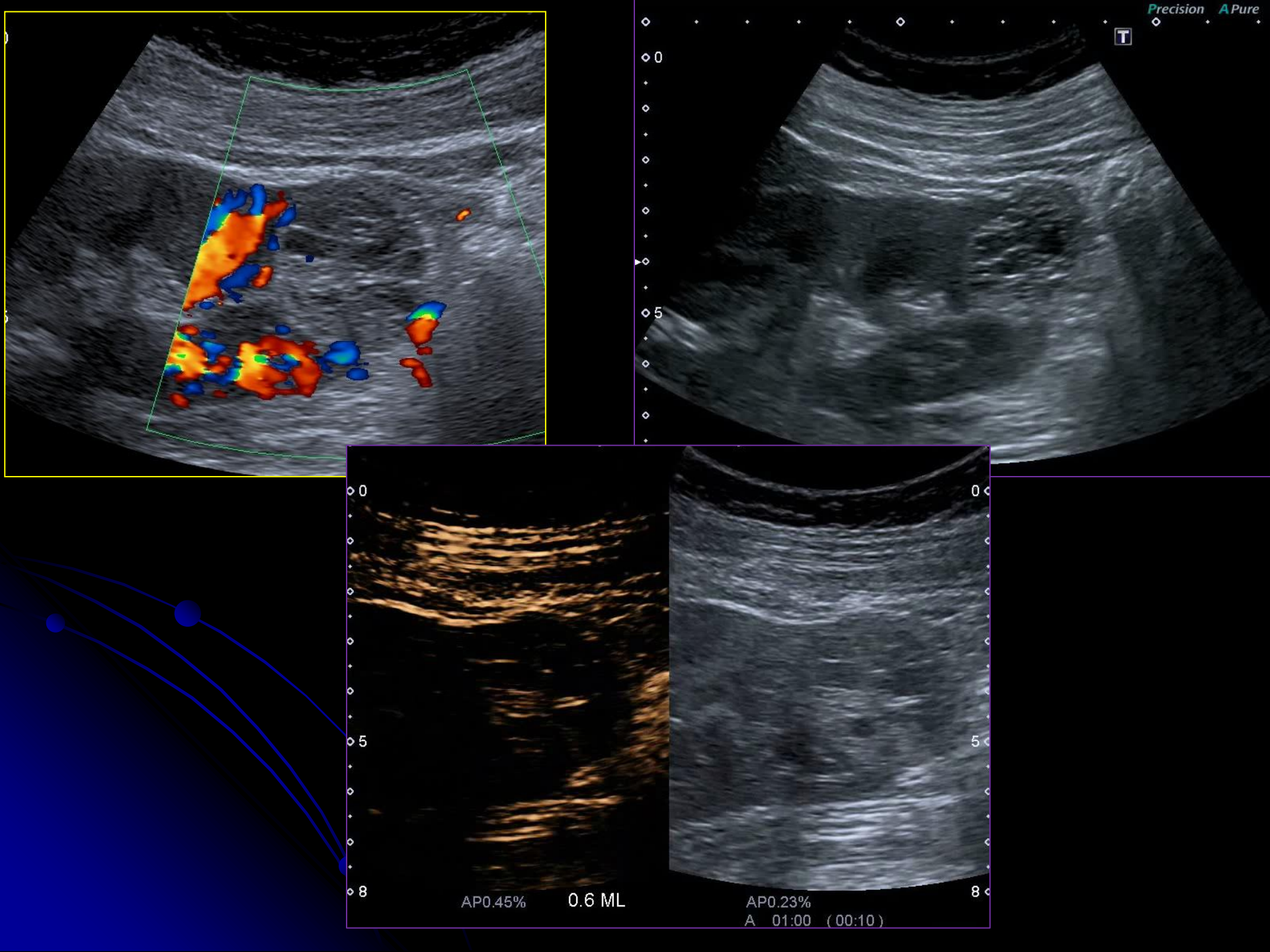
Interesting Feature #3

- **Early Phase**
  - Higher sensitivity to low amount of circulating contrast
  - No enhancement means no (or almost no) circulating vessels



EFSUMB recommendations

- **Renal tumors**
- Different than Liver : not used to differentiate solid tumors (same pattern)
- But:
  - Characterization of complex cystic masses as benign, indeterminate or malignant to provide information for the surgical strategy. (Recommendation level: A;1b)
  - Differential diagnosis between solid lesions and cysts presenting with equivocal appearance at conventional US. (Recommendation level: B;2b)
  - Differentiation between renal tumors and anatomical variations mimicking a renal tumor (“pseudo-tumors”) when conventional US is equivocal. (Recommendation level: B;1b).
  - However, both CEUS and CECT have limitations in rare very small isoenhancing tumors**.**

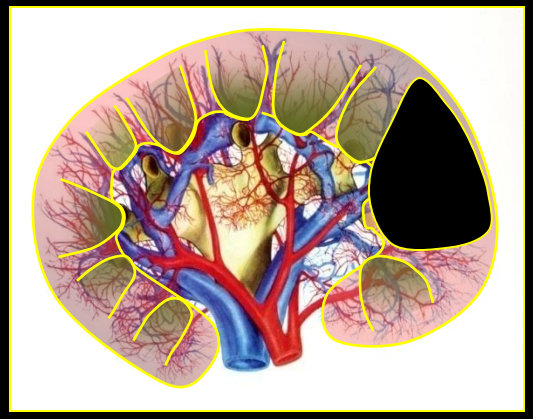

Precision
A Pure
T
0
5
0
5
8
AP0.45%
0.6 ML
0
5
8
AP0.23%
A 01:00 (00:10)

