Difference between cryoballoon and radiofrequency ablations for atrial fibrillation based on electroanatomical mechanisms

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COI Disclosure

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Disclosure

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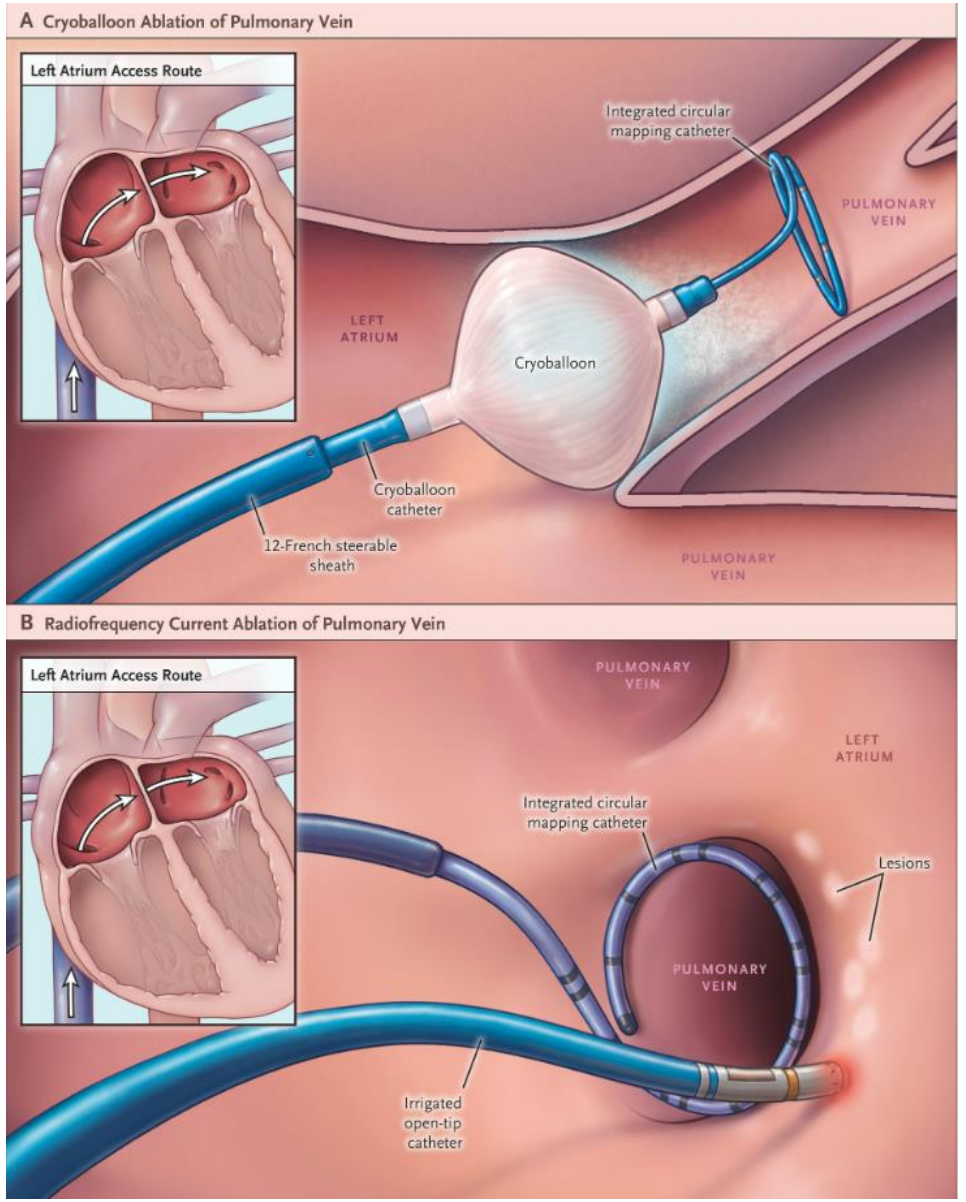
Backgrounds

- The clinical usefulness of early rhythm control in AF (Atrial fibrillation) has been established, and the **demand for AF catheter ablation (AFCA)** is rising.

- **Cryoballoon ablation** is a procedure that involves the application of a specialized 28-mm cryoballoon to ablate the pulmonary vein (PV) orifice in a single contact.

- **Cryoballoon pulmonary vein isolation (Cryo-PVI)** has comparable results to conventional **radiofrequency pulmonary vein isolation (RF-PVI)** in patients with AF.

