Revisiting of pulmonary vein stenosis after high-power short-duration radiofrequency ablation in patients with atrial fibrillation

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Disclosure

The authors have no financial conflicts of interest to disclose concerning the presentation

BACKGROUND

- AF catheter ablation (AFCA)
  - Maintenance sinus rhythm
  - Preventing AF recurrence

- Conventional power RFCA vs. High power short duration RFCA (HPSD-RF)
  - Similar efficacy outcome
  - Similar safety outcome
  - Reduction procedure time

  → Increasing portion of HPSD-RF

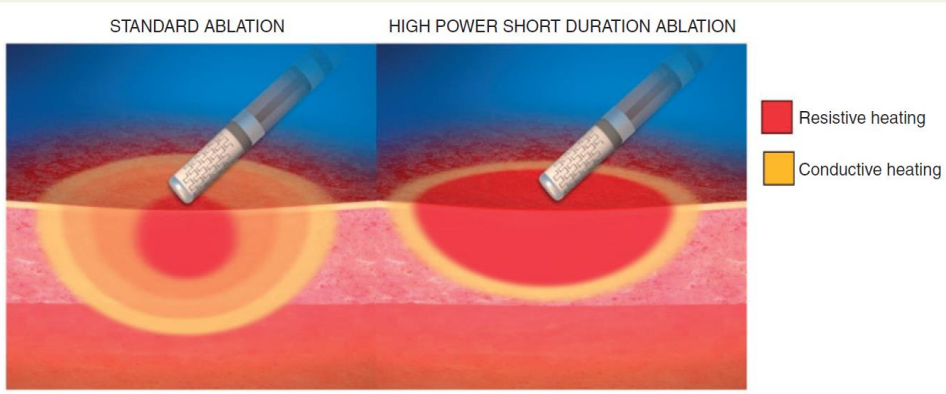


Figure 1 Lesion creation for HPSD ablation compared to standard ablation. HPSD, high-power short-duration ablation.