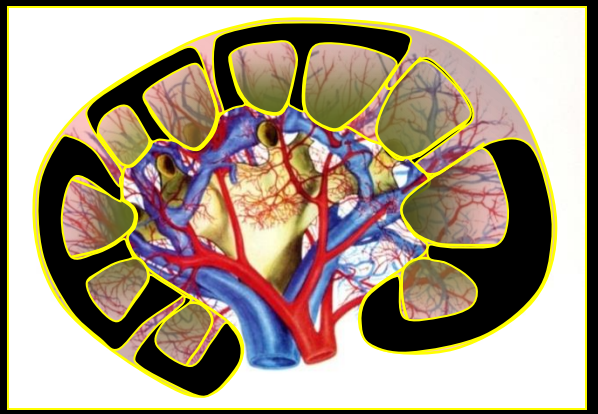
EFSUMB RECOMMENDATIONS

- **Renal tumors**
- Different than Liver : not used to differentiate solid tumors (same pattern)
- But:
  - Characterization of complex cystic masses as benign, indeterminate or malignant to provide information for the surgical strategy. (Recommendation level: A;1b)
  - Differential diagnosis between solid lesions and cysts presenting with equivocal appearance at conventional US. (Recommendation level: B;2b)
  - Differentiation between renal tumors and anatomical variations mimicking a renal tumor (“pseudo-tumors”) when conventional US is equivocal. (Recommendation level: B;1b).
  - However, both CEUS and CECT have limitations in rare very small isoenhancing tumors.

- **Vascular occlusion**
- Suspected vascular disorders, including renal infarction and cortical necrosis.

(Recommendation Level: A;1a)





Recommended for vascular diseases

- **Occlusive vascular Lesions (**Segmental deficit ,sometimes multifocalVarious origin: embolic disease, occlusion, dissection, acute graft rejection)

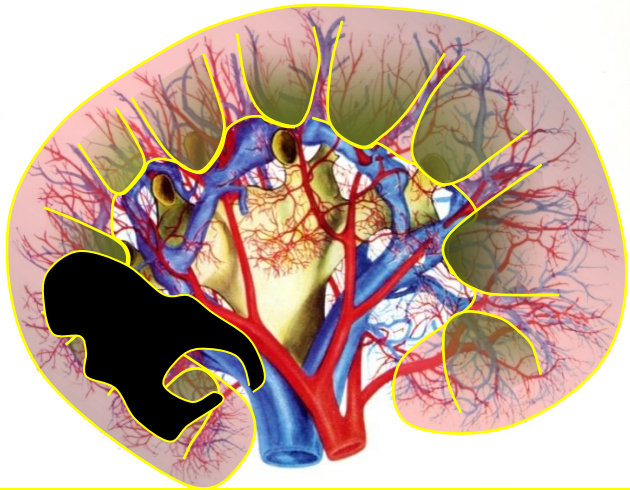
  - Large vessels:

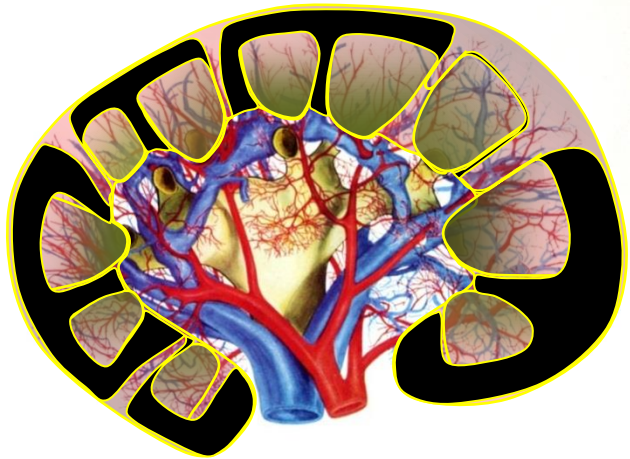
  - stenosis or occlusion of the main artery
  - occlusion of a renal artery branch
  - Renal vein thrombosis

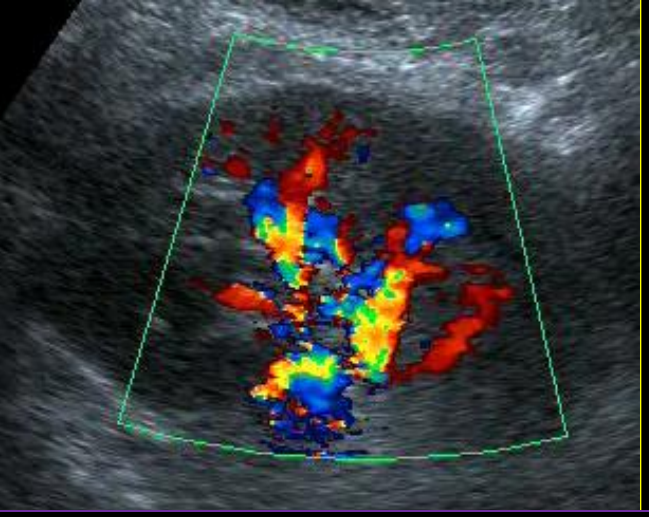
  - small vessels:

