Contrast Ultrasound of the Pediatric Abdomen: A Practical Approach

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CEUS experience 10 years

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US No. 1 study in pediatric imaging

CT/MR are complementary and focused studies after US

Courtesy Erika Bartos
Leading indications of pediatric CEUS applications based on own experiences and published papers

Abdominal trauma

Oncology

VUR
“...CEUS in paediatric applications remains of critical importance, because of its obvious benefits compared to alternative imaging modalities, which in most cases necessitate exposure to ionizing radiation and the use of potentially harmful contrast agents.”
Application of a second-generation US contrast agent in infants and children—a European questionnaire-based survey

Michael Riccabona

Pediatric Radiology 42.1471. 2012.

- European survey - 45 centers
- 5,079 studies
- Austria, Finland, France, Germany, Greece, Hungary, Italy, Norway, Poland, Romania, Slovenia, Spain, Sweden, Switzerland.

- 948 IV CEUS applications
- 5 pts with minor side effects
- 1 severe anaphylactic reaction
Off-Label Use of Ultrasound Contrast Agents for Intravenous Applications in Children
Analysis of the Existing Literature
Elsa Rosado, MD, Michael Riccabona, MD

Retrospective Analysis of the Safety and Cost Implications of Pediatric Contrast-Enhanced Ultrasound at a Single Center
Gibran T. Yusuf, Maria E. Sellars, Annamaria Deganello, David O. Cosgrove, Paul S. Sidhu

Role of Contrast-Enhanced Ultrasound (CEUS) in Paediatric Practice: An EFSUMB Position Statement

J Ultrasound Med 2016; 35:e21–e30
AJR:208, February 2017

EJU 38.1.33-43. 2017

136 references
ADVANTAGES OF PEDIATRIC CEUS

• No ionizing radiation – ‘Image gently’

• No nephroxicity, CEUS is independent of renal function

• Dynamic contrast study: continuous observation of vascular changes, no time window, observation of microcirculation

• CEUS study can be performed in critical care setting

• Safe examination; low incidence of adverse reactions

• Examination cost is lower than CT or MRI

• CEUS can decrease the number of unnecessary MR/CT studies and biopsies
LIMITATIONS OF PEDIATRIC CEUS

- Same limitations as with B-mode US: obesity, bowel gas, bones, deep and multiple lesions
- Studies require patient respiratory cooperation
- Characterization of small and multiple focal parenchymal lesions is limited
- IV line / injection is needed
- No information about the renal function (no excretion)
- Experience and training in CEUS (and in US) is essential
- Off-label use and lack of reimbursement
Potential Indications of Pediatric CEUS 1

- **VUR** (vesicoureteral reflux) – voiding urosonography
- Blunt abdominal **trauma** – parenchymal injuries
- **Focal hepatic** lesions (characterisation and F/U)
- Abdominal / pelvic / thoracic **fluid collections** (ICU)
- Pediatric **kidney disease**
- **Active bleeding** – trauma, biopsy, unknown origin
- **Transplant** evaluation – complications (liver, kidney, BMT)
Potential Indications of Pediatric CEUS 2

- IBD activity and complications
- Tumor monitoring during treatment
- Testicular / ovarian torsion (viability)
- Vascular tumor, vascular malformation
- Femoral head perfusion, rheumatoid arthritis
- If CE MR or CT is contraindicated (or not available)
- In selected cases: ICU, ED
TRAUMA and CEUS
Liver trauma

9 yr boy motor cycle accident

CT at admission
Liver injury: follow up with CEUS (12 y f) – NC B-mode US + CDI
Liver injury: follow up with CEUS (12 y f)
Liver injury follow up with CEUS (12 y f) – 1 month later
Splenic and renal trauma

9 y old girl with blunt abdominal trauma B-mode and CD US
9 y old girl, with blunt abdominal trauma - CECT
9 y old girl, with blunt abdominal trauma - CEUS
9 y old girl, with blunt abdominal trauma – CEUS – renal cortical necrosis
11 y old boy, abdominal blunt trauma, suprarenal gland hematoma?
11 y old girl, left abdominal blunt trauma, splenic and kidney injury?

CT at admission
11 y old girl, left abdominal blunt trauma, splenic and kidney injury?
11 y old girl, left abdominal blunt trauma, splenic and kidney injury?
11 y old girl, left abdominal blunt trauma, splenic and kidney injury?
Pediatric abdominal trauma and CEUS

- Minor abdominal trauma
- MDCT / NC US / CEUS comparison
- 30/33 solid injuries were detected by CEUS

Solid organ injuries: NC US vs CEUS

Miele V. et al.: Role of Contrast Enhanced Ultrasound (CEUS) in the evaluation of localized low-energy abdominal trauma in a pediatric population: our initial experience. ECR 2013. C-0873
TRAUMA and CEUS INDICATIONS

- Low energy abdominal trauma with suspected parenchymal injury at admission
- Follow up CEUS with known injuries detected by CT
- Detection of complications (re-bleeding, splenic artery pseudoaneurysm, infection)
TUMOR and CEUS
Liver CEUS Indications 1.