M. Kottmaier, et al., *EP Europace* **2020**, *22*, 388-393

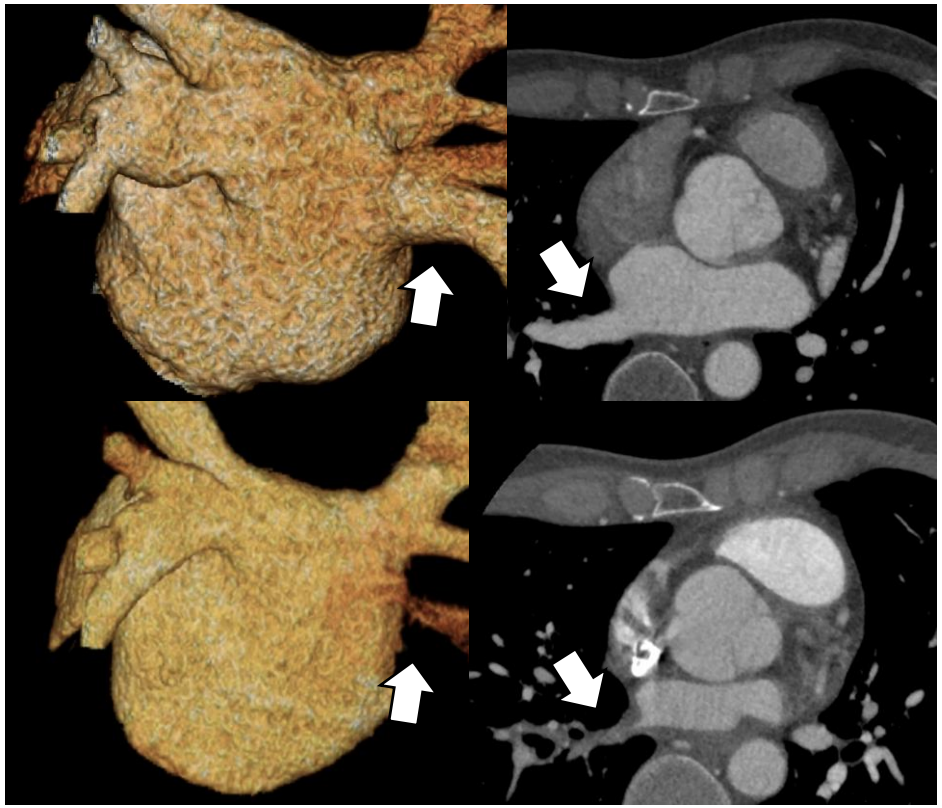
BACKGROUND

- **Pulmonary vein stenosis** after AFCA
  - Well known complication of AFCA
  - Normally appearing 3 ~ 6 months after procedure
  - Incidence :

    All - from 0% to 44% (median 5.4%)

    Severe (necessary for intervention) < 1%

C. Teunissen, et al., *JACC: Clinical Electrophysiology* **2017**, *3*, 589-598



BACKGROUND

- **PV stenosis after HPSD-AFCA**
  - “Overall complication rate for HPSD and LPLD are at least comparable”

R. A. Winkle, Journal of Cardiovascular Electrophysiology 2021, 32, 2813-2823
J. Kewcharoen, et al., Journal of Cardiovascular Electrophysiology 2021, 32, 71-82

- **In HPSD, resisting heating (>50℃) causes** :
  - Immediate, irreversible myocardial tissue injury with cellular death
  - More damage to tissue could be provoke pulmonary vein stenosis.

INTRODUCTION

- **Study design**
  - Single center prospective population-based cohort study
    (Yonsei AF Ablation Cohort Database)

  - Total 5,246 cases in March 2009 to June 2022
    - Exclusion criteria : 1) AF c RVD, 2) History of AF surgery, 3) Cryoablation
    - Finally, **3,851 cases** were analyzed.
    - **Propensity score overlap weighting** was used.
      - PS variables : age, sex, paroxysmal AF, the number of AFCA, CHA2DS2-VASc score, LA-AP diameter, LA volume index, LV ejection fraction

  - **Symptomatic pulmonary vein stenosis** : **With symptom or sign(CXR) & confirmed by CT with pulmonary vein stenosis**

RESULTS – Baseline characteristics

		Before overlap weighting		
	Overall (N=3851)	Conv-AFCA (N = 2832)	HPSD-AFCA (N = 1019)	p-value
Age	59.1 ± 12.2	58.6 ± 10.7	60.3 ± 15.6	<0.001
Sex (male)	2888 (75.0%)	2119 (74.8%)	769 (75.5%)	0.716
BMI	25.1 ± 3.1	25.1 ± 3.0	25.1 ± 3.1	0.416
Paroxysmal AF	2555 (66.3%)	1975 (69.7%)	580 (56.9%)	<0.001
The number of repeated AFCA	1.1 ± 0.4	1.1 ± 0.4	1.2 ± 0.4	<0.001
CHA2DS2-VASc score	1.7 ± 1.5	1.6 ± 1.5	1.8 ± 1.5	0.004
Hypertension	1800 (46.7%)	1319 (46.6%)	481 (47.2%)	0.758
Diabetes mellitus	587 (15.2%)	417 (14.7%)	170 (16.7%)	0.15
Heart failure	487 (12.6%)	281 (9.9%)	206 (20.2%)	<0.001
Stroke	377 (9.8%)	265 (9.4%)	112 (11.0%)	0.149
TIA	45 (1.2%)	36 (1.3%)	9 (0.9%)	0.413
Vascular disease	351 (9.1%)	294 (10.4%)	57 (5.6%)	<0.001
Echocardiographic findings				
LV EF (%)	63.2 ± 8.1	63.2 ± 8.1	63.2 ± 8.1	0.835
LA AP diameter (mm)	41.2 ± 6.3	41.0 ± 6.0	42.0 ± 6.9	<0.001
LA volume index (ml/m2)	37.4 ± 12.8	36.2 ± 12.3	40.5 ± 13.7	<0.001
E/Em	10.2 ± 4.3	10.1 ± 4.3	10.3 ± 4.2	0.225

