«Which stent for which coarctation based on mechanical properties ? »

Modelisation

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CHU Nantes

JFCPC 2015
<table>
<thead>
<tr>
<th>Affiliation/Financial Relationship</th>
<th>Company</th>
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<tbody>
<tr>
<td>Grant/Research Support</td>
<td>Lilly</td>
</tr>
<tr>
<td>Consulting Fees/Honoraria</td>
<td>AstraZeneca</td>
</tr>
<tr>
<td>Major Stock Shareholder/Equity</td>
<td>Actelion</td>
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<tr>
<td>Royalty Income</td>
<td>Abbott Vascular</td>
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<tr>
<td>Ownership/Founder</td>
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<tr>
<td>Intellectual Property Rights</td>
<td></td>
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<tr>
<td>Other Financial Benefit</td>
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</tr>
</tbody>
</table>
The laboratory

- **Bench test:**
  - Camera
  - Binocular magnifying glass
  - Microscanner

- **In-vivo studies**
  - Rats
  - Rabbits
  - Pigs
3D reconstruction
In vivo analysis
In vivo analysis (2)

- Pigs:
Scanning electron microscopy (J28)
Aortic coarctation
Texture analyzer
TA HD PLUS

Measuring the force versus displacement

<table>
<thead>
<tr>
<th>Max Force</th>
<th>± 5kg</th>
<th>± 500kg</th>
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</thead>
<tbody>
<tr>
<td>Force Resolution</td>
<td>0.1g</td>
<td>10g</td>
</tr>
<tr>
<td>Force Accuracy</td>
<td>0.025%</td>
<td>0.025%</td>
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</tbody>
</table>

Texture Technology
Caliper

<table>
<thead>
<tr>
<th>Measuring range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-150mm</td>
<td>0.01mm</td>
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</tbody>
</table>

Fischer scientific
## Analysed stents

<table>
<thead>
<tr>
<th>Modèle</th>
<th>Laboratoire</th>
<th>Composition</th>
<th>Diamètre d'usage</th>
<th>Longueur d'usage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>AndraStent XL</td>
<td>ANDRAMED</td>
<td>Cobalt-Chromium</td>
<td>14-25 mm</td>
<td>14-25 mm</td>
<td>1</td>
</tr>
<tr>
<td>AndraStent XXL</td>
<td>ANDRAMED</td>
<td>Cobalt-Chromium</td>
<td>20-32 mm</td>
<td>16-24 mm</td>
<td>1</td>
</tr>
<tr>
<td>Valéo</td>
<td>BARD</td>
<td>Stainless steel 316L</td>
<td>9 mm</td>
<td>NC</td>
<td>2</td>
</tr>
<tr>
<td>Covered CP stent 16 mm</td>
<td>NuMED</td>
<td>Platinium/Iridium (90/10)</td>
<td>12-24 mm</td>
<td>10.5-16.1 mm</td>
<td>1</td>
</tr>
<tr>
<td>Covered CP stent 28 mm</td>
<td>NuMED</td>
<td>Platinium/Iridium (90/10)</td>
<td>12-24 mm</td>
<td>19.1-26.2 mm</td>
<td>1</td>
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<tr>
<td>CP stent 55 mm</td>
<td>NuMED</td>
<td>Platinium/Iridium (90/10)</td>
<td>12-24 mm</td>
<td>NC</td>
<td>1</td>
</tr>
<tr>
<td>Palmaz</td>
<td>CORDIS</td>
<td>Stainless steel 316L</td>
<td>14-25 mm</td>
<td>37.79-30.58 mm</td>
<td>1</td>
</tr>
<tr>
<td>IntraStent™ Mega™ LD Stent</td>
<td>Ev3</td>
<td>Stainless steel 316L</td>
<td>9-12 mm</td>
<td>26 mm</td>
<td>1</td>
</tr>
<tr>
<td>IntraStent™ Max™ LD Stent</td>
<td>Ev3</td>
<td>Stainless steel 316L</td>
<td>12 mm</td>
<td>26 mm</td>
<td>2</td>
</tr>
<tr>
<td>IntraStent™ DoubleStrut™ LD Stent</td>
<td>Ev3</td>
<td>Stainless steel 316L</td>
<td>9-12 mm</td>
<td>56 mm</td>
<td>1</td>
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</tbody>
</table>
Mechanical tests

- Recoil and foreshortening
- Overall compression
  - Overall Radial Force
- Local compression
  - Segmental Radial Force
- Longitudinal compression
Mechanical tests

- Recoil and foreshortening

- Overall compression
  - Overall Radial Force

- Local compression
  - Segmental Radial Force

- Longitudinal compression
Recoil : Diametrical reduction after balloon deflation

Foreshortening : Longitudinal reduction between the initial and final state of the stent
Initial Recoil

- After first inflation at 18 mm

Recoil initial

Minus 1 mm after deflation in case of 18-20 mm vessel
- Mean recoil after 3 deployment.

