Role of contrast enhanced Cone Beam CT in the Treatment of Ruptured AAA - Are we ready to go?

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Disclosures

• Consultant
  – Arsenal, Cook, Endologix, Gore, Medtronic, Cook

• Research Grant /research support
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• Advisory Board
  – Endologix, Gore, Medtronic, Siemens

• Paid speaker
  – Cook, Endologix, Gore, Maquet, Medtronic, Siemens

• Major stokeholder
  – none
In-Hospital Management of suspected ruptured AAA

Emergency Room

Ultrasound

hemodynamically stable
systolic pressure > 60 mmHg
CT-Angiography

Hybrid OR

Percutaneous femoral access on table angiography

favourable proximal neck
pEVAR

Hostile or no proximal neck

OR - occlusion balloon CHEVAR

hemodynamically unstable
systolic pressure < 60 mmHg

(Hybrid-) OR

Open Repair (OR)
In-Hospital Management of suspected ruptured AAA

- **Emergency Room**
  - Ultrasound
    - hemodynamically stable
      - systolic pressure > 60 mmHg
        - CT-Angiography
          - Hybrid OR
            - Percutaneous femoral access
              - Cone beam CT
                - favourable proximal neck
                  - pEVAR
                - Hostile or no proximal neck
                  - occlusion balloon
                    - CHEVAR
            - (Hybrid-)Operating Room
              - Open Repair (OR)
Def.: **contrast enhanced Cone Beam CT (ceCBCT)**

postprocessed 3 D rotation angiography with a multi-axial robotic based angiographic system
ceCone Beam CT Acquisition (Heidelberg Protocol)

- Data acquired by flat panel detector of C-arm (Artis zeego)
- Rotational sweep covering 200° for 3D projection
- 248 frames over 5 seconds at intervals of 0.8 degrees
- 45 cc contrast + 25 cc saline through 5 Fr pigtail (above renals)
- Injection rate i.a. 10 cc/s with 2 sec. delay
- 4 x 4 binning projection images (480 columns x 612 rows)
- Automatically transferred to workstation (syno X, Siemens)
- Dyna CT with voxel size of 0.78mm, 305 axial slices
- Visualized either as slices (e.g. MPR, MIP) or 3D-VR
ceCBCT is established in elective EVAR (TEVAR/FEVAR)

Intraoperative CT in EVAR is definitively helpful in elective EVAR
Intraoperative contrast-enhanced cone beam computed tomography to assess technical success during endovascular aneurysm repair

<table>
<thead>
<tr>
<th></th>
<th>Completion Angio</th>
<th>Dyna CT (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Endoleak (n)</td>
<td>28</td>
<td>41</td>
</tr>
<tr>
<td>Type I EL</td>
<td>1</td>
<td>+ 3</td>
</tr>
<tr>
<td>Type II EL</td>
<td></td>
<td>+ 11</td>
</tr>
<tr>
<td>Limb stenosis/-thrombosis</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Iliac dissection</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Any event</td>
<td>29</td>
<td>48</td>
</tr>
</tbody>
</table>

Dyna CT was feasible in 80%
Completion angio missed 19 events (18%)
DynaCT was feasible in 81% of procedures
4.5% of patients needed early reintervention
In 6-36%, technical resolvable problems were detected being missed in uniplanar completion angiography
Standard pre-discharge imaging did not identify further graft related complications in the DynaCT group
Introduction of DynaCT resulted in significant reduction of reinterventions
Advantages of ceCBCT: Radiation and Contrast

Radiation Impact

- Per-operative Radiation
  - Graft type, p=0.557
  - BMI, p=0.103
  - Average DAP = 12%

- Global radiation (CBCT vs. DSA + CTA):
  - 44% reduction

- Contrast Volume
  - 33% reduction

Courtesy of S. Haulon. Presented at Veith 2014
Workflow in Heidelberg for ceCBCT in elective EVAR

- **Procedure**
  - EVAR Completion DSA
  - Postoperative CTA
  - Technical Success?