- **Incidental liver lesion** by abdominal US (characterisation, avoid biopsy)
- **Blunt trauma** of the liver
- **Differentiation of focal fatty infiltration / sparing** and focal neoplasm
- **Follow up of benign liver mass**
- **Follow up malignant liver masses during treatment**
Liver CEUS Indications 2.

- **Equivocal abnormality** after MR, CT, or guided biopsy
- Poor or non-visualization of mass at time of US-guided biopsy
- US-guided **local ablation** of focal mass
- Liver transplant evaluation
Incidental liver masses at long term F/U

17 y old girl with treated neuroblastoma. MR (2015): liver masses
Follow up with US/MR + CEUS (2016)
17 y old girl with treated neuroblastoma. MR (2015): liver masses
At age 18 and 19 yrs follow up with US + CEUS (2016) – no change
17 y old girl with treated neuroblastoma. MR (2015): liver masses
At age 18 and 19 yrs follow up with US + CEUS (2016) – no change
15 y old boy with multiple liver masses, enlarged lymph nodes. US and MR Surgery + chemotherapy. Histology **desmoplastic small-round cell tumor** Follow up with MR / US + CEUS
6 months F/U, BMT, NC US / MR Liver cyst and viable tumor?
3 months later CEUS
6 months F/U, BMT. NC US / MR Liver cyst and viable tumor?
3 months later CEUS, 3 small masses
19 y old male with known CF - liver mass characterization
Infantile hepatic hemangioma

CEUS: IV. 0,5 cc UCA
7 yo girl treated for neuroblastoma at age 13 months. FLL found on CT for abdominal pain.

Case of MB McCarville / St. Jude Hospital
Arterial Phase Iso-Enhancing

Portal Venous Phase Iso-Enhancing
Delayed Phase Iso-Enhancing

Regenerative Nodule
Our pediatric CEUS liver studies:

• 22 pediatric patients, between 2010-2016
• FLL was detected and characterised in 10 patients after chemotherapy
• Follow up with CEUS and MRI
• 5 FNH, 1 case residual tumor, 1 case haemangioma

Comment: Incidence of FLLs in post-chemo patients can be 100 times higher than in normal population*

* Chiorean L et al. Benign liver tumors in pediatric patients - Review with emphasis on imaging features. World J Gastroenterol 2015. 28; 21(28): 8541-8561
Splenomegaly, hypoechoic solid splenic mass, 11 y old boy, NC B-mode and MVI
Splenomegaly, hypoechoic solid splenic mass, 11 y old boy  
CEUS: IV. 0,7 cc SonoVue
Splenomegaly, hypoechoic solid splenic mass, 11 y old boy  

**CEUS:** IV. 0.7 cc SonoVue
Bowel infection or GVH? in a 9 yr old BMT patient
VUR detection with VUS (Grade 1-5):
Grade 1. Microbubbles in the ureter, only
Grade 2. Microbubbles in the urinary tract, no dilatation
Grade 3. Microbubbles in the urinary tract, significant pyelectasy and mild calyceal dilatation
Grade 4. Microbubbles in the urinary tract, significant pyelectasy and calyceal dilatation
Grade 5. Microbubbles in the urinary tract, significant pyelectasy and calyceal dilatation and tortuous ureter
CE voiding urosonography: Intrarenal reflux (IRR)

- 29 patients (18 / 11 F / M), av. age 25 mo
- Indications: recurrent UTI, postoperative F/U
- IRR: 22 patients

Z. Karadi, (SE, 2nd Dept. Of Pediatrics)
Method of IV pediatric CEUS 1.

**UCA dose** depends on

- Size / age of the patient
- Type of UCA
- Type of the study (depth)
- US system, type of transducer
- Software version of the US system

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**TABLE 1: Dose (mL) of Contrast Agent Administered to Pediatric Patients According to Local Protocols**

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Liver</th>
<th>Spleen and Kidneys</th>
<th>Testis and Microvascular System</th>
<th>Intracavitary¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–5</td>
<td>0.6</td>
<td>0.6</td>
<td>4.8</td>
<td>0.1</td>
</tr>
<tr>
<td>6–12</td>
<td>1.2</td>
<td>1.2</td>
<td>4.8</td>
<td>0.1</td>
</tr>
<tr>
<td>12–18</td>
<td>2.4</td>
<td>1.2</td>
<td>4.8</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Yusuf et al.  
AJR:208, Febr 2017
Method of IV pediatric CEUS 2.

- **Timing** of scanning and recording
- Selection of the ROI / **scan plane**
- 2nd person must be present during the study
- Be prepared for **allergic** reaction, **ICU** is available
- Consider **hyperdynamic circulation**
Potential indications of CEUS in Pediatric Patients:

**CONCLUSIONS**

- Contrast US has a great potential in pediatric imaging in *experienced* hands
- No radiation, no sedation, no renal risk
- Main indications: trauma, tumor, VUR
- CEUS methodology needs further studies
- Potential of US *guided local* treatments
- Correlation with other imaging studies
Questions and comments?

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