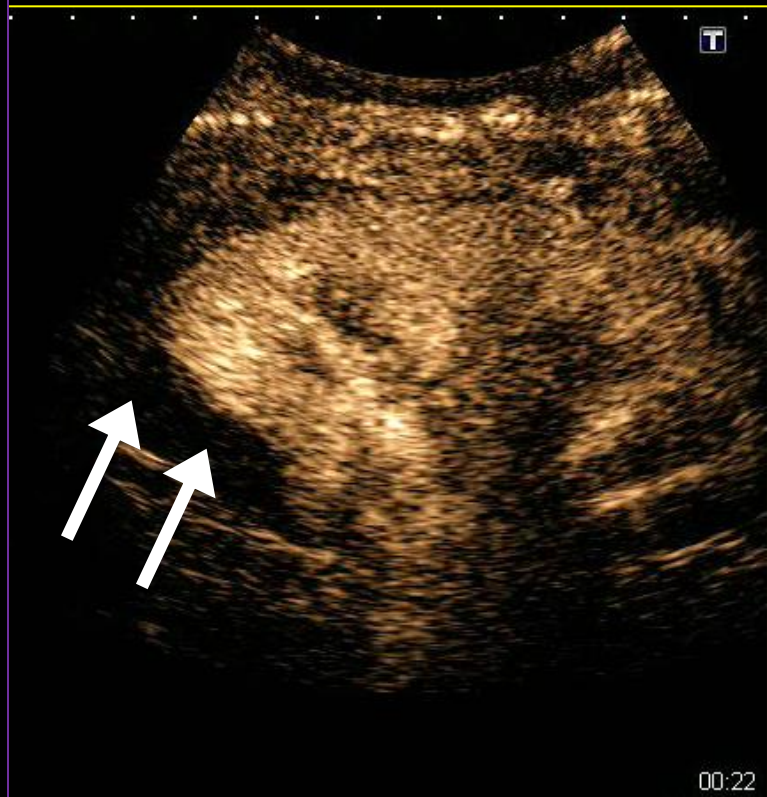
  - cortical/ medullary necrosis

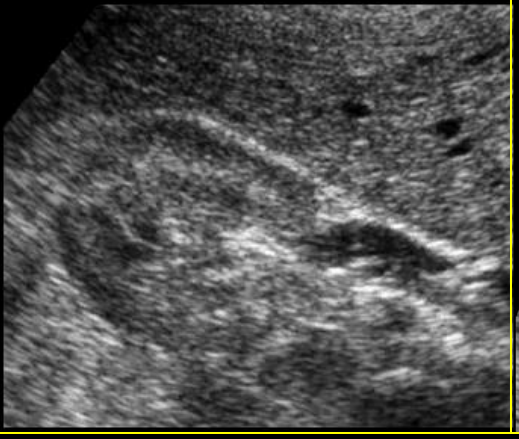
- **Non occlusive vascular diseases**
  - Arterio-venous fistula
  - aneurysm et false-aneurysm

