Morphology and Functional Characteristics of the Left Atrial Appendage

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Left Atrial Appendage

1. What are known?
2. Our Missions

Left Atrial Appendage Anatomy

- Mitral valve
- Left phrenic nerve
- Left circumflex artery
- Left superior pulmonary artery
- Warfarin ridge
- LAA

Percutaneous Left Atrial Appendage Closure

Left Atrial Appendage (LAA): What are known?

- Anatomy
- Embryology
- Function

- Elliptical ostium of the LAA: long axis 10-40mm, a short axis 5.2-19.5mm (5.7% round shape)
- Changes of ostium diameter: 1-2mm in sinus rhythm, no change during AF
**Left Atrial Appendage Anatomy**

A casts of the LAA by using synthetic resin

- The volume were 770-19270 mm$^3$ (mean 5220 ± 3041).
- The LAA volume increase with aging, regardless of the gender.

**Left Atrial Appendage Morphology**

- CT and MRI allow us to recognize the morphology easily.

*Chicken* Wing (48% of patients)

*Cactus* (30% pts)

*Windsock* (19% pts)

*Cauliflower* (3% pts)

The morphology of LAA associates with prevalence of stroke.

**Left Atrial Appendage Morphology**

Morphology of the LAA is more complex, bizarre, and variable than previously thought...

**Left Atrial Appendage (LAA): What are known?**

- Anatomy
- Embryology
- Function

**Left Atrial Appendage Embryology**

- The LAA: primitive left atrial tissue,
  : very well contracting, trabeculated tube
- The LA: outgrowth of the pulmonary veins.

Intussusception of the pulmonary vein into the LA

The left superior caval vein possesses its own walls outside the developing left atrium.
Left Atrial Appendage Embryology

Area of the Pectinate muscle = primitive left atrial

Left Atrial Appendage (LAA): What are known?

• Anatomy
• Embryology
• Function

Left Atrial Appendage function

: Secretion of Atrial natriuretic peptide (ANP)

Left Atrial Appendage function

3D-TEE Analysis (n=194 with history of stroke)

Left Atrial Appendage function

Atrial Pressure and Atrial Natriuretic Peptide (ANP)

LA Pressure
ANP (pg/mL)
RA Pressure
ANP (pg/mL)

LAA function and Atrial Natriuretic Peptide (ANP)

LAA EF
LAA area
LAA volume

Relationships between 3D-TEE Anatomical Parameters and Function of LAA

Matsumoto et al, submitted
**Our Missions: Left Atrial Appendage (LAA)**

CT based 3D Reconstruction (for Free Measurements) and 3D Printing

*Iwate Medical University, Iwate Prefectural University Combined Teams of LAA Project*

**Visualization/ Segmentation of LAA**

- Volume Rendering of LAA

  - Left atrial appendage
  - Left upper Pulmonary vein
  - Warfarin ledge
  - Left circumflex artery
  - Mitral valve

**A Variety of LAA**

**Measurement of any parameters**

- By using Measure Manager
  - max diameter, min diameter, orifice area, LAA volume

**Process of making the LAA 3D models**

1. CT-VE→STL→Freeform
2. Correction and Editing
3. Smoothening
4. Boolean operations
5. Making of opening space
6. Processing
7. Output the 3D models

*Project of Left Atrial Appendage*
What we need to know is...

Precise measurement of orifice of LAA.

Correct sizing allows us to perform implantation safely.

Somewhat arbitrary definition of the LAA orifice is needed.

- Hypothesis:
  LAA orifice planes could be determined by combinations of the following anatomical landmarks:

  - Warfarin ridge
  - Left circumflex artery
  - Mitral valve

Where is the orifice of LAA?

Is there the Landmarks of the LAA orifice?

Comparison for each definitions

<table>
<thead>
<tr>
<th>Definition</th>
<th>Description</th>
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<tbody>
<tr>
<td>DEF#1</td>
<td>Center of warfarin ridge, orifice of LCx, and bifurcation of LCx and obtuse marginal branch.</td>
</tr>
<tr>
<td>DEF#2</td>
<td>A plane of warfarin ridge and mitral valve annulus.</td>
</tr>
<tr>
<td>DEF#3</td>
<td>That by observers' discretion by progressive rotation of LAA geometry.</td>
</tr>
</tbody>
</table>

- OA measured by DEF#2 was 1.39 times greater than DEF#1 (537±186 mm² vs 387±129 mm², p=0.0007) and 1.21 times greater than DEF#3 (537±186 mm² vs 445±161 mm², p=0.034).
- Significant positive correlations were appreciated between DEF #1 and DEF#3.
Comparison for each definitions

- Brand-Altman plots of each comparison were shown in the figure, demonstrating that systematic bias between DEF#1 and DEF#3 was the smallest.

For the Future

- Precise measurement is needed.
- There is the possibility that we have the individual definition of the LAA orifice.
- Progressive rotation of 3D-CT imaging makes it easy to think the protocols of procedure for each individuals.

Our Goals: Development of Simulation Software

- The Virtual view like TEE by using CT images
- Procedure guidance; Trans septal puncture, catheter guidance
- Appropriate sizing of LAA and choice device size
- Pre operation simulation