PRESERVATION OF THE PULMONARY VALVE
(NOT JUST THE ANNULUS)
IN REPAIR OF TETRALOGY OF FALLOT

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Preservation of the PV in ToF repair

- Despite the awareness of late consequences of pulmonary valve regurgitation, **TAP remains the most prevalent technique** for repairing ToF.

- Recent interest for **preserving the PV competence**, thus avoiding regurgitation, during ToF repair.
Our PV preservation technique

Since 2007 in selected patients

• **Intra-operative PV balloon dilatation** during ToF repair


With this concept in mind

To better understanding PV anatomy in ToF, in order to identifying patients who could benefit from PV preservation we have inspected:

• 79 → Anatomical specimens
  Non operated patients with ToF

And combined to the intraoperative evaluation of:

• 82 → Patients
  Underwent early ToF repair at our institution (since 2007)
Anatomical specimens

Total: N=79

- 50 Cardiac Registry, Boston Childrens Hospital
  Harvard Medical School

- 29 Regional registry of cardiovascular and cerebro-vascular pathology
  University of Padua

Specimens excluded:
- ToF undergone RVOT enlargement (Brock procedure); ToF with PV atresia, ToF with absent pulmonary valve, and ToF with atrio-ventricular septal defect.

Specimens included:
- ToF undergone palliation with a systemic-to-pulmonary shunt.
Methods

Anatomical series

In ToF specimens we analyzed the PV for:

- **Number of leaflets and commissures**
- **Presence of leaflet’s dysplasia**
Methods

Clinical series

In patients who underwent PV preservation during ToF repair (n=46) we measured, in addition:

- The effective PV opening in mm. (at the valvar level, before any surgical maneuver);
- The true PV annulus diameter (after PV commissurotomy);
- The final PV diameter (after balloon dilation) and valve Z-score was calculated.
# Results

Anatomical Specimens/intraop. evaluation

<table>
<thead>
<tr>
<th>Pulmonary valve (PV):</th>
<th>Dysplastic PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unicuspid</td>
<td>14 (9 %)</td>
</tr>
<tr>
<td>Bicuspid</td>
<td>118 (74 %)</td>
</tr>
<tr>
<td>Tricuspid</td>
<td>28 (17 %)</td>
</tr>
</tbody>
</table>

51% of the valves had NORMAL LEAFLETS!
Surgical results

82 PATIENTS

Period: June 2007 – January 2015

51 Balloon dilatation attempts

5 Conversions in TAP repair

46 Successes (56% of 82 pts)

31 “Classic” surgical TAP repair

Reason for PV preservation failure:
1) Tearing of the hinges of the PV leaflets due to over-sizing of the balloon catheter (n=3) (early in our experience)
2) Very low PV Z-score (<-4) (n=2).
Results: additional plasty

Surgical experience

46/82 (53%)
PRESERVATIONS
(After PV balloon) dilation

18/46 (39%)
No additional maneuvers

28/46 (61%)
Additional maneuvers
PV plasty after balloon dilation

Initial indication: less severe forms (PV Z score ≥ -3)

Current indication: PV Z-score ≥ -4

When PV z-score < -3:

1. **Leaflets delamination (E):** the coaptation area is extended by carefully shaving and delaminating the base of each PV cusp at the hinge point extending down into the RV myocardium, when necessary.

2. **Resuspension (F):** the extended cusps are re-suspended creating new PV commissures.

3. **Patch augmentation (G):** occasionally PV cusps are extended using small triangles of prosthetic (biologic) patch material.
Bovine model of PV delamination

Pulmonary valve delamination plasty technique

Experimental reproduction in a cow

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## Results

### Surgical evaluation

**n=46 patients who underwent PV preservation**

46 of the 82 consecutive patients (56%)

