The most relevant new technologies
ULTRASOUND

1. Contrast Enhanced Ultrasound
   Basics
   Clinical Applications
2. Elastography
   Mechanical Elastography
   Transient Dynamic E.
3. Ultrasound Simulation
   Teaching
   Quality Management

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**Type of Contrast Agent**

**Leovist Suspension**

Galactose Microparticles  
Palmitic Acid  
Bolus 7 ml (2.5 g, 300 mg/ml)

**SonoVue Suspension**

SF6, Phospholipids  
Bolus 4.8 ml

Granules  
Leovist = 99.9% Galactose + 0.1% Palmitic Acid

Suspension  
Hydrophobic Pol  
Hydrophilic Pol  
Phospholipids  
SF6
CEUS Techniques

Low-MI

Filter Method (cheap) PI-CHI/Coded Best Resolution CPS VRI Best Sensitivity (CHI-Power)

Special Software! Older Instruments: No upgrade!
Quality differences in between methods: spatial-, contrast-, time Resolution
## Contrast-Echography of Liver Tumors

### Action after Injection

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection</td>
<td>0 s</td>
</tr>
<tr>
<td>Arterial Phase</td>
<td>&lt;30 s</td>
</tr>
<tr>
<td>Portal Phase</td>
<td>30-120 s</td>
</tr>
<tr>
<td>Late Phase, postvascular Phase</td>
<td>&gt;120 s</td>
</tr>
<tr>
<td>Liver spezific Phase (Levovist, Optison)</td>
<td>&gt;180 s</td>
</tr>
</tbody>
</table>
Definition of characteristic Contrast Behaviour

1. Focal Fatty Infiltration, Regenerative Nodule: as normal Liver Parenchyma

2. Hemangioma: „globular enhancement“, centripetal Filling

3. Focal Nodular Hyperplasia (FNH): strong arterial, portal and postvascular Phase

4. Adenoma: Short arterial Phase, than as normal Liver

5. Metastasis: arterial Phase, „rim enhancement“, no portal P. early wash out
Liver Hemangioma

VRI (Vascular Recognition Imaging) Low MI (SonoVue)
Characterisation by Flow Characteristics and Vascularity

FNH: CPS

FNH: Microvascular-Imaging
Metastasis Characterisation and Detection

CHI (Puls-Inversion)
Contrast-Enhanced Sonography for the Characterisation of Hepatozellular Carcinomas – Correlation with Histological Differentiation
Strobel D et al., Ultraschall in Med 2005, 26:270-276

**HCC:** no wash out in the late phase in 58%!
Characterisation only by arterial phase and irregular vascularity!
SonoVue „Low MI Imaging“ and Optimization by Adaptive Optimization Algorithm „Photopic“

HCC low MI (SonoVue)

Cairo, March 31, 2005
FNH ?  If doubt: Biopsy! This is HCC !
## Echocontrast Imaging of Liver Tumors

### Characterization of Liver Tumors

<table>
<thead>
<tr>
<th>Tumor</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCC</td>
<td>68% - 94%</td>
<td>60% - 96%</td>
</tr>
<tr>
<td>Metastasis</td>
<td>83% - 91%</td>
<td>76% - 100%</td>
</tr>
<tr>
<td>Hemangioma</td>
<td>44% - 88%</td>
<td>98% - 100%</td>
</tr>
<tr>
<td>FNH</td>
<td>83% - 100%</td>
<td>98% - 100%</td>
</tr>
<tr>
<td>Hyperpl. nodules</td>
<td>71-100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Results:
Advantage of CEUS over CT in hypovascular Lesions and Abscesses

Berlin, 04.05.2006
Abscess (Complication of Hepato-Jejunostomy)
Clinical Value of Contrast Enhanced Ultrasound

**Liver**
Tumor Characterisation
Value: Characterisation as MR, for some entities more certain
Detection of metastasis
Value: Comparable Multi-Detector- CT
Hepatic abscess: Value: Characterisation of hypovascular Tumors in CT

**Pancreas**
Tumor Characterisation
Value: Best Test for Characterisation, but EUS-Biopsy needed

**Ischemic Lesions:**
Infarction of spleen, kidney, bowel, traumatic ischemic lesions, organ hematoma (spleen, liver etc.)
Value: as MD-CT, but no unwanted side effects of contrast agent