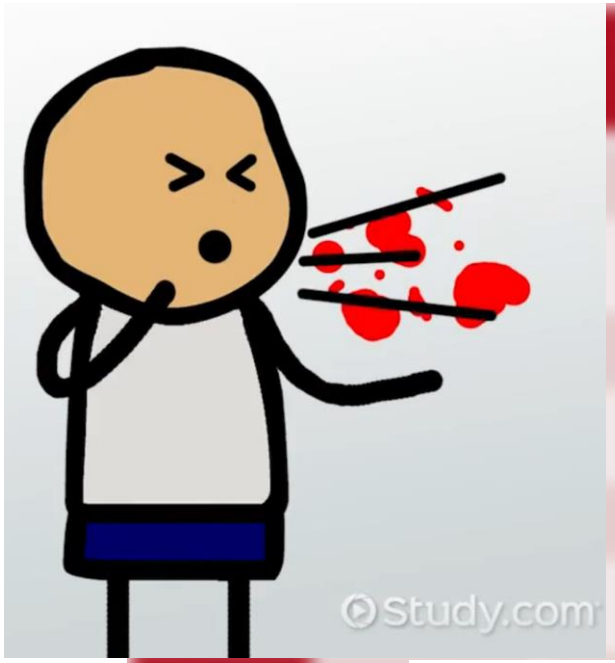
RESULTS – Baseline characteristics

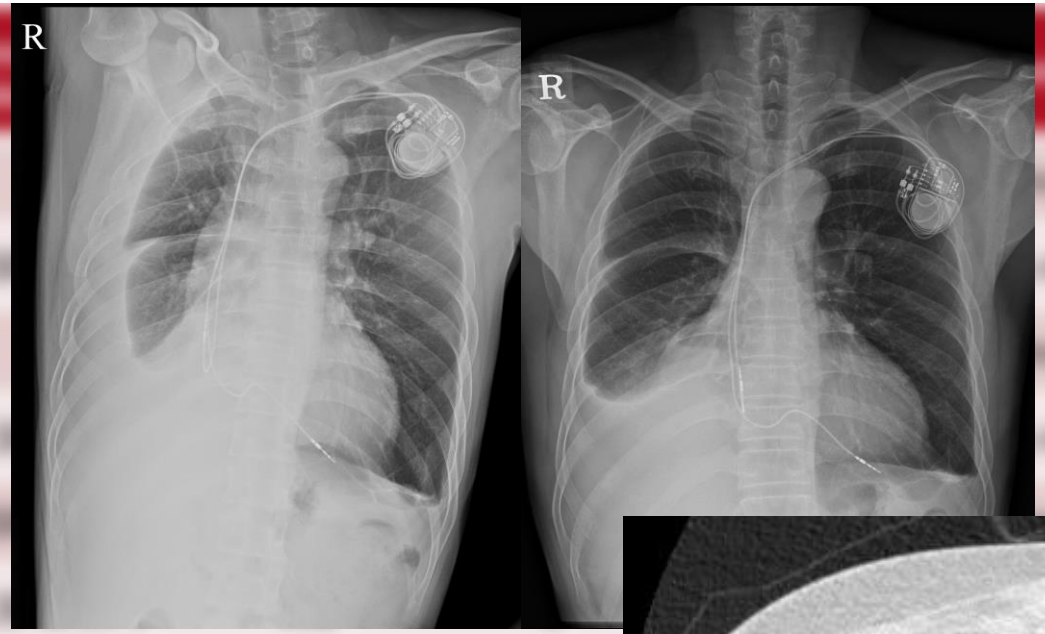
		Before overlap weighting			After overlap weighting		
	Overall (N=3851)	Conv-AFCA (N = 2832)	HPSD-AFCA (N = 1019)	p-value	Conv-AFCA (N = 2832)	HPSD-AFCA (N = 1019)	p-value
Age	59.1 ± 12.2	58.6 ± 10.7	60.3 ± 15.6	<0.001	59.5 ± 10.4	59.5 ± 11.1	1
Sex (male)	2888 (75.0%)	2119 (74.8%)	769 (75.5%)	0.716	75.5%	75.5%	1
BMI	25.1 ± 3.1	25.1 ± 3.0	25.1 ± 3.1	0.416	25.0 ± 3.0	25.2 ± 3.1	0.122
Paroxysmal AF	2555 (66.3%)	1975 (69.7%)	580 (56.9%)	<0.001	60.9%	60.9%	1
The number of repeated AFCA	1.1 ± 0.4	1.1 ± 0.4	1.2 ± 0.4	<0.001	1.2 ± 0.4	1.2 ± 0.4	1
CHA2DS2-VASc score	1.7 ± 1.5	1.6 ± 1.5	1.8 ± 1.5	0.004	1.7 ± 1.5	1.7 ± 1.5	1
Hypertension	1800 (46.7%)	1319 (46.6%)	481 (47.2%)	0.758	46.9%	46.1%	0.675
Diabetes mellitus	587 (15.2%)	417 (14.7%)	170 (16.7%)	0.15	14.3%	16.5%	0.101
Heart failure	487 (12.6%)	281 (9.9%)	206 (20.2%)	<0.001	15.7%	15.7%	1
Stroke	377 (9.8%)	265 (9.4%)	112 (11.0%)	0.149	9.5%	10.9%	0.232
TIA	45 (1.2%)	36 (1.3%)	9 (0.9%)	0.413	1.3%	0.9%	0.422
Vascular disease	351 (9.1%)	294 (10.4%)	57 (5.6%)	<0.001	10.1%)	5.5%	<0.001
Echocardiographic findings							
LV EF (%)	63.2 ± 8.1	63.2 ± 8.1	63.2 ± 8.1	0.835	63.2 ± 8.6	63.2 ± 7.9	1
LA AP diameter (mm)	41.2 ± 6.3	41.0 ± 6.0	42.0 ± 6.9	<0.001	41.6 ± 6.2	41.6 ± 6.8	1
LA volume index (ml/m2)	37.4 ± 12.8	36.2 ± 12.3	40.5 ± 13.7	<0.001	39.0 ± 13.6	39.0 ± 12.7	1
E/Em	10.2 ± 4.3	10.1 ± 4.3	10.3 ± 4.2	0.225	10.5 ± 4.7	10.1 ± 4.1	0.021