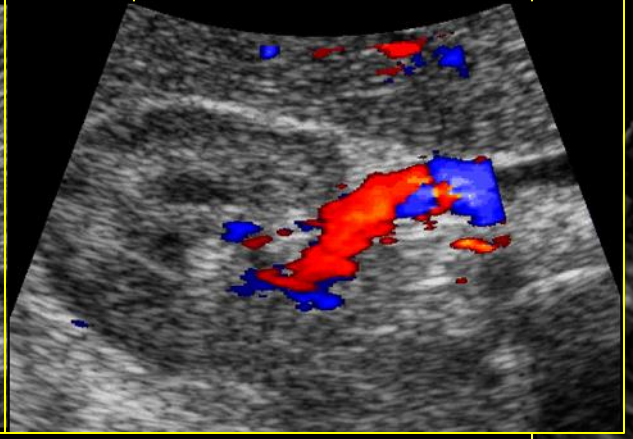


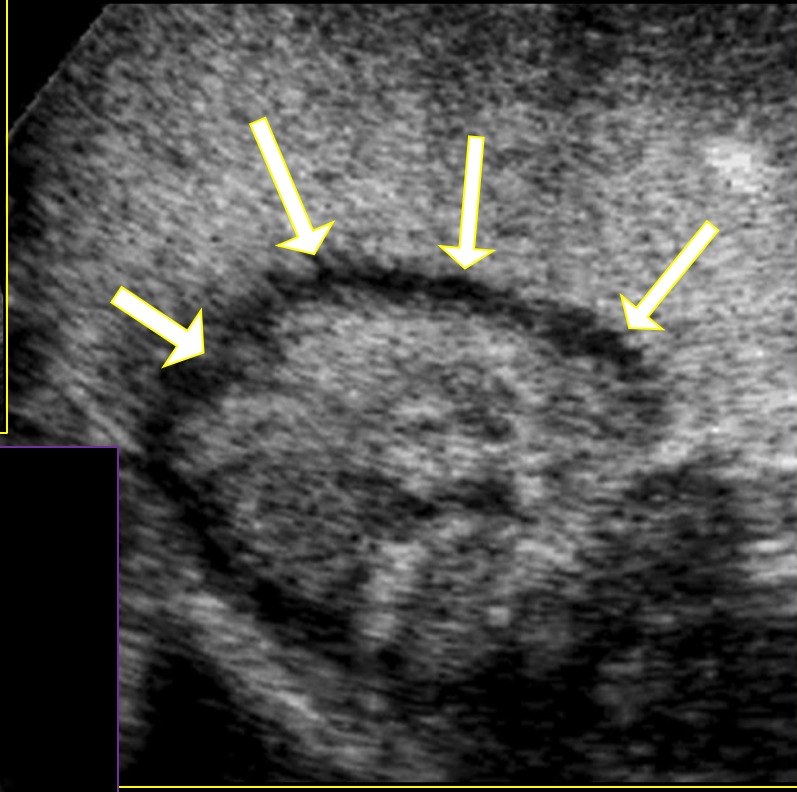


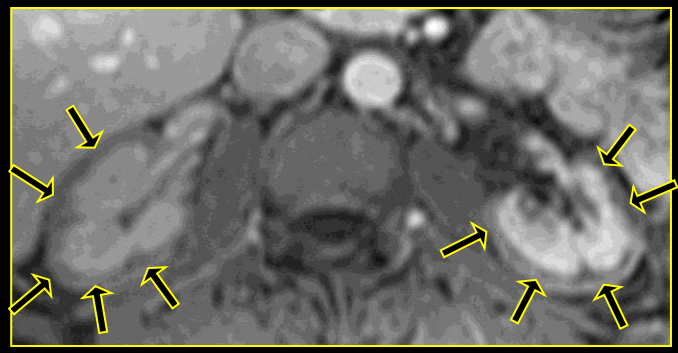


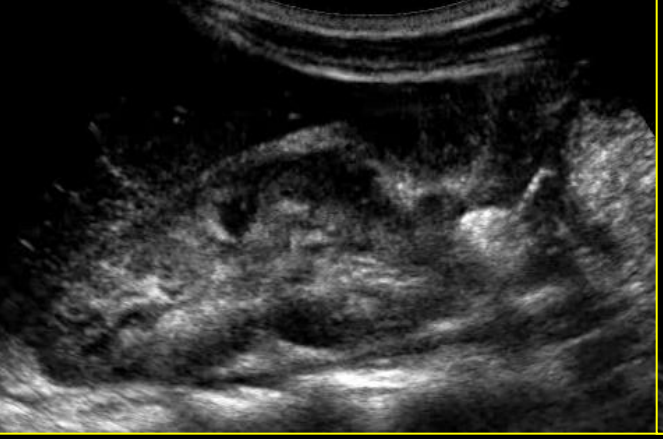

00:22

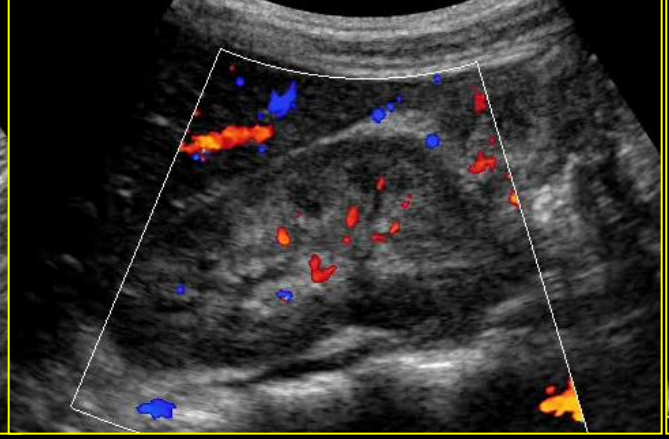


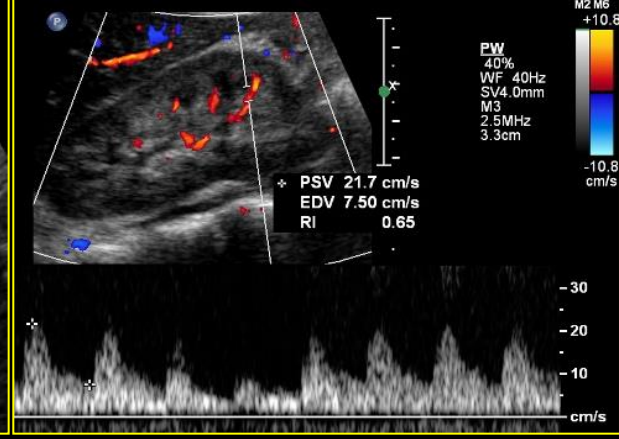