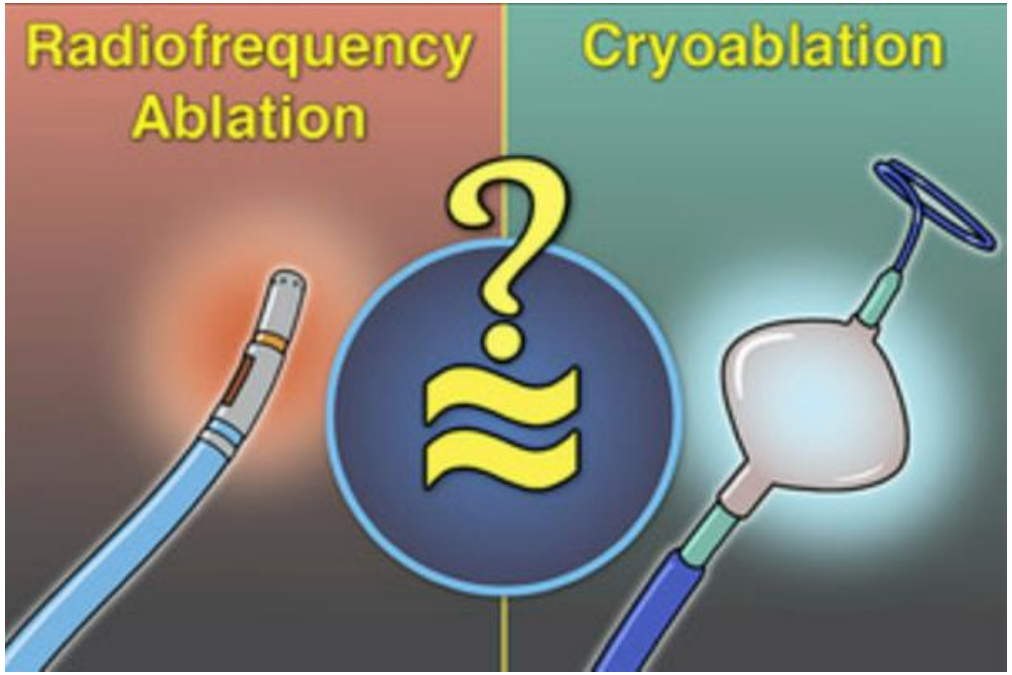


Backgrounds

- Atrial structural remodeling has been proposed as a contributing factor to the recurrence of AF.

- Critical mass reduction by AFCA can reduce wave break and disrupt AF maintenance.

- **Ablations using a 28-mm cryoballoon have limitations in wide circumferential PVI than RF-PVI.**
- **Cryo-PVI has limitations in extra-PV trigger (ExPVT) mapping and ablation.**



Objectives

- **The purpose of study**
  - To compare **long-term outcomes** after AFCA between **Cryo-PVI** and **RF-PVI**

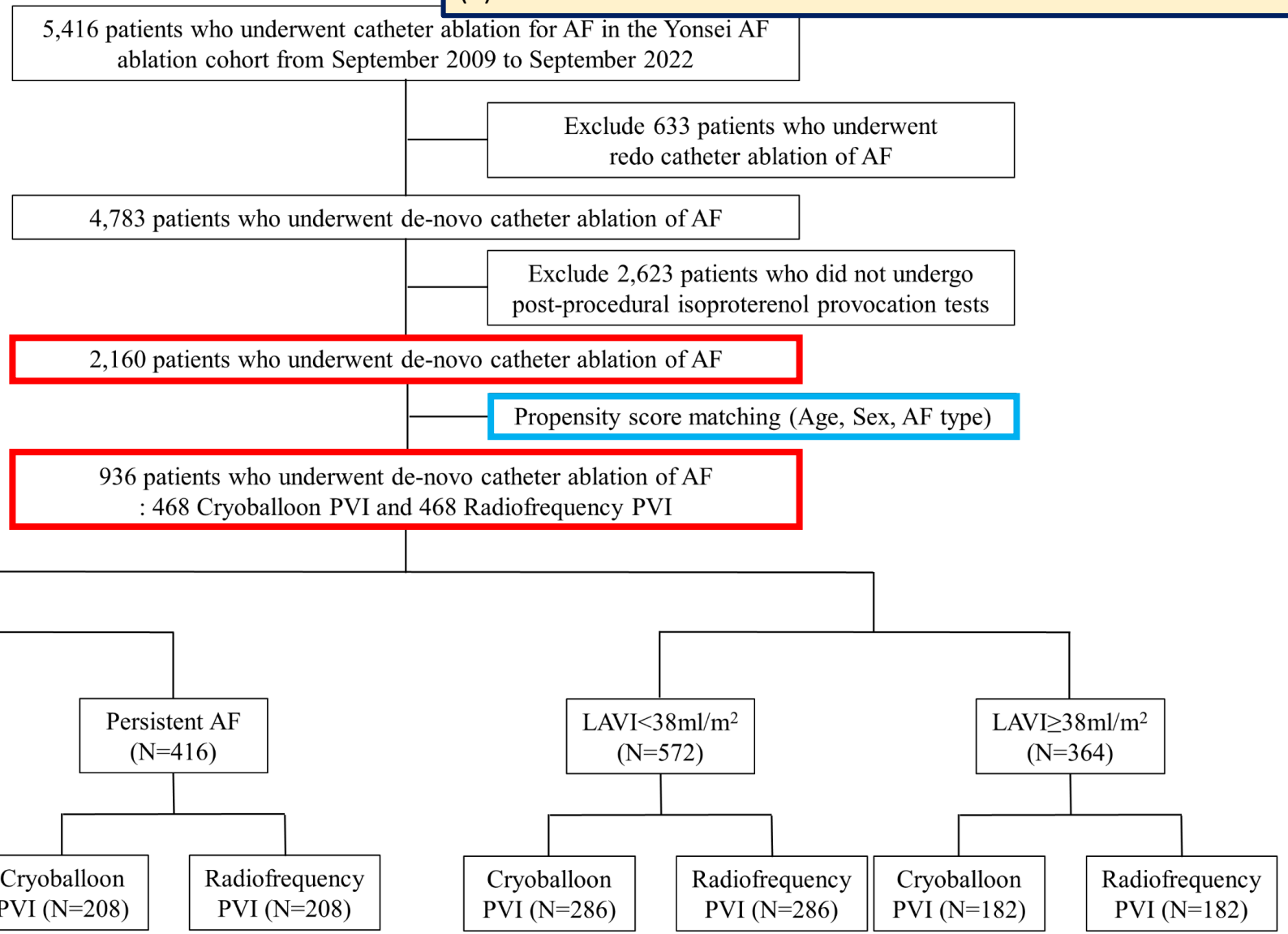
    according to **LA size**, **extra PV trigger**, and **AF type**.
  - To evaluate the **potential electroanatomical mechanisms** underlying these differences.