RESULTS – Procedure related outcome

- Procedure time
  - 163.6 ± 62.0 vs. **117.4 ± 31.2** min (Conv-RFCA vs. HPSD, p < 0.001)
- Fluoro time
  - 37.3 ± 119.8 vs. **24.3 ± 9.1** min (Conv-RFCA vs. HPSD, p < 0.001)
- Ablation time
  - 4140.2 ± 1799.6 vs. **2127.4 ± 1086.1** sec (Cov-RFCA vs. HPSD, p < 0.001)
- **Symptomatic pulmonary vein stenosis** after AFCA
  - Total **14 cases** (Overall event rate : 13/3851, **0.36%**)

	RF protocol, Type of cath	Stenotic lesion	Type of AF	No. of AFCA procedures	Time to Dx (Day)	Symptom	Intervention
Case 1	ConvP, Unidentified catheter	LSPV	PAF	Re-do	454	Hemoptysis	Observation
Case 2	ConvP, Unidentified catheter	RSPV, RIPV	PAF	Re-do	623	Dyspnea of exertion	RIPV stent insertion Surgical pleurodesis
Case 3	ConvP, Unidentified catheter	RSPV	PAF	Tri-do	390	Hemoptysis	Observation
Case 4	ConvP, Unidentified catheter	LSPV, LIPV	PAF	De novo	432	Dyspnea of exertion	Failed intervention
Case 5	ConvP, Cool Flex™	RSPV, RIPV	PAF	De novo	265	Hemoptysis	RIPV stent insertion
Case 6	ConvP, Cool Flex™	LSPV, LIPV	PAF	De novo	287	Chest pain, cough	LIPV stent insertion
Case 7	HPSD, FlexAbility™	RIPV	PAF	De novo	195	Dyspnea of exertion Pleural effusion	Thoracic surgery (Wedge resection)
Case 8	HPSD, FlexAbility™	RIPV	PAF	De novo	48	Dyspnea of exertion	Observation
Case 9	HPSD, FlexAbility™	RIPV	PAF	De novo	154	Hemoptysis Chest pain	Observation
Case 10	HPSD, FlexAbility™	RIPV	PAF	De novo	255	Hemoptysis	RIPV stent insertion
Case 11	HPSD, FlexAbility™	LIPV	PAF	De novo	412	Hemoptysis	Observation
Case 12	HPSD, FlexAbility™	LIPV, LSPV	PAF	Re-do	383	Hemoptysis	Balloon angioplasty
Case 13	HPSD, FlexAbility™	RIPV	PAF	De novo	361	No symptom (Pleural effusion on CXR)	Observation
Case 14	HPSD, FlexAbility™	RSPV, RIPV	PeAF	Re-do	541	DOE	RSPV stent insertion