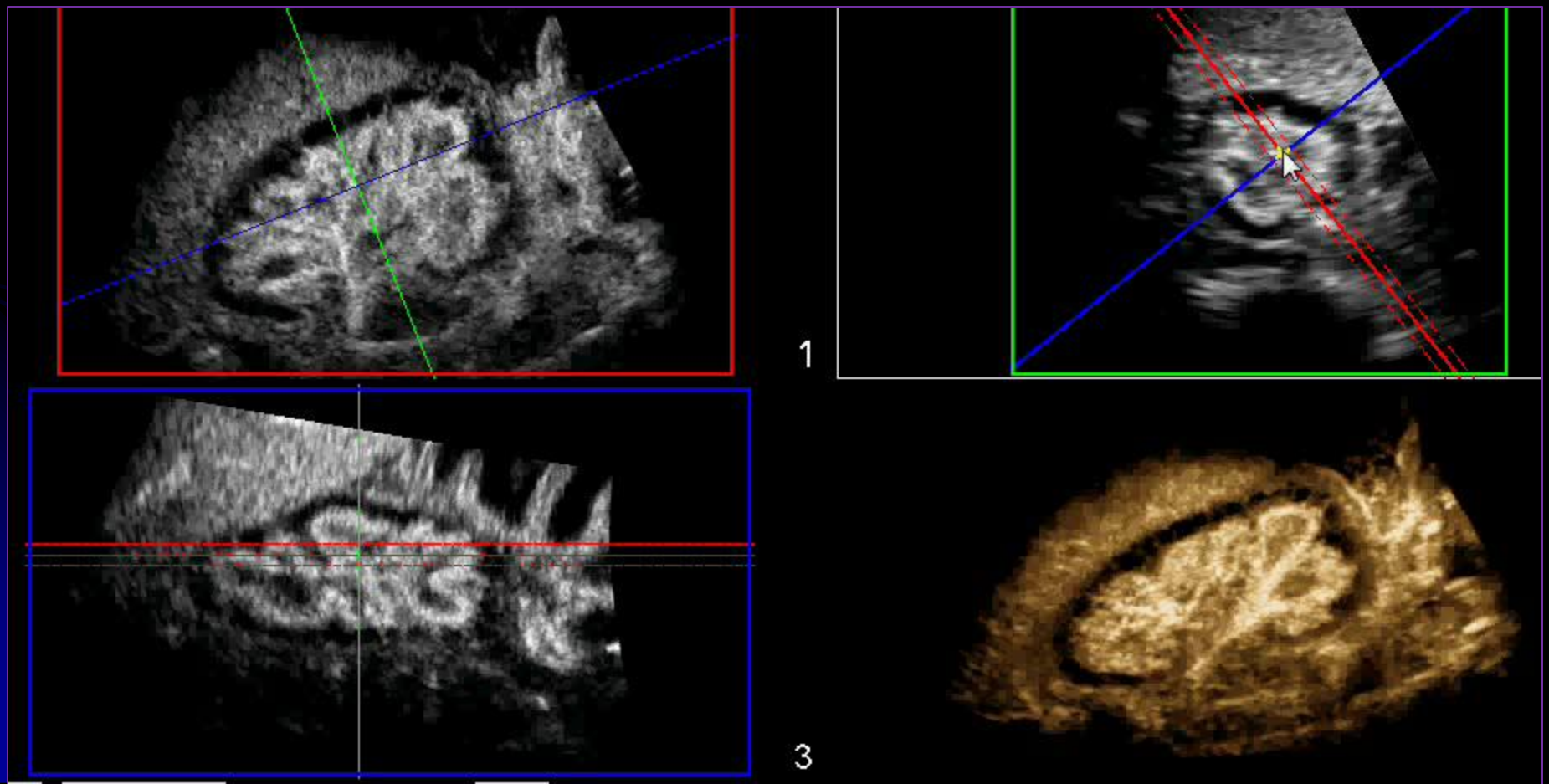






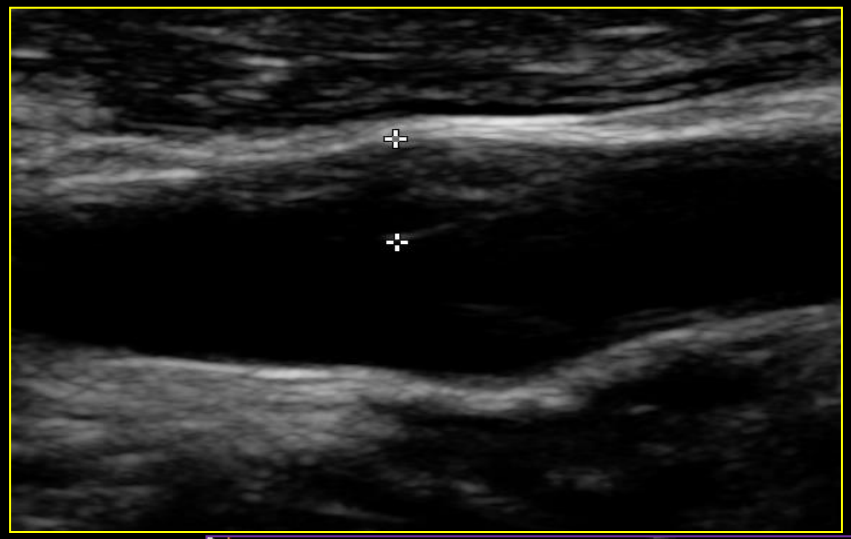


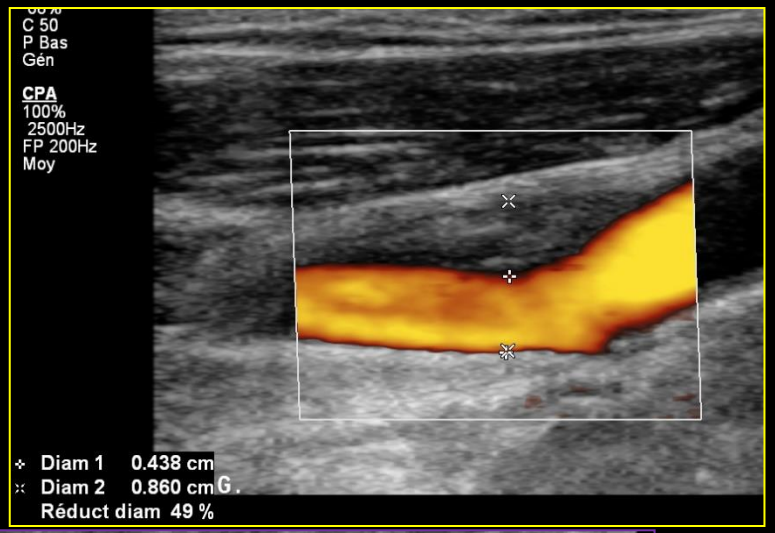

PW
40%
WF 40Hz
SV4.0mm
M3
2.5MHz
3.3cm
M2 M6
+10.8
-10.8
cm/s
PSV 21.7 cm/s
EDV 7.50 cm/s
RI 0.65
30
20
10
cm/s