Methods

Exclusion criteria

(1) Permanent AF refractory to electrical cardioversion

(2) Atrial fibrillation with rheumatic valvular disease



Methods

- **Electrophysiological mapping** and **catheter ablation**

  - **RF-PVI**
    - ✓ **Open-irrigated tip catheter**
    - ✓ Power of RFCA : **25-60W**
    - ✓ Ablation endpoint: average impedance drop >10% of the baseline or a >80% decrease in the local electrogram voltage amplitude
    - ✓ Circumferential PV isolation

  - **Cryo-PVI**
    - ✓ **28mm Cryoballoon** with a multipolar spiral catheter (Achieve, 20mm)
    - ✓ Injecting contrast medium
    - ✓ **Each PV ostium or antrum: 4 minutes**
    - ✓ During Rt sided PV isolation

      : Stimulate right phrenic nerve with a quadripolar catheter

Methods

- **Isoproterenol provocation** and **extra PV trigger (ExPVT)**

  - ✓ Infusion isoproterenol for at least 3 minutes before induction
  - ✓ Induction by 10 seconds burst of high current pacing from the high RA (250ms-120ms)
  - ✓ Internal cardioversion using biphasic shock with R-wave synchronization

  - ✓ **Additional AF triggers were observed**

    → **Identify the potential location of the extra pulmonary vein trigger (ExPVT)**

  - ✓ **ExPVT : AF triggering point caused by isoproterenol provocation after a bidirectional block of CPVI**

Methods

- Measurements of LA area after ablation using computational modeling

  - ✓ **Virtual ablation of RF-PVI and Cryo-PVI** was performed on the **same surface mesh of the LA** using computational modeling.
    - ✓ **RF-PVI** modeling was performed on the LA surface using the **drawing tool of CUVIA software** (Laonmed Inc., Seoul, Korea).
    - ✓ **Cryo-PVI** modeling was performed using the **Meshlab software (Meshlab 2022.02, Pisa Italy)** to create four spheres measuring 28 mm in diameter, which were placed in each PV ostium to delineate the cryoballoon.

  - ✓ Computed the area of each LA isolated by the contact area using a depth-first search-based graph-coloring algorithm.

Methods

- Echocardiographic and cardiac computed tomographic evaluations
- Obtained LA pressure, LA voltage map during procedures
- **Post-ablation management and follow-up**
  - ✓ Outpatient clinic at **1, 3, 6, and 12 months and every 6 months**
  - ✓ **Twenty-four-hour Holter monitoring** was performed at 3, 6, and 12 months and every 6 months
  - ✓ **AF recurrence** was defined as **any episode of AT or AF lasting >30 s**.
  - ✓ AF recurrence **after a 3-month blanking period** was classified as clinical recurrence.

- **Statistics analysis**
  - **To determine the LA cutoff size** between RF-PVI and Cryo-PVI,

    we compared the **log-likelihood values of multivariate Cox proportional hazard models** at **each possible cutoff value for LAVI.**
  - The cutoff value with maximum likelihood was chosen as the optimal value.

