Artificial intelligence and robots in the OR
- Still room for ebM?
Innovation Center Computer Assisted Surgery (ICCAS)

- Affiliated to Medical School of Universität Leipzig
- ~85 engineering and computer science researchers
Technology is an integral part of medicine

Medicine

Biomedical and information technology

Personalized
Predictive
Preventive
Participatory

4P medicine

Hood and Friend 2011
Technology has a different evolution speed

- Information retrieval from distant monitors and devices
- Vendor dependent device operation
- Technical obstacles for advanced workflow management
- Limited flexibility in the selection and combination of systems

[Quelle: Bulitta, 2006]
acquire
analyze
act
acquire
act
analyze
Robotic systems for surgery

- Master-slave systems
- (Semi-) autonomous systems
Current evidence for robotic systems

- Operation times
- Operative costs
- Blood loss
- Complication rates
- Hospital stay length
- Transfusion rate

Be aware that the safety and effectiveness of using robotically-assisted surgical devices in mastectomy procedures or in the prevention or treatment of cancer has not been established.

FDA, Feb 28, 2019
Imaging and cooperative robots

© Siemens Artis Zeego
Imaging and cooperative robots

Bieck et al. 2017
acquire

act

analyze
FDA-approved AI-algorithms

https://medicalfuturist.com/
Current research areas

- **Anaesthesia management**
  - Risk for postoperative pain, nausea, and respiratory depression
  - Predict hypotension, hypoxemia

- **Surgery**
  - Prediction of procedure times and anticipation of risk situations
  - Decrease human-technology interaction, Automatic documentation

- **Administration**
  - Decrease non-value-adding activities
  - Provide KPIs
Situation aware biomedical technologies

Neumuth et al. 2009, Franke et al. 2015
Situation aware biomedical technologies
Medical device interoperability

- **HIS, PACS**: © Ch. Toulon
- **Dokumentation**: © Oehm & Rehbein
- **3D-Rekonstruktion**: © Medstation
- **US-Registrierung**: © OrthoMit
- **Tracking**: © NDI
- **OP-Tisch**: © Trumpf
- **Roboter**: © meditec HIA
- **Planung**: © Aesculap
- **Tools**: © SurgiTAX
- **Displays**: © Maquet
- **MMI**: © Philips

**SDC** – Service oriented device connectivity

ISO/IEEE 11073-10207
IEEE 11073-20701
ISO/IEEE 11073-20702

**SDC** – Service oriented device connectivity
acquire
analyze
act
Hyperspectral Imaging
Hyperspectral imaging for tissue perfusion

Pathological bowel

Perfusion state?

a) Patient with postop. perfusion insufficiency

b) and c) Patients without postop. perfusion insufficiency

Jansen-Winkeln et al. Chirurg 2018
HSI-based discrimination of thyroid and parathyroid

Total number of spectra: $n_{\text{thyroid}} = 3128$, $n_{\text{parathyroid}} = 383$

Barberio et al. 2018
But surgery is just one option ...
Digital patient models for decision-making

Integration viewpoint by using MEBN

Cyko et al. 2017

ENT-Tumorboard at the University Hospital Leipzig, Germany
Prediction and clinical decision support
Artificial intelligence and robots in the OR
- Still room for ebM?
The digital footprint

act
acquire
analyze
The digital footprint

act
acquire
analyze
Numeric vs. symbolic process models

- Surgical Workflow
- Numerical models (digital footprint)
- Symbolic models
Model generalization

Single cases

A → B → C

A → B → A → C

...

A → B → C → D

Merged model

START

A → B

C → D

END
Model analysis: workflow assessment

Preparation → Capsulorhexis → Lens Removal → Lens Implantation → Removal of Healon → Completion

START 100% → paracentesis paracentesis knife cornea 93% → inject healon chamber ant 81% → capsulorhexis rhexis cannula capsula lentis 92% → cut lancet clear cut cornea 94% → excision material utrata’s tweezers capsula lentis 86% → END

(model filtered with threshold 5%)

Neumuth et al. 2011
Phase Capsulorhexis or Cataract interventions: Generic process models for outpatient (n=51) and inpatient cases (n=54) (model filtered with threshold 5%)
## Model analysis: resource impact estimation

### Nissen fundoplication, animal study

**Laparoscopic cases vs. telemanipulator-assisted cases (each n=12)**

<table>
<thead>
<tr>
<th>Phases</th>
<th>LAP [avg ± std]</th>
<th>TEL [avg ± std]</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total intervention</td>
<td>01:41:05 ± 00:21:56</td>
<td>01:36:47 ± 00:17:08</td>
<td>p = 0.045</td>
</tr>
<tr>
<td>Preparation</td>
<td>00:42:31 ± 00:16:56</td>
<td>00:38:44 ± 00:07:34</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>Dissection</td>
<td>00:18:49 ± 00:10:44</td>
<td>00:13:10 ± 00:06:40</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>Reconstruction</td>
<td>00:33:25 ± 00:10:08</td>
<td>00:37:32 ± 00:07:44</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>Conclusion</td>
<td>00:06:19 ± 00:01:49</td>
<td>00:07:12 ± 00:02:22</td>
<td>p &gt; 0.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subphases</th>
<th>LAP [avg ± std]</th>
<th>TEL [avg ± std]</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconstruction hiatus</td>
<td>00:09:15 ± 00:07:22</td>
<td>00:06:54 ± 00:01:50</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>Reconstruction collar</td>
<td>00:08:25 ± 00:02:13</td>
<td>00:10:49 ± 00:03:32</td>
<td>p &gt; 0.05</td>
</tr>
<tr>
<td>Wrap creation</td>
<td>00:03:09 ± 00:00:44</td>
<td>00:04:45 ± 00:05:10</td>
<td>p = 0.014</td>
</tr>
<tr>
<td>Reconstruction Fundoplication</td>
<td>00:12:43 ± 00:02:31</td>
<td>00:15:32 ± 00:03:13</td>
<td>p &gt; 0.05</td>
</tr>
</tbody>
</table>

Krauss et al. 2012

Nissen fundoplication, animal study laparoscopic cases vs. telemanipulator-assisted cases (each n=12)
Model analysis: technology requirements

- Opening of the skin
- Preparation of muscle tissue
- Bone removal
- Removal of inter vertebral disc
- Completion

<table>
<thead>
<tr>
<th>n=14</th>
<th>Unit</th>
<th>AVG</th>
<th>Min</th>
<th>Max</th>
<th>SDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time Frame</td>
<td>hh:mm:ss</td>
<td>00:45:08</td>
<td>00:22:23</td>
<td>01:13:43</td>
</tr>
<tr>
<td></td>
<td>Iterations</td>
<td>activity</td>
<td>15.2</td>
<td>7</td>
<td>27</td>
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<tr>
<td></td>
<td>Cumulated Duration</td>
<td>hh:mm:ss</td>
<td>00:19:55</td>
<td>00:12:40</td>
<td>00:32:11</td>
</tr>
</tbody>
</table>

Neumuth et al. 2009
Objective: Development of an eco system for data acquisition and AI-based analysis for post market surveillance of medical devices
Summary

• Robots have arrived in ORs
• AI in the OR has not yet arrived

• Technologies have digital footprints that enable continuous ebM without cognitive biases

If you can't measure it, you can't improve it.

(Peter F. Drucker)
Thank you.

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