Mean Recoil < initial Recoil (except for Palmaz stent)
Foreshortening
Foreshortening

10% : Minus 0.5 cm in length for a 45-50 mm stent!
15% : Minus 0.75 cm in length for a 45-50 mm stent!
Foreshortening

Valeo could be open until 18 mm…but should it be…
(nominal diameter 6-10 mm)
Mechanical tests

- Recoil and foreshortening
  - Overall compression
    - Overall Radial Force
  - Local compression
    - Segmental Radial Force
  - Longitudinal compression
Overall compression between two parallel plates

- Determination of the radial force to develop a diametrical reduction of 60%
There is a relationship between required force and stent’s length.
- Ratio Force/Lenght

- Low resistance of intraStent DoubleStrut

\[
\text{Ratio} = \frac{\text{Force appliquée}}{\text{longueur_stent}}
\]
- Ratio Force/Lenght

- Low resistance of intraStent DoubleStrut
Ratio Force/Lenght

- Low resistance of intraStent DoubleStrut

Overall compression between two parallel plates
Overall compression between two parallel plates

- **Ratio Force/Lenghth**

- **Low resistance of intraStent DoubleStrut**

\[
\text{Ratio} = \frac{\text{Force}_\text{appliquée}}{\text{longueur}_\text{stent}}
\]
Local compression

- Determination of the radial force developed locally to 60% of diameter reduction.
Local compression

- Stents classification according to the cell resistance to the applied stress

Force à 60% de réduction diamétrale
- Longitudinal reduction of 50% of the original length
**Longitudinal Compression**

E : elastic deformation of the stent

Force enregistrée à 1…

Palmaz, CCP Stent 16mm, CCP Stent 28, CP Stent 55mm : destructurations
Take home messages

- **AndraStent XL**: Important recoil and foreshortening important but a good radial force: *Short stenosis requiring a good radial force. Curves*

- **AndraStent XXL**: Important recoil but low foreshortening and an excellent radial force: *Recommended. Curves*

- **Valéo**: Small recoil at 18 mm but very high foreshortening and as a consequence an excellent radial force: *should we use it at 18 mm?*

- **CP ou CCP stent**: Important recoil and foreshortening but a good radial force, intermediate recoil and radial force with important foreshortening (15%) «Classical lesion » without significant curve »

- **Palmaz**: The worst recoil, important foreshortening (10%), correct radial force «Classical lesion » without significant curve »

- **IntraStent™ Mega™ and Max™ LD Stent**: Low recoil, 13% foreshortening, good radial force «Classical lesion requiring a low recoil and good radial force »

- **IntraStent™ DoubleStrut™ LD Stent**: No recoil but the lower radial force: » «coarcation of the young in a curve »
AndraStent XL:

Important recoil and important foreshortening but a good radial force: Short stenosis requiring a good radial force, curves.
Valéo:

Small recoil at 18 mm but very high foreshortening and as a consequence an excellent radial force: should we use it at 18 mm?
CP ou CCP stent :

Important recoil and foreshortening but a good radial force, intermediate recoil and radial force with important foreshortening (15%) « Classical lesion » without significant curve
Study limitations

- n=2
- *Ex vivo* manipulations
- *Ongoing study*

BVS Bench Testing

Appearances are Sometimes Deceptive
Thank you for your attention
Bibliographie

• Analyseur de Texture TA.HD Plus www.texturetechnologies.com


• Ormiston J, Webber B, White J, Ubod B, Webster M. Point compression and stent longitudinal deformation: a novel clinically-relevant bench tests comparing 6 contemporary stent designs. EuroIntervention 2013. doi: 10.1161/CIRCINTERVENTIONS.113.000621


• Illustration coeur : www.ikonet.com
PKP (POT, Kissing, final POT)

- Final result very similar to PSP
- Good result on Main branch