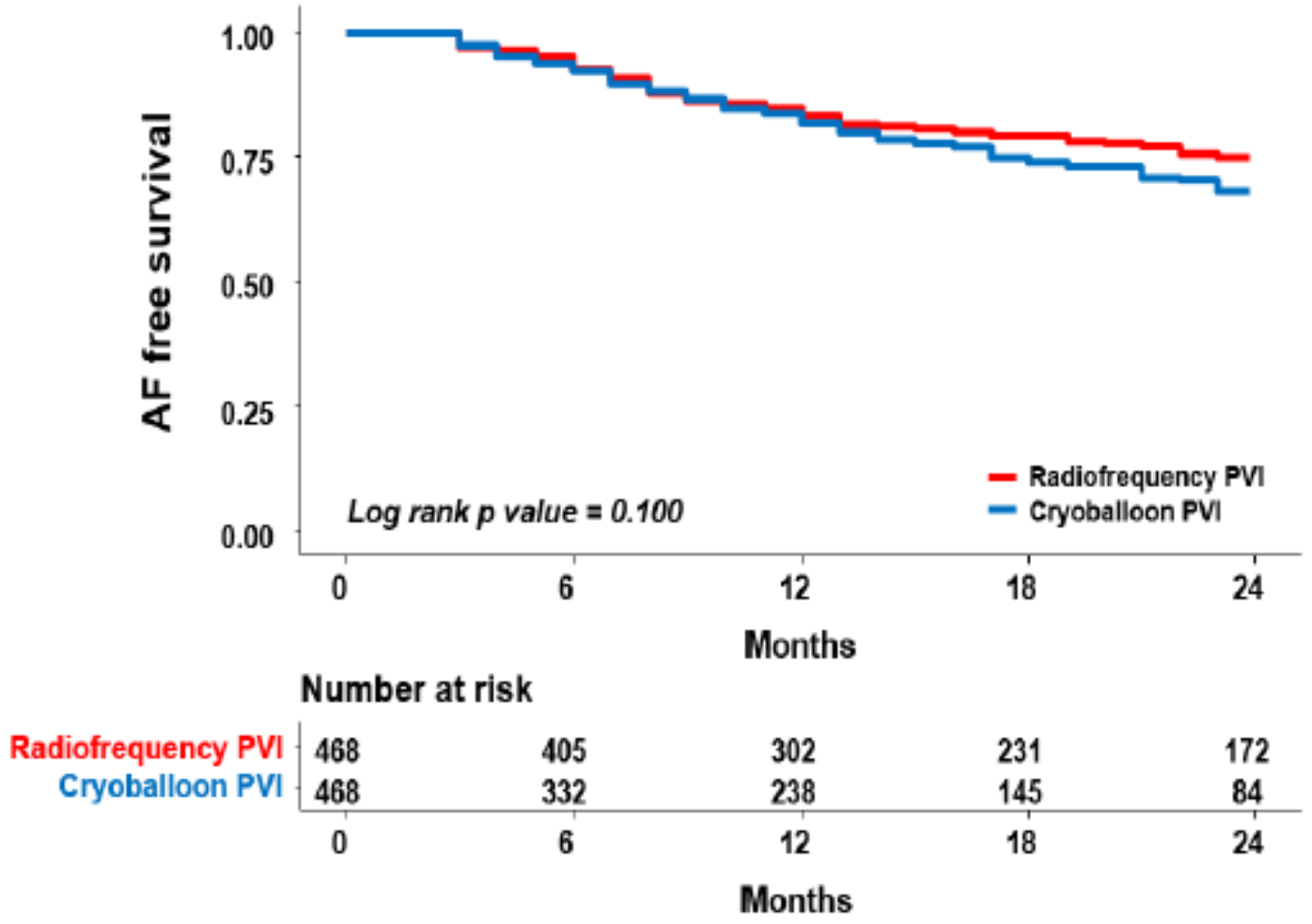
Results

- Baseline characteristics according to ablation strategy

	Overall (N=936)	Cryoballoon PVI (N=468)	Radiofrequency PVI (N=468)	P-value
Clinical variables				
Age, years	61.7±11.2	61.6±11.3	61.8±11.1	0.793
Paroxysmal AF, %	522 (55.8)	260 (55.6%)	262 (56.0%)	0.948
Male, %	688 (73.5)	346 (73.9%)	342 (73.1%)	0.824
LA size using modality				
LA diameter, mm	41.0±5.8	40.1±5.6	41.9± 5.9	**<0.001**
LA volume index, ml/m^2	39.1±12.5	38.0±12.0	40.2±13.0	**0.007**
LA volume/BSA, ml/m^2	84.5±23.3	81.7±22.2	87.1±24.0	**0.001**
Ablation variables				
Ablation time, min	41.0±28.9	21.5±6.9	60.5±29.5	**<0.001**
CTI ablation, %	612 (65.4)	152 (32.5%)	460 (98.3%)	**<0.001**
Extra PV trigger, %	110 (11.8)	57 (12.2%)	53 (11.3%)	0.761

