Ultrasound Contrast Media

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Bubbles

Gas
- Intravenous
- Big difference in acoustic impedance
- Hyperechoic
- Hyperattenuating
- Reverberation artifacts

<table>
<thead>
<tr>
<th>Normal/Bubbles</th>
<th>Air</th>
<th>1.2</th>
<th>320</th>
<th>1-0 (e-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>1.35</td>
<td>420</td>
<td>1-0 (e-6)</td>
</tr>
<tr>
<td></td>
<td>Soft tissue</td>
<td>1.45</td>
<td>1426</td>
<td>1-0 (e-6)</td>
</tr>
<tr>
<td></td>
<td>Bone</td>
<td>1.90</td>
<td>692</td>
<td>7.09 (e-6)</td>
</tr>
</tbody>
</table>

Agitated Saline
- Larger than capillaries
- Doesn’t cross lungs
- Used to identify R to L shunts

Contrast Media
- 1-7 µm
- Crosses to left-sided circulation
- Can identify and assess vessels and tissue perfusion throughout the body

Composition
- Air or high molecular gas
- Albumin or lipid microsphere

Elimination
- Small doses
- Short 1/2 life
- Exhaled
- Metabolized

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Heart
Liver
Spleen
Pancreas
Kidneys
Lymph Nodes
OB/GYN
Conclusion
Contrast Media

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- Ultrasound sine waves have + and - deflections
- Resonant frequency - in sync with microbubble oscillations
- Mechanical Index - force of compression and rarefaction

Mechanical Index

Low MI (<0.1)
- Linear Oscillation

Intermediate MI (0.1-0.5)
- Nonlinear Oscillation
- Expands > shrinks
- Harmonic frequencies

High MI (>0.5)
- Transient nonlinear echo
- Destructive
- “Stimulated Acoustic Emission”

Harmonic Frequencies

A. Conventional Imaging
B. Harmonic Imaging

Citations


Harmonic Frequencies

Contrast Specific Imaging
- Second harmonic imaging
- Pulse-inversion harmonic imaging
- Cadence-contrast pulse sequencing

Second Harmonic Imaging
- Fundamental frequency is transmitted
- Only second harmonics are received

Pulse-Inversion Harmonic Imaging
- 2 pulses of sound are transmitted with sine waves in opposite directions
- Return echo of linear oscillators cancel out
- Return echo of nonlinear oscillations of contrast media have a return signal

Citations
Cadence Contrast Pulse Sequencing

- 3 pulses of varied phase and amplitude
- Return echo of linear oscillators cancel out
- Nonlinear oscillators have return fundamental and harmonic signals

Citations

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LV Opacification

Improved imaging of:
- Delineation of the wall-lumen interface
- LV volume
- Ventricular wall motion
- Mural perfusion

Citations


Normal Myocardium

FIGURE 14-16 The process of performing real-time myocardial perfusion imaging. A, A high slice image of the LV is acquired. B, A high slice image of the LV is acquired immediately after the administration of agitated microbubbles is performed. C, Improved imaging of the myocardium with myocardial perfusion is visualized with the microbubbles within the contrast-enhanced phase. LV = left ventricle.

Citations
Intracardiac Mass

- Contrast detects whether the mass is perfused or not
- 16 patients
- Optison or Definity
- High MI flashed to destroy microbubbles and observe replenishment

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Thrombus

**Cardiovascular Events**

- Destroy microbubbles with a flash of high MI
- Normal myocardium replenishes
- Mild or no contrast in poorly perfused areas

**Non-human primate studies**


**Liver**

- 20% hepatic artery, 80% portal vein
- 3 phases of contrast enhancement
  - Arterial: 10-25 s
  - Portal: 30-120 s
  - Delayed: 30 s - several minutes

**Normal Liver**

- A
- B

**Malignant Liver Tumors**

- Have increased arterial blood supply
- Early wash-in, early wash-out
- Hypoechoic in portal and delayed phase
  - Sensitivity: 100%
  - Specificity: 94%
  - PPV: 94%
  - NPV: 100%
  - Accuracy: 97%

**Citations**

Malignant Liver Tumors


Benign Liver Tumors

Spleen

2 phases of contrast enhancement
- Arterial phase
  - Non-homogeneous enhancement
  - Variable flow rates through sinuses
  - Unreliable interpretation
- Delayed phase
  - 1-7 minutes

Citations

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Normal Spleen

Arterial Phase

Delayed Phase

Splenic Lesions

- Not very accurate for discriminating between benign and malignant lesions
- HSA and LSA - distinct perfusion patterns
- Malignant lesions and hematomas - Hypo
- Improved detection of:
  - Hemangiosarcoma
  - Lymphoma
  - Microabscesses
  - Traumatic lesions
  - Infarctions


Splenic Tumors

B-Mode

Delayed Phase

### Kidneys

**Contrast Enhancement**
- Renal arteries - 10 s
- Cortex - 15 s
- Medulla - 30 s

**Characterization of various lesions:**
- Renal carcinoma
- Hemangiosarcoma metastases
- Renal cysts
- Hematomas


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### Normal Kidneys

**Arteries**

**Cortex**

**Medulla**


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### Renal Carcinoma


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### Acute Renal Infarction

**Normal**

**Infarct**

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Renal Nodule

Normal

Citations

Lymph Nodes

Characteristics to differentiate benign vs malignants
- Size
- Vascular architecture
- Pulsatility Index

Contrast Ultrasonography
- Over 2x vessel detection compared to power Doppler


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Early Detection of LSA

Citations

Small Intestine

Normal values:
- Wash-in & wash-out perfusion pattern
- Dose: Definity 0.03 mL/kg IV bolus

May provide baseline information for studying:
- Infarction
- Necrosis from obstruction
- Infiltrative inflammatory or neoplastic disease


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- **Kidneys**
- **Intestine**

**OB/GYN**

**Conclusion**

- **Time-Intensity Curve**

**Genitourinary**

- **Assess uterine perfusion during embryo implantation**
- **Identify corpus luteum from adjacent ovarian tissue**
- **Evaluate uterine intervillous flow in early pregnancy**

- **Non-human primate studies:**

**Gravid Uterus**

Conclusion

- Ultrasound contrast agents enhance evaluation of cardiac, abdominal, and superficial soft tissue structures
- Increase sensitivity for perfusion deficits
- Can increase accuracy diagnosing certain specific diseases
- Large potential for expanding research