Study.com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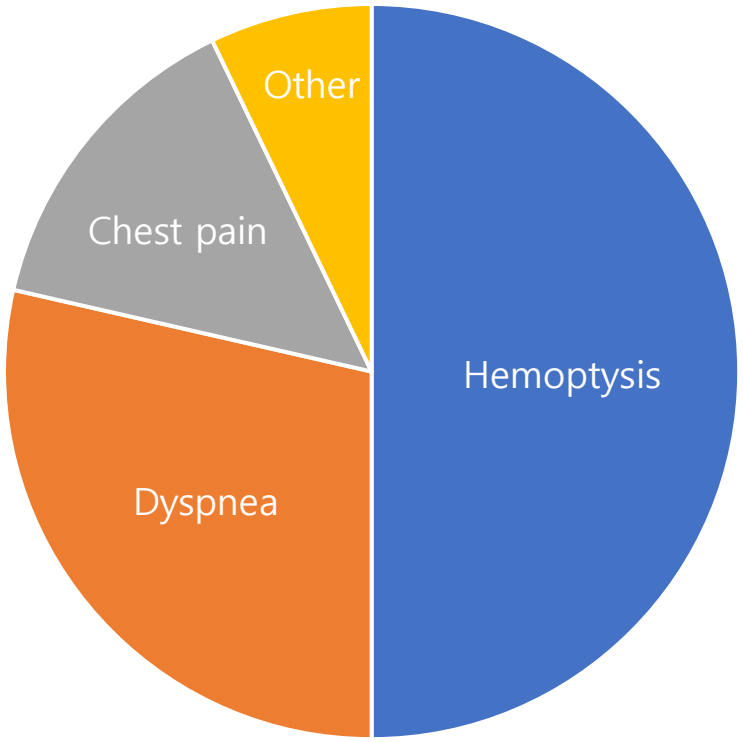
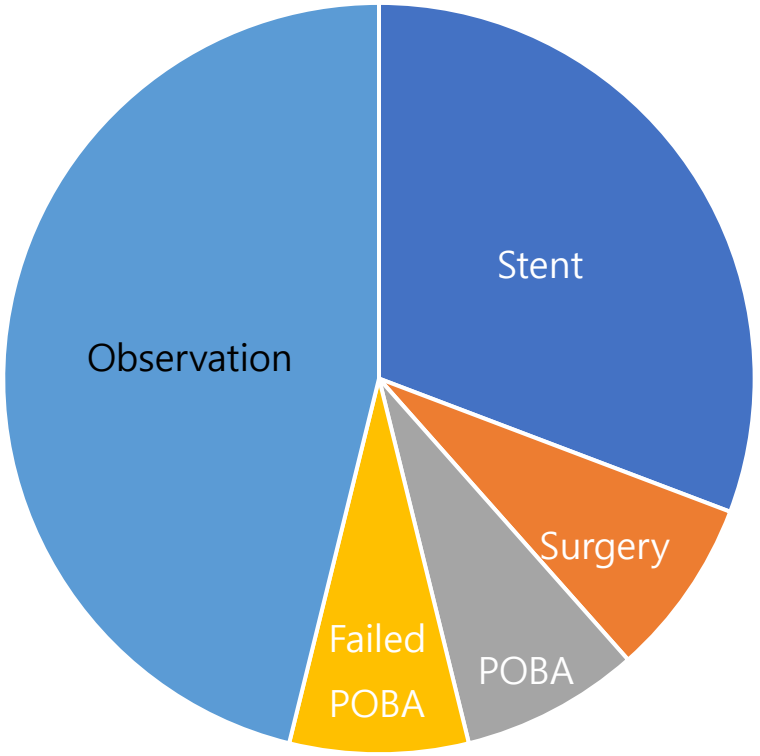
RESULTS - Procedure related complications