Results

- Kaplan-Meier curves of AF recurrence after catheter ablation according to ablation strategy



Results

- Cox regression analysis of atrial fibrillation rhythm outcome in large LA (LAVI≥38ml/m^2)

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Age	1.006 (0.987 – 1.026)	0.531		
Male	0.792 (0.520 – 1.207)	0.278		
Paroxysmal AF	0.805 (0.525 – 1.234)	0.320		
LA volume/BSA	1.012 (1.005 – 1.020)	0.001	1.014 (1.006 – 1.021)	<0.001
Extra PV trigger	1.021 (0.570 – 1.830)	0.943		
Cryoballoon PV isolation	1.514 (1.021 – 2.244)	0.039	1.588 (1.059 – 2.381)	0.025

Results

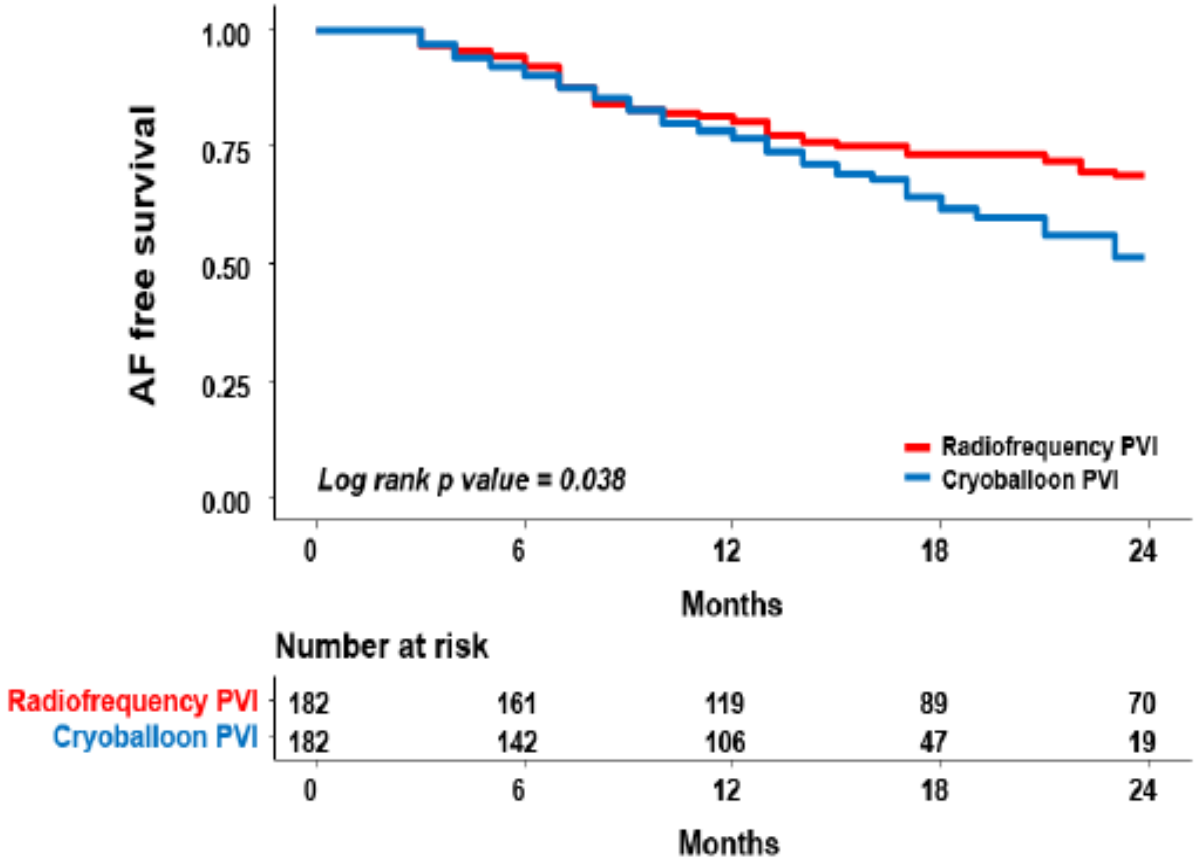
- Cox regression analysis of atrial fibrillation rhythm outcome in persistent AF