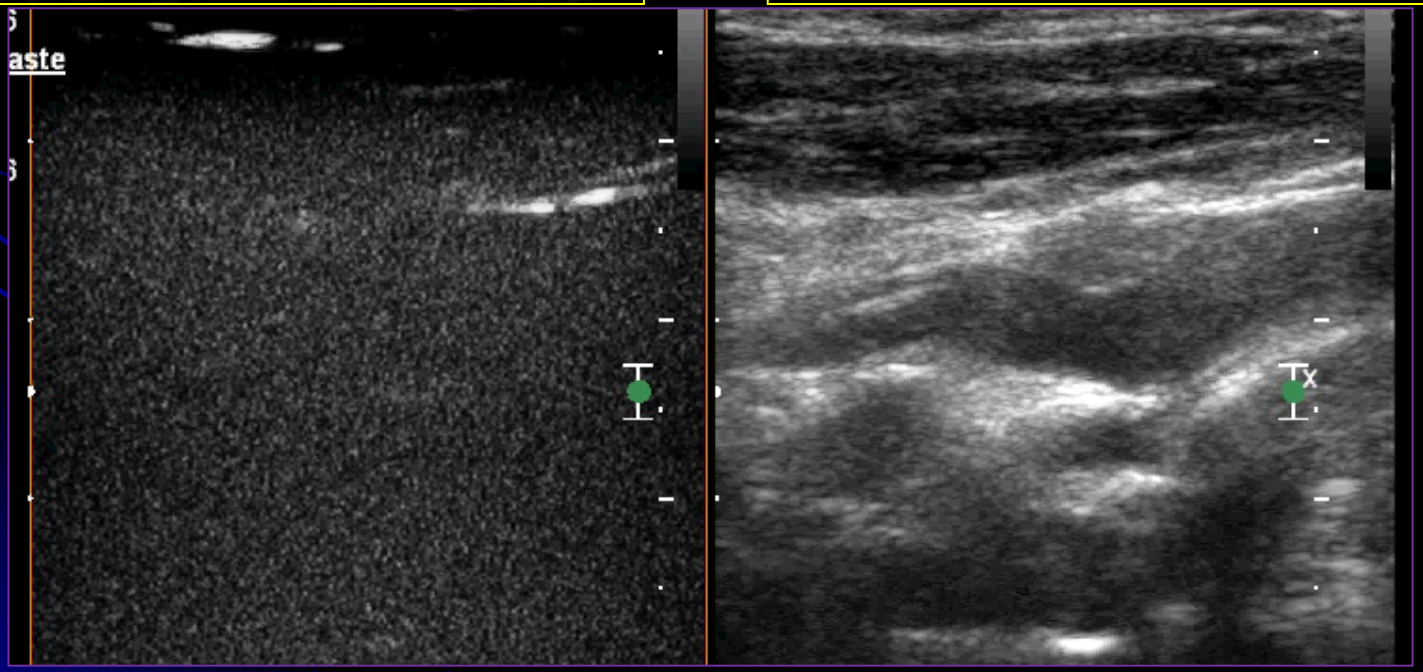

1
3

Microvascularisation des plaques carotidiennes

Images : Dr Corinne Gautier

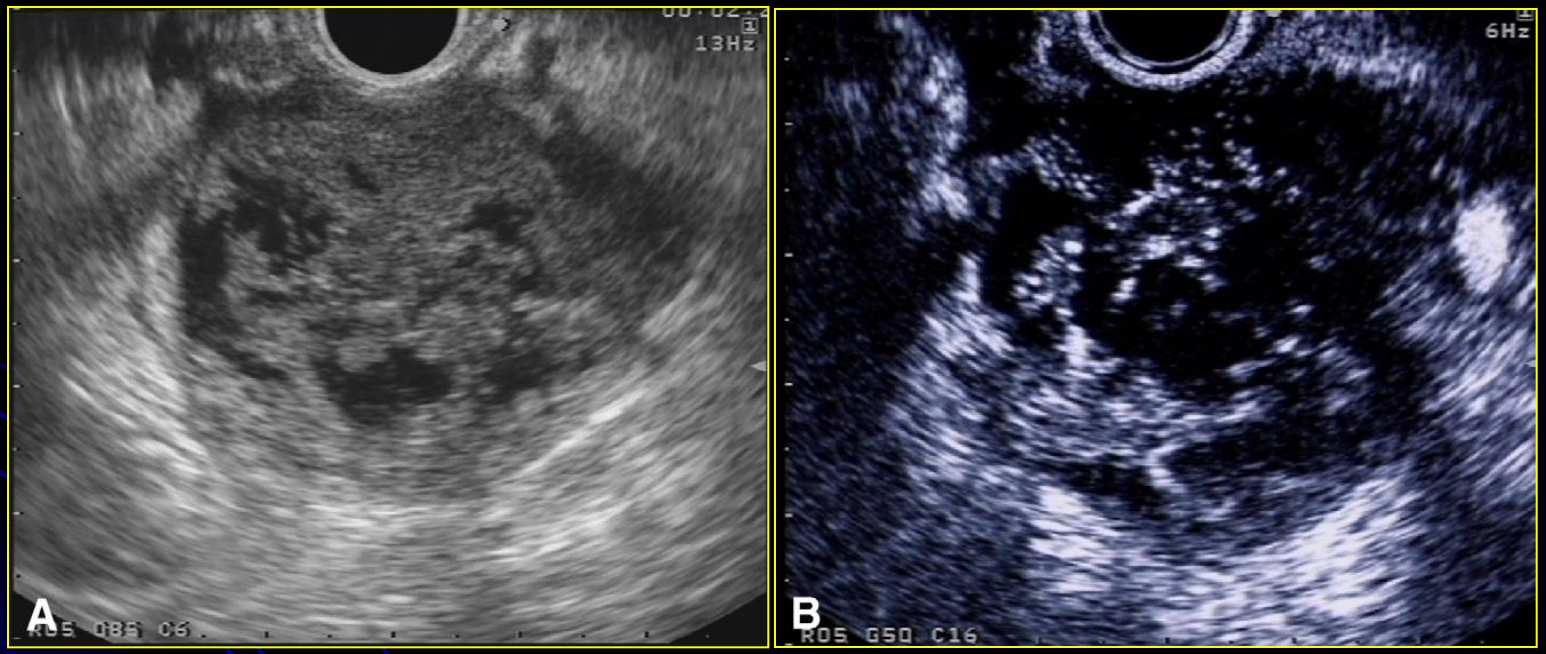






Other EFSUMB RECOMMENDATIONS

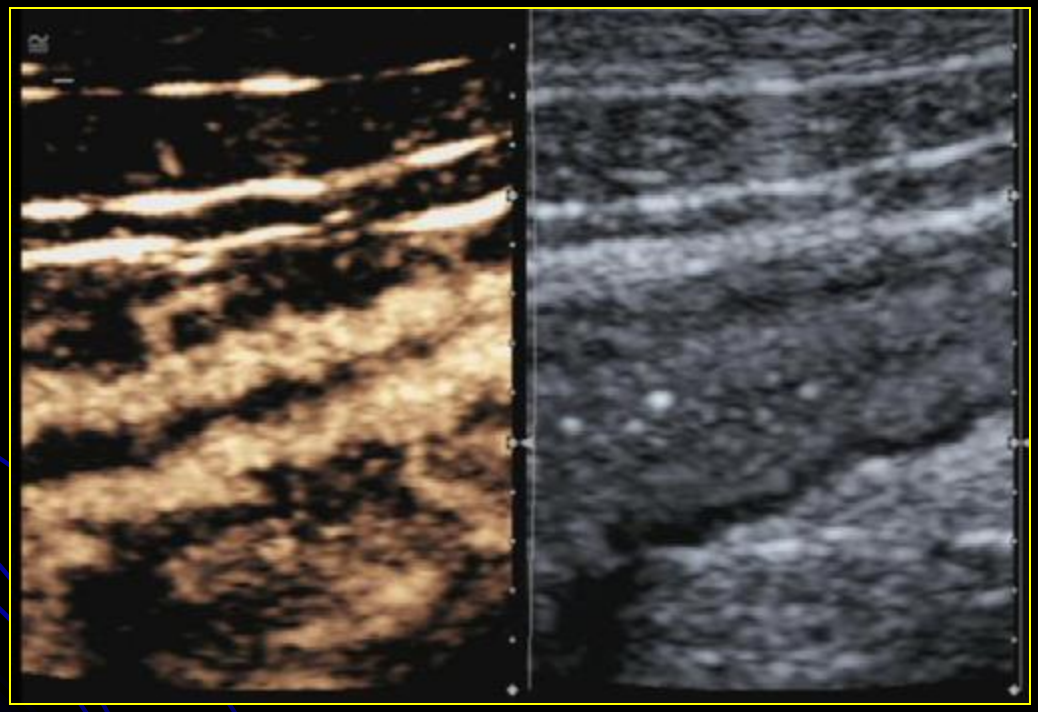
- **Many other recommandations**
  - cystic masses of the pancreas even using endoscopic US