**Kidney:**
Value: Characterisation of cystic or hypovascular Tumors in CT
Elastography-methods I

Sensitivity Prostatic-Ca. 84.1%
Prosp. Study N= 404
Konig, et al. J. Urology 2005,
KMR, Ruhr-Uni-Bochum

Elastography: Displacement Computation

A-Line without Compression
A-Line under Compression
Displacement
\( \Delta l = c \tau(z_i) \)

B-Mode Image
Histology

Rigid
Soft

Tissue Characterization and Elastography
Ruhr-Universität Bochum
Hochfrequenztechnik
Neue Verfahren in der Gastroenterologie

Elastography by EUS
www.echosens.com
2. Dynamic Elastography

Quantitative analysis of liver fibrosis by transient elastography (Fibroscan- 50 Hz Vibrator, 5 MHz acquisition)


Erasmus Liver Day 30.11.2005
Value of two noninvasive methods to detect progression of fibrosis among HCV carriers with normal aminotransferase.

Results

Fig. 1. Scatterplot of individual METAVIR scores in relationship to the results of FibroTest (open circles, upper panel) and Fibroscan (solid circles, lower panel).
1. Excellent agreement in between histologic score and Fibroscan (kappa 1.0),

2. All patients with low fibrosis score (=/<F2) with no need of repeated biopsies and no need of antiviral treatment detected

3. Vice versa all patients with fibrosis progression (> = F2) and need of treatment detected (cut off 8.4 Kilo-Pascal; Sensitivity/Specificity 100%/100%.

4. Fibroscan (transient Elastography) can replace biopsy for quantification of fibrosis (?)

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Terkamp et al. Z Gastroenterol. 2004 Nov;42(11):1311-4

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**Introduction**

Simulation can be done in different ways

1. **Animal Model**: Find an animal model for simulation of human conditions

2. **Virtual Modeling**: Create a virtual 3D digital model similar to real life situations or conditions

3. **Human Virtual Model**: Digitize 3-D real life conditions, reconstruct and project it to create a real life impression and condition
Details of Ultrasound Simulator

The simulator consists of:
1. Powerfull workstation
2. life-like mannequin (Dummy)
3. Integrated electromagnetical localisation unit
4. Dummy-Transducer
5. 3-D electromagnetic sensor in Dummy Transducer

3 Steps to simulation:
1. Volume acquisition of patient findings with given pathology
2. Positioning of volume anatomically correct inside the mannequin
3. Simulation of patient examination. Read out of image plane according to probe position (TGC, gain setting, measurements possible)
Data aquisition for simulator and display of data

Step 1
1. 3-D-Ultrasound Data aquisition by electromagnetic scanhead tracking
2. store 3-D-Data of 3-D-Volume of interest (example: Right upper quadrant) in Workstation

Step 2
3. Project the aquired ultrasound volume into a mannequin (adjusting voxel address to dummy

Step 3
4. Use dummy transducer with internal sensor to read out scanplanes out of volume located in the mannequin reversing the recording process.
Simulation of Abdomen Sonography. Evaluation of a New Ultrasound Simulator

Terkamp et al., Ultraschall in Med, 2003, 24:239-244

Details:
Results:

**Accuracy**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Simulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 +/- 9%</td>
<td>71 +/- 8%</td>
</tr>
</tbody>
</table>

**Confidence**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Simulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>68 +/- 6%</td>
<td>64 +/- 12%</td>
</tr>
</tbody>
</table>

**Examination Time**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Simulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,57 +/- 3</td>
<td>9,59 +/- 3</td>
</tr>
</tbody>
</table>

**Handling**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Simulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>74 +/- 7%</td>
<td>61 +/- 12%</td>
</tr>
</tbody>
</table>

Conclusion: The Simulator is doing the job!

Side effect: 20-30% of findings overlooked! Training to short!
Improvement by US-Simulator-Training
Correct indentification of pathology and anatomy
Terkamp et al., DDW 2004

Results of Abdominal Ultrasound training courses 2002/3
Ultrasound Simulation
Ultrasound-Simulator: Clinical Value?

1. The ultrasound simulator simulates ultrasound B-Mode examination of the abdomen similar to real life.

2. Teaching ultrasound by Means of the ultrasound simulator increases anatomical understanding and detection rate of ultrasound pathology.

3. The ultrasound simulator is therefore suitable for a qualified ultrasound education and for objective standardized evaluation of abdominal ultrasound skills and quality management.

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