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Age	0.995 (0.978 - 1.012)	0.554		
Male	0.718 (0.472 - 1.092)	0.121		
Paroxysmal AF	1.009 (0.949 - 1.072)	0.776		
LA volume/BSA	1.014 (1.007 - 1.022)	<0.001	1.015 (1.007 - 1.023)	<0.001
LA pressure, peak	1.021 (1.002 - 1.041)	0.033	1.024 (1.004 - 1.045)	0.020
Extra PV trigger	1.507 (0.874 - 2.597)	0.140		
Cryoballoon PV isolation	1.702 (1.152 - 2.513)	0.008	2.003 (1.321 - 3.037)	0.001

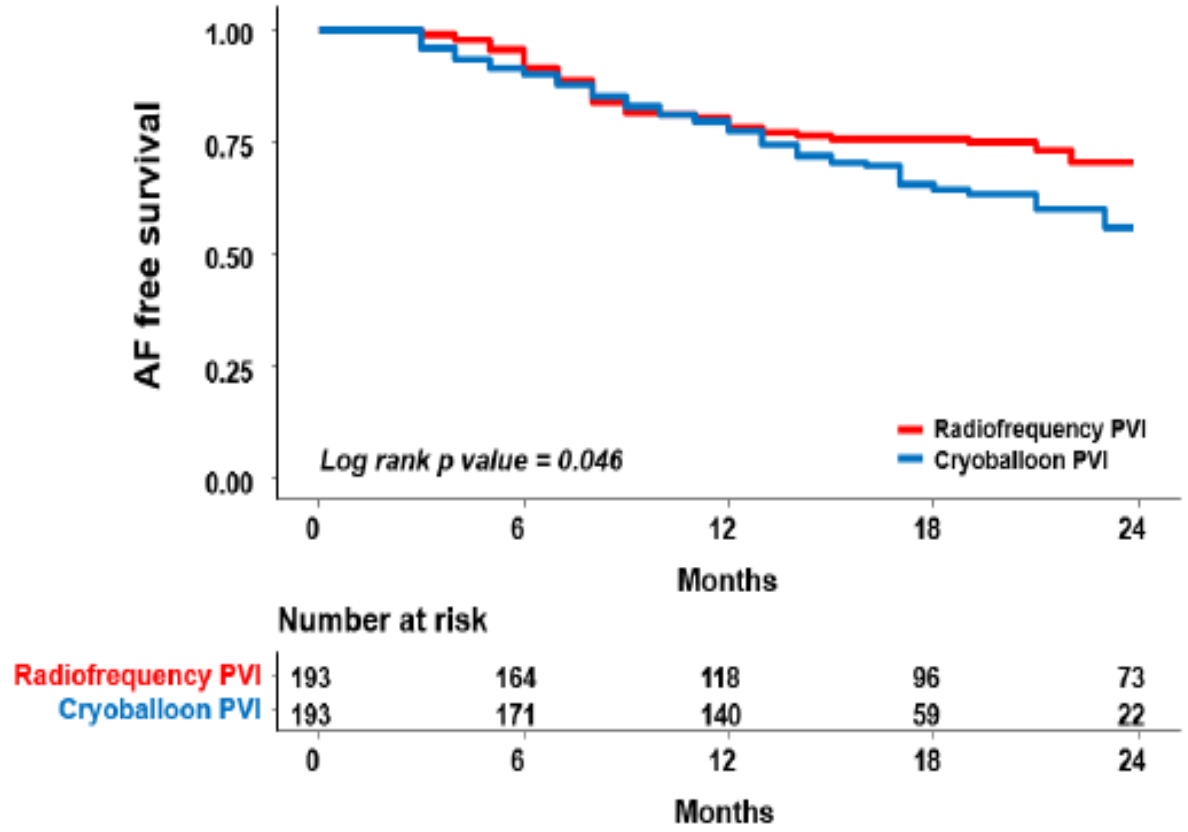
Results

- Kaplan-Meier curves of AF recurrence after catheter ablation

(A) Patients with large LA (LAVI≥38ml/m^2)



