Evolvement of Imaging and Dose Reduction Techniques for Image Guided Endovascular Treatment of Complex Aortic Pathologies

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Disclosures

* Research-grants, travelling, proctoring speaking-fees, IP, royalties with Cook.

* Consultant with Philips

* Research, consulting, royalties with Vascutek.

* Shareholder Mokita Medical
Early X-Ray Usage

- Shoe stores
- Ca. 10 000 ex in USA 1920-1950
A long time ago.......

Thoracic Live X-Ray

Radiologists hands
......and today.

Dr. Edward Diethrich
Founder and Medical Director
Arizona Heart Foundation
1935-2017
Clinical innovations and milestones over time

1891
- Invention Philips x-ray tubes for medical applications

1929
- World's first cardiac catheterization

1958
- First coronary angiogram

1960

1977
- First coronary angioplasty

1979
- First DSA system

1986
- First design sketch of modern C-arc

1990
- Introduction of Integris

1991
- Introduction of bolus chase

Basic diagnostic and interventional imaging

- 1891
- 1960
- 1990
Clinical innovations and milestones over time

Innovations in Advanced 3D imaging and guidance, Dose management, Functional imaging & Devices

Selection of tools and applications

- DoseAware
- EmboGuide
- EP Navigator
- VesselNavigator
- StentBoost Live
- Dynamic Coronary Roadmap
- 2D Perfusion
- AlluraClarity
- Volcano Acquisition
- AlluraFamily withFD
- XperCT
- Image fusion
- 3D Roadmap
- HeartNavigator
- EchoNavigator
- AneurysmFlow
- 3DRA
- StentBoost
- StentBoost Live
- Spectranetics Acquisition
- Azurion Family
Clinical innovations and milestones over time

The Vascular Procedure Portfolio

Innovations in Advanced 3D imaging and guidance, Dose management, Functional imaging & Devices

Selection of tools and applications
German Aortic Center
Hamburg

The Vascular Procedure Portfolio

DoseAware

VesselNavigator

Volcano Acquisition

Spectranetics Acquisition

3DRA
StentBoost

AlluraClarity

2D Perfusion

Azurion Family

Innovations in Advanced 3D imaging and guidance, Dose management, Functional imaging & Devices

Selection of tools and applications
German Aortic Center
Hamburg

CT-Fusion of Live-Fluoro

Real-Time Staff-Dose Monitoring

Ceiling mounted FD System (20 inch) with grid switch X-ray tube and ClarityIQ Real-Time Fluoro/DSA Noise-Reduction Technology
Dose = radiation x time
X-Ray Dose Calculation

Dose (mSv) \( H \) = \( \frac{I \cdot K_x}{r^2} \cdot T \cdot \frac{1}{S_g} \)

- \( I \) = Tube-type and use (DL-constant)
- \( K_x \) = Ampere [mA] (tube current)
- \( r \) = Distance
- \( T \) = Duration
- \( S_g \) = Shielding-coefficient
Distance and Dose

- If you double the distance to the source:
  - Area $\times 4$
  - Dose per area $/4$

- If you triple the distance to the source:
  - Area $\times 9$
  - Dose per area $/9$

Small changes in distance have high impact on dose!
Distance and Dose

Hirshfeld et al., Circulation 2005
Field of View

Use Shutters, reduce the FOV!

- Reduction on dose area product (patient)
- Reduction of scatter radiation (personal)
- Image quality improves
Isodose Lines

Isodose-lines depend on angulation!

Effective dose (personal)

Dose area product (patient)

Kuon, J Am Coll Cardiol 2004
scatter radiation emits from entrance point of beam into the patient.