<table>
<thead>
<tr>
<th>Pulmonary valve (PV):</th>
<th>Preserved PV:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Unicuspid</td>
<td>• 0 / 4 (0%)</td>
</tr>
<tr>
<td>• Bicuspid</td>
<td>• 37 / 67 (55%)</td>
</tr>
<tr>
<td>• Tricuspid</td>
<td>• 9 / 10 (90%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Median diameter (range) mm</th>
<th>Median PV Z-score (range) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective PV orifice</td>
<td>5.00 (3-8)</td>
<td>-2.89 (-1.9 - -4.7)</td>
</tr>
<tr>
<td>True PV annuls diameter (after commissurotomy)</td>
<td>7.00 (6-9)</td>
<td>-2.1 (-1 - -3.1)</td>
</tr>
<tr>
<td>Final PV diameter (after balloon dilation)</td>
<td>10.00 (8-12)</td>
<td>-0.2 (+0.2 - -1)</td>
</tr>
</tbody>
</table>

- The median increase in PV diameter after commissurotomy was **2 mm**.
- Balloon dilation resulted in a further median increase of **3 mm**.
Results

Surgical evaluation

- The preoperative 2D-echo PV Z-score was lower in patients who had a bicuspid PV compared to patients with a tricuspid PV.

- Patients who underwent a complex PV plasty had a lower preoperative 2D-echo PV Z-score compared to patients who had a simple PV plasty.
### Echocardiographic evaluation at follow-up

<table>
<thead>
<tr>
<th>n=46 patients who underwent PV preservation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Degree of PV regurgitation (2D echo)</strong></td>
</tr>
<tr>
<td>None / mild</td>
</tr>
<tr>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Total population (n=46)</strong></td>
</tr>
<tr>
<td>40/46 patients (86%)</td>
</tr>
<tr>
<td>6/46 patients (14%)</td>
</tr>
<tr>
<td><strong>F-U time:</strong> 4.7 years (range 0.6-8.1 years)</td>
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</table>

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<tr>
<th>Complex plasty (n=20)</th>
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<tbody>
<tr>
<td><strong>Degree of PV regurgitation</strong></td>
</tr>
<tr>
<td>None / mild</td>
</tr>
<tr>
<td>Moderate</td>
</tr>
<tr>
<td>18/20 patients (90%)</td>
</tr>
<tr>
<td>2/20 patients (10%)</td>
</tr>
<tr>
<td><strong>F-U time:</strong> 3.4 years (range 0.5-4.6 years)</td>
</tr>
</tbody>
</table>

Echocardiographic evaluation at follow-up

<table>
<thead>
<tr>
<th>Degree of RVOT gradient (mmHg)</th>
<th>&lt;20 mmHg</th>
<th>20 – 40 mmHg</th>
<th>&gt;40 mmHg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population (n=46)</td>
<td>25 (54.3%)</td>
<td>20 (43.4%)</td>
<td>1 (2.1%)</td>
</tr>
</tbody>
</table>

F-U time: 4.7 years (range 0.6-8.1 years)

n=46 patients who underwent PV preservation

Conclusions

• **The vast majority of ToF hearts** (>90%) have a bicuspid or tricuspid PV which is not dysplastic and therefore, amenable to preservation.

• Our early surgical results suggest that a **bicuspid or a tricuspid PV is the most favorable surgical anatomy** for applying these PV preservation maneuvers, independently from the presence or degree of leaflet dysplasia.
Conclusions

• We have recently expanded our technique to patients with a smaller PV annulus (Z-score < -3) by adding in all PV reconstruction.

• In more severe cases, where PV leaflets tissue is unable to cover the whole RVOT area, after PV dilation, we have recently introduced the delamination plasty technique with PV cusps extension.
Conclusions

• We have not seen any sign of PV dysfunction, RV muscle hematoma or other anomaly suggesting failure of the PV plasty procedures.

• We believe that the low pressure in the pulmonary circuit is the key for the success of our applied PV plasty techniques.
Conclusions

• Our mid-term results show that this new surgical technique can reduce early post-operative pulmonary regurgitation.

• It appears that the preservation of PV function during early repair of ToF can be extended to the majority of patients with classic ToF.
THANKS FOR YOUR ATTENTION

Anatomical Theatre – Palazzo Bo - Padova

Galileo Galilei’s chair– Palazzo Bo - Padova