  - No → Reintervention
  - Yes → Standard Follow-up

- **past years**

- **Procedure**
  - EVAR: Fusion Imaging
  - Intraoperative Dyna CT
  - Technical Success?

  - No → Immediate Revision
  - Yes → CEUS
    - Standard Follow-up

- **present**
Advantages of ceCBCT in AAA & rAAA Treatment

- DynaCT allows intraop. Imaging of intraoperative results
- Reduction of early (< 30d) reintervention rate (10%) \(^1\) by on table by detection of EL I&III, limb stenosis/thrombosis, accididental coverage of renals
- Reduction of reintervention-associated mortality rate\(^2,3\)
- Reduction of radiation and contrast
- Reduction of prolonged hospital stay and costs
- Time saving in rAAA reducing risk of free aneurysm rupture during CTA

\(^1\) Greenhalgh et al Lancet 2004;364:843 \(^3\) Sampram JVS 2003;37:930-7; \(^3\) Hobo JVS 2006 43:896-902
Is ceCBCT ready for Implementation in rAAA Protocol?

- Yes, if...
  - If it is performed without significant time delay
  - If it covers region of interest
  - If resolution is good/sensitive enough for measurement
Eide K et al. EJVES 2011;42:332-339 (n= 20)

- compare accuracy of MD-CT image and ceCBCT prior to EVAR regarding:
  - Visualization of periaortic soft tissue > hemorrhage, rAAA
  - pre-treatment measurements > device selection
<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparing DynaCT with MDCT. Mean measured lengths and diameters in mm (95% CI).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DynaCT</td>
</tr>
<tr>
<td>1. Max diameter of the aneurysm</td>
<td>64 (63, 65) n = 40</td>
</tr>
<tr>
<td>2. Length of aneurysm upper neck</td>
<td>35 (33, 36) n = 39</td>
</tr>
<tr>
<td>3. Diameter of aneurysm upper neck</td>
<td>22 (22, 23) n = 39</td>
</tr>
<tr>
<td>4. Length from distal renal artery to bifurcation</td>
<td>131 (129, 133) n = 39</td>
</tr>
<tr>
<td>5. Length from distal renal artery to right internal iliac orifice</td>
<td>186 (184, 188) n = 29</td>
</tr>
<tr>
<td>6. Length from distal renal artery to left internal iliac orifice</td>
<td>188 (184, 192) n = 17</td>
</tr>
</tbody>
</table>

*n* = the total number of observations for each measurement. *n* = 40 means 20 patients observed by 2 investigators. *n* < 40 means some observations could not be evaluated because the most distal structures were outside the imaged volume.

**Conclusion:** The result indicates that DynaCT gives sufficient information to determine the correct treatment and for selecting the proper stent graft before EVAR. A limited volume size reduces the evaluation of the iliac arteries.
Imaging Quality is similar and sufficient
ceCBCT can identify ruptures in aneurysms
Literature – ceCBCT in ruptured cases

- Single case report
- Free ruptured AAA
- Stabilized by balloon blockage
Current Limitations of ceCBCT: Volume of Acquisition

- Restricted field (ca 24 cm craniocaudal extent) > either abdominal or thoracic but not both
- Time delay in unstable patients > 5 min acquisition time (in well rehearsed team)
- Evaluation of morphology
  - Underestimation of calcification
  - Undersizing the proximal neck by 2 mm, especially in rAAA
  - Caveat: device selection regarding oversizing
Summary

• CBCT became already standard for intraop. evaluation after EVAR
• Preoperative assessment of rAAA is technically feasible
• CBCT has sufficient sensitivity for diagnosis of rAAA
• CBCT showed in neuroimaging studies location of rupture
• Evidence to support the advantages and application for rAAA is low
• actually not existing....
Conclusions

- Further research and clinical evaluation is needed
- Comparison of measurement techniques CT vs. ceCBCT
- Need for new workflow for rAAA with direct transfer to OR and on table evaluation of AAA morphology regarding EVAR suitability
- Potential to replace preop. CT-scan saving time and eventually lifes
- ceCBCT will become part of the management of rAAA
In my mind: **Yes** - we are ready to go!
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