Symptom or Sign



Treatment



	PV stenosis (N=14)
Time to diagnosis (day)	**327.6 ± 148.9 (median)**
Age	51.15 ± 14.83
Sex (Male)	10 (76.9%)
BMI	24.3 ± 2.98
Paroxysmal AF	**13 (92.9%)**
CHA2DS2VASc	0.85 ± 0.99
No of. Total AFCA	1.38 ± 0.66

RESULTS – Procedure related complications

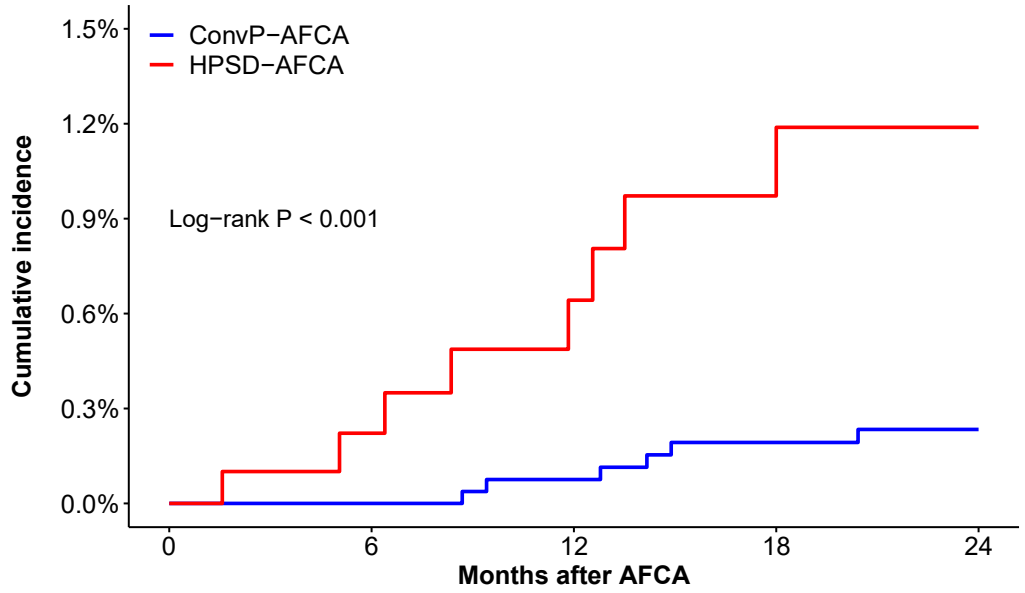
	Overall (N=3851)	Conv-AFCA (N = 2832)	HPSD-AFCA (N = 1019)	p-value
Overall Complications	175 (4.6%)	134 (4.7%)	42 (4.1%)	0.476
Major complications*	122 (3.2%)	86 (3.0%)	36 (3.5%)	0.502
Symptomatic PVS	14 (0.4%)	6 (0.2%)	8 (0.8%)	0.021
Minor complications†	48 (1.2%)	42 (1.5%)	6 (0.6%)	0.041

- Symptomatic pulmonary vein stenosis, atrio-esophageal fistula, pericardial tamponade, stroke or transient ischemia attack, phrenic nerve paralysis, access site pseudoaneurysm or arterio-venous fistula

† Pericarditis, fever, transient bradycardia, transient phrenic nerve paralysis, pleural effusion and others

RESULTS