Kitano M, Sakamoto H, Matsui U et al. A novel perfusion imaging technique of the pancreas: contrast-enhanced harmonic EUS (with video).Gastrointest Endosc 2008; 67: 141–150

Other EFSUMB RECOMMENDATIONS

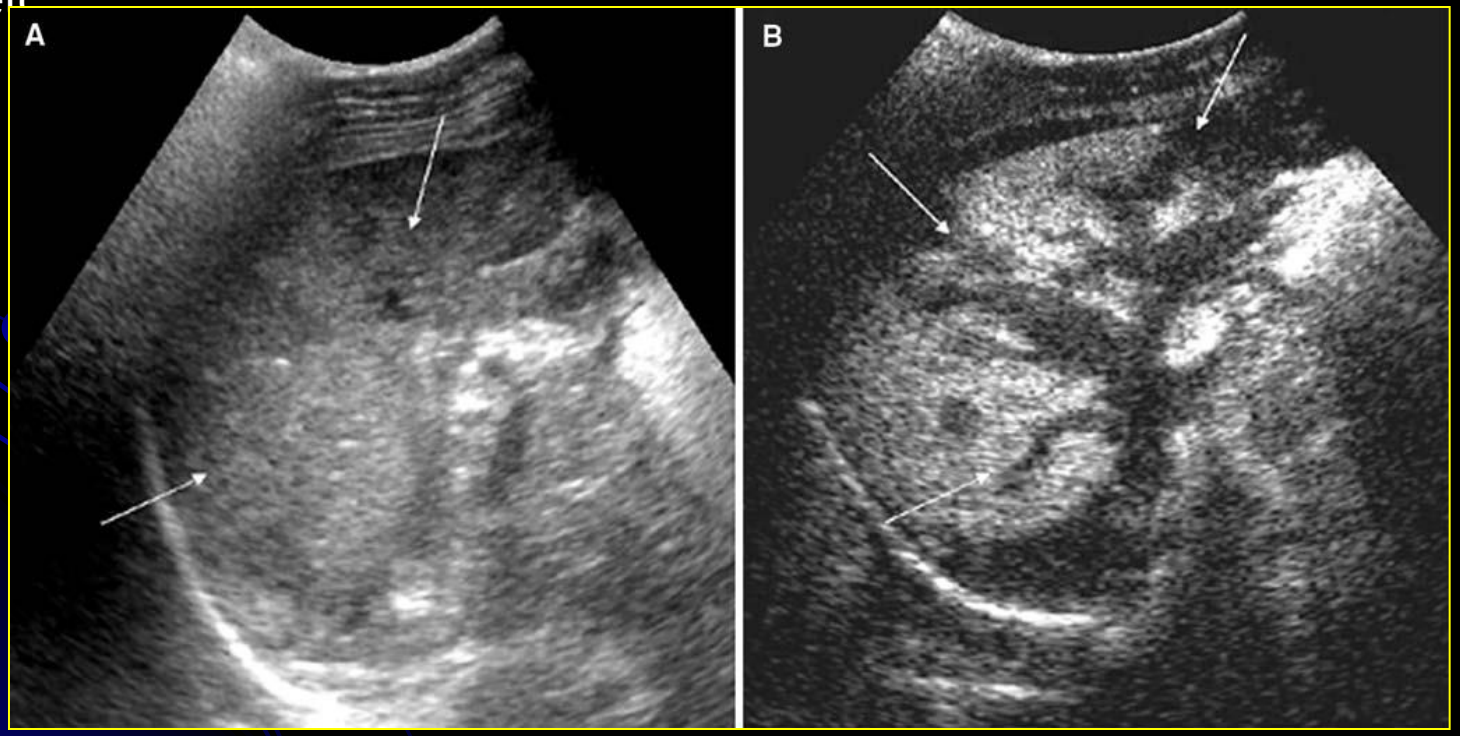
- **Many other recommandations**
  - cystic masses of the pancreas even using endoscopic US
  - level of inflammation in bowel wall in crohn disease