- Depends on Angulation
Education and Training
Education and Training

The impact of ALARA Principles

Efficacy of a Minicourse in Radiation-Reducing Techniques in Invasive Cardiology
A Multicenter Field Study
Eberhard Kuon, MD,* Kerstin Weitmann, MSc;† Wolfgang Hoffmann, MD;† Marcus Dörri, MD;† Thorsten Reffelmann, MD;† Astrid Hammel, MD;† Alexander Riad, MD;† Matthias C. Buseh, MD;† Klaus Emper, MD;† Stephan B. Felix, MD;†

(N=154 participants)
→ 48% DAP reduction
→ 21% Fluoro time reduction
→ 9% less runs
→ 27% less DAP/frame (collimation)
→ 39% less DAP/s (collimation)

Reducing radiation exposure during invasive coronary angiography and percutaneous coronary interventions implementing a simple four-step protocol
Moritz Seiffert • Francisco Ojeda • Kai Müllerleile • Elvin Zengin • Christoph Sinning • Christoph Waldeyer • Edith Lubos • Ulrich Schäfer • Karsten Sydow • Stefan Blankenberg • Dirk Westermann

Procedure Comparison before (N=1656) and after training (N=1451)
→ 53% DAP reduction

The impact of Procedure Complexity

Median DAP

→ Abdominal Aortic Endografting Range
  12.2 – 276 (Gy*cm²) (N=14)

→ Thoracic Endografting Range
  20 – 309 (Gy*cm²) (N=5)

→ Complex Aortic Endografting
  44 – 1188 (Gy*cm²) (N=5)

BUT: Simple Absolute Value comparison is scientifically incorrect!
IEC-Norm and FDA allow ±35% DAP value system calibration Error!

Hertault A. et al., Editor's Choice - Minimizing Radiation Exposure During Endovascular Procedures
Complex EVAR and TEVAR

GERMAN AORTIC CENTER HAMBURG

- 07/2015 – 12/2015 N = 32 (single center)

- Allura XPER Acquisition system
  (Allura Xper; Philips, Best, The Netherlands)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>n</th>
<th>Fluoroscopy Time (min.)</th>
<th>Median DAP (Gy.cm²)</th>
<th>Median Air Kerma (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEVAR</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEVAR</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVAR</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Branched TEVAR</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fenestrated TEVAR</td>
<td>4</td>
<td></td>
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</tbody>
</table>

n = number of patients
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<tr>
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<tbody>
<tr>
<td>F-EVAR</td>
<td>14</td>
<td>88 ± 30</td>
<td>391 ± 202</td>
<td>5933 ± 2567</td>
</tr>
<tr>
<td>B-EVAR</td>
<td>10</td>
<td>90 ± 41</td>
<td>603 ± 306</td>
<td>6708 ± 3427</td>
</tr>
</tbody>
</table>
Equipment

mobile

fixed

IMAGE QUALITY

DETECTOR SIZE

RADIATION PROTECTION

WORKFLOW

RADIATION

De Ruiter et al. 2016; J Endovasc Ther 23:130-8
The impact of Equipment (Mobile vs. Fixed)

Fixed systems lead to increased likelihood of higher DAP (due to more power)

## Acquisition System

### Allura Xper: n=22

<table>
<thead>
<tr>
<th></th>
<th>Mean FT (min.)</th>
<th>Mean DAP Gy cm²</th>
<th>Mean AK (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>XPER</td>
<td>32</td>
<td>76 ± 37</td>
<td>385 ± 241</td>
</tr>
<tr>
<td>Clarity</td>
<td>22</td>
<td>63 ± 36</td>
<td>203 ± 168</td>
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</tbody>
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### Allura Clarity: n=32

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- P = 0.197
- P = 0.004
- P = 0.005

Unpublished data Hamburg
• 2D – 3D Registration

• 3D – 3D Registration
  (extra Radiation)

• CONE BEAM CT
  (extra Radiation + Contrast)
CT-Fusion
The impact of Image Fusion

Fusion Technology

39% radiation dose reduction (AK) (p=0.004)
31% fluoro time reduction (p=0.01)
52% contrast agent reduction (p<0.001)

However (N=16 vs. 16)

Stangenberg L. et al., A novel tool for three-dimensional roadmapping reduces radiation exposure and contrast agent dose in complex endovascular interventions
Conclusion

- AWARENESS AND KNOWLEDGE
- IDENTIFICATION OF RISK FACTORS
- PROTECTIVE MEASURES
Welcome to Essen!

5th AORTIC LIVE SYMPOSIUM

AORTIC LIVE 2018
October 29-30, 2018
Congress Center Essen, Germany

In 2018 Aortic Live Symposium will return to Essen, Germany again. We are looking forward to welcoming you again next year!
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