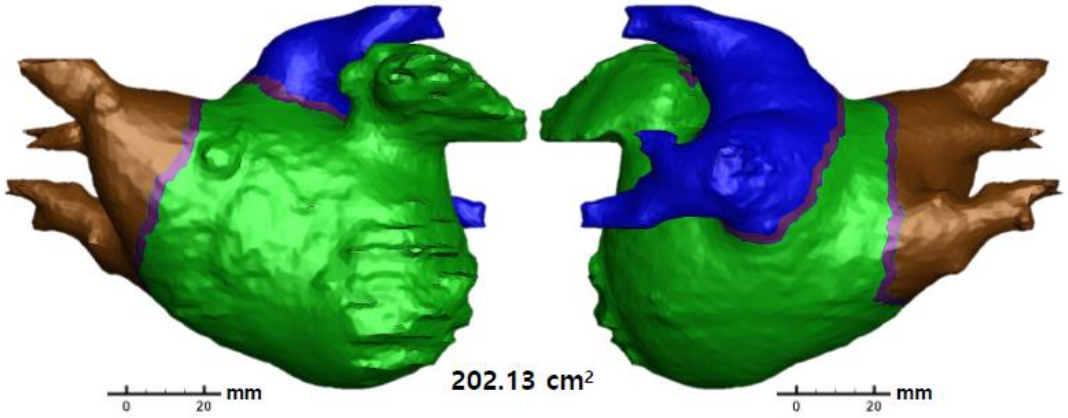
(B) Patients with persistent AF



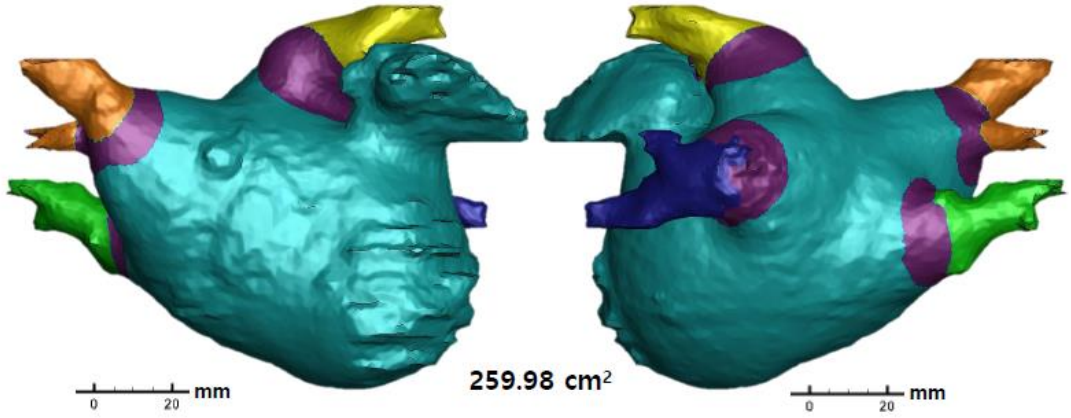
Results

(A) Large LA (Total LA area : 343.04 cm^2)

Radiofrequency PVI

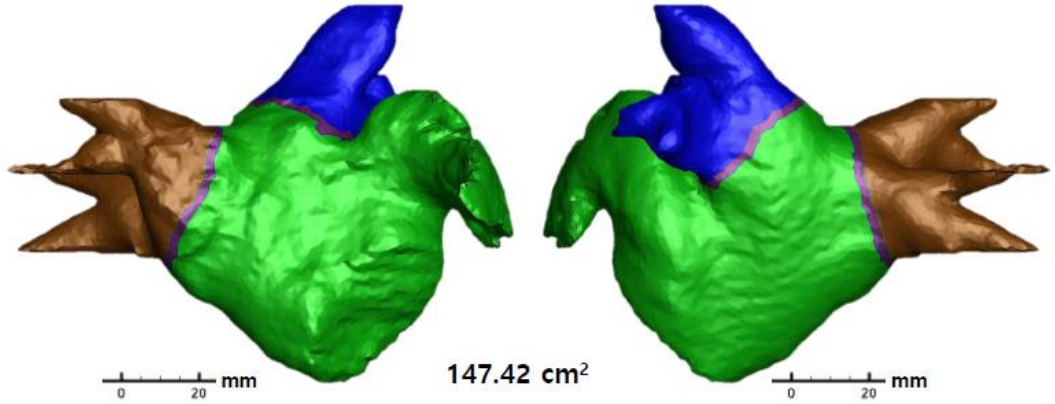


Cryoballoon PVI

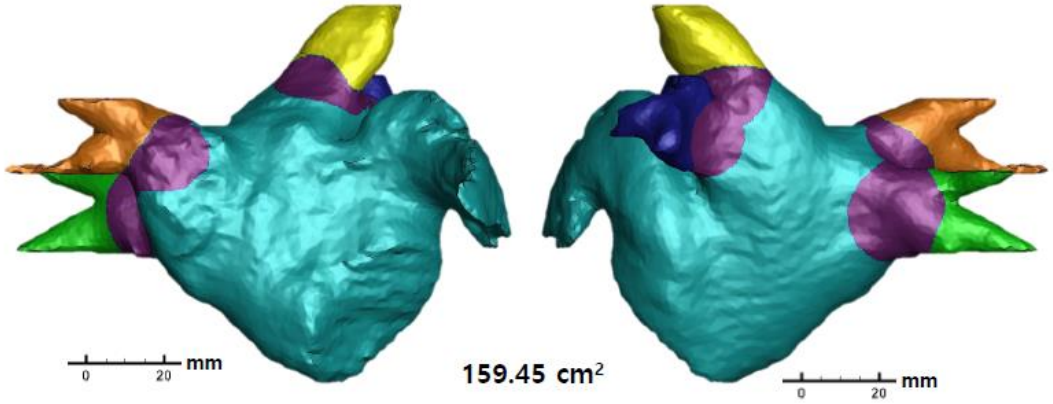


(B) Small LA (Total LA area : 246.69 cm^2)