Girlich C, Schacherer D, Jung EM et al. Comparison between a clinical activity index (Harvey-Bradshaw-Index), laboratory inflammation markers and quantitative assessment of bowel wall vascularization by contrast-enhanced ultrasound in Crohn's disease. Eur J Radiol 2011

Other EFSUMB RECOMMENDATIONS

- **Many other recommandations**
  - cystic masses of the pancreas even using endoscopic US
  - level of inflammation in bowel wall in crohn disease
  - fracture of the spleen after a trauma
  - etc



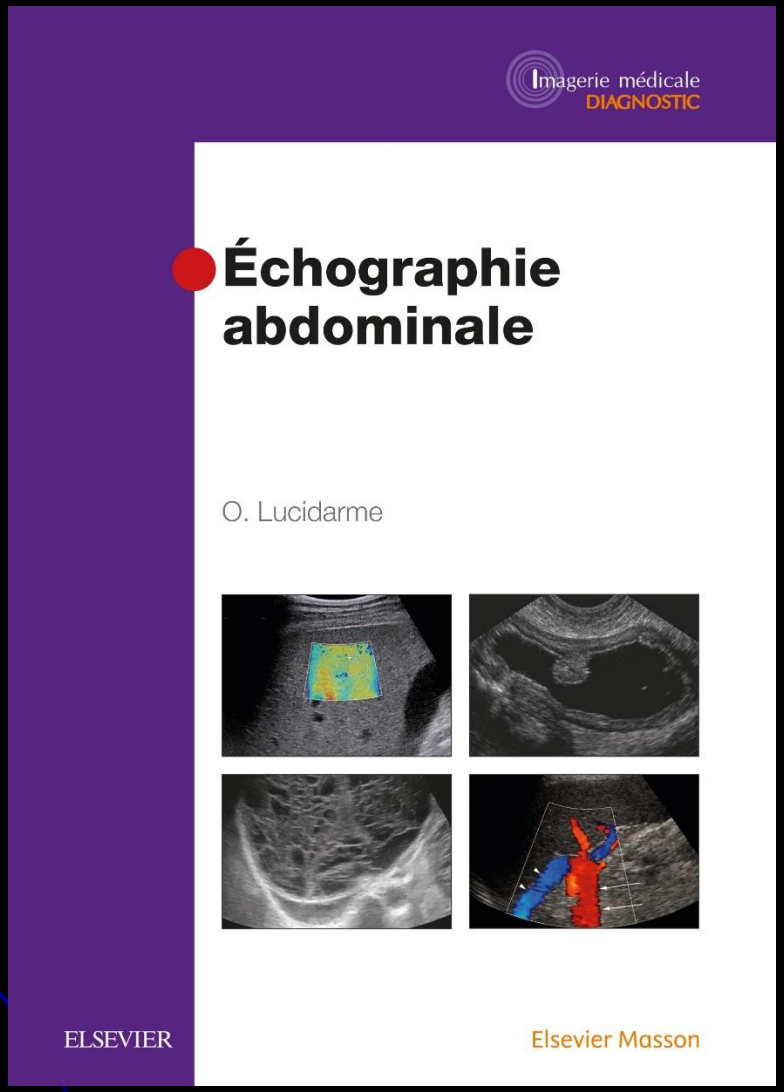
Catalano O, Aiani L, Barozzi L et al. CEUS in abdominal trauma: multicenter study. Abdom Imaging 2009; 34: 225–234

Conclusion

- Very convenient technique
  - To assess liver tumors and renal vascular disorders
  - Many others organs and vessels
  - Effect of a treatment of the vascular bed
- Very well tolerated
  - Interesting solution in case of renal impairment

Thank you
Merci

Olivier.lucidarme@psl.aphp.fr


Imagerie médicale
DIAGNOSTIC
Échographie abdominale
O. Lucidarme
ELSEVIER
Elsevier Masson