Radiofrequency PVI

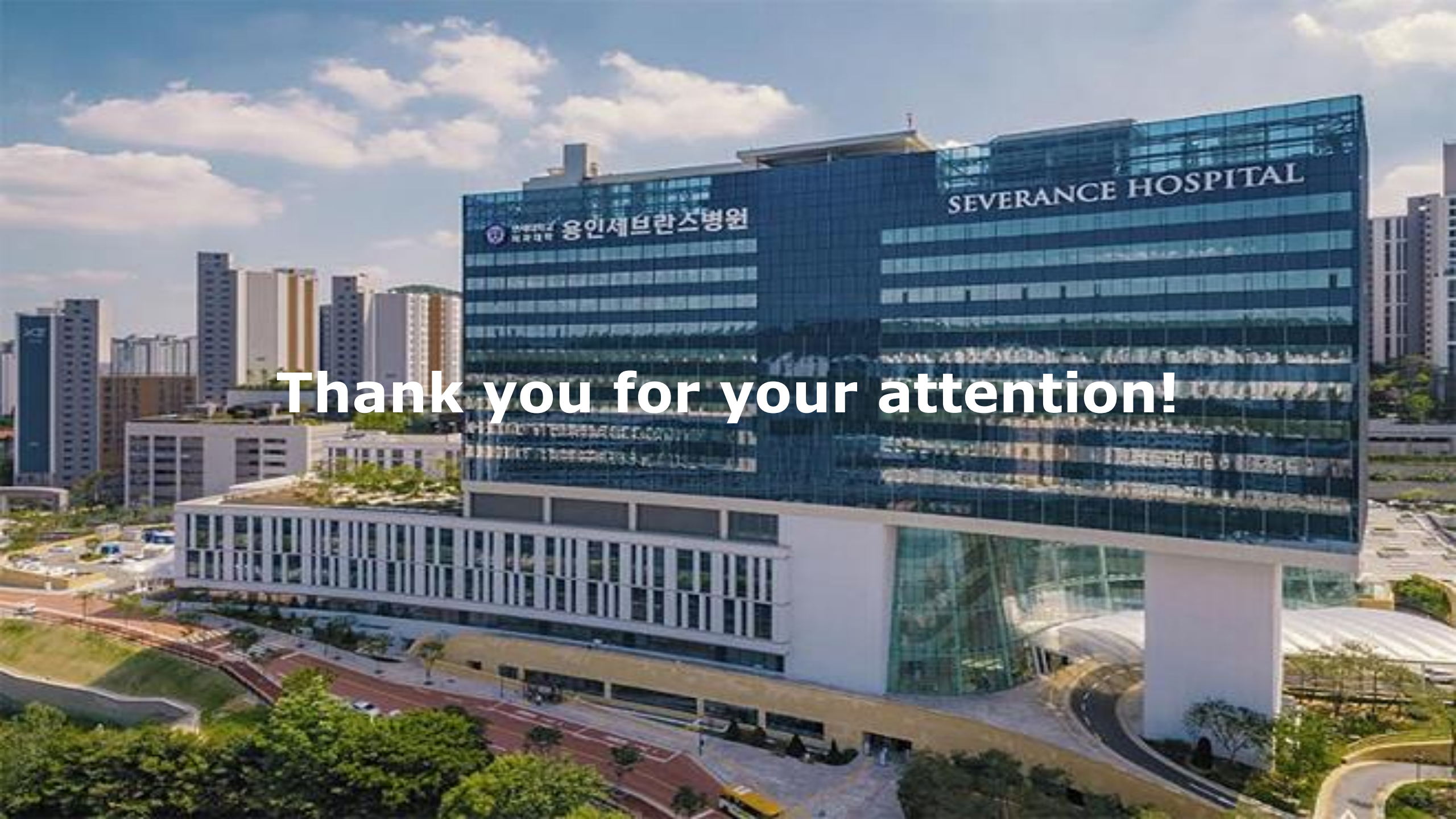


Cryoballoon PVI



Summary and conclusions

- In this retrospective cohort study, we compared the long-term outcomes of AF between Cryo-PVI and RF-PVI.
- We found that **Cryo-PVI was independently associated with a higher AF recurrence** following ablation procedures than RF-PVI in patients with a **large LA size (LAVI ≥38 mL/m^2)**.
- Among patients with **persistent AF**, particularly in those **without ExPVT**, **Cryo-PVI was independently associated with a higher AF recurrence** following ablation procedures than RF-PVI.
- However, **no significant differences between Cryo-PVI and RF-PVI** were observed in patients with paroxysmal AF.



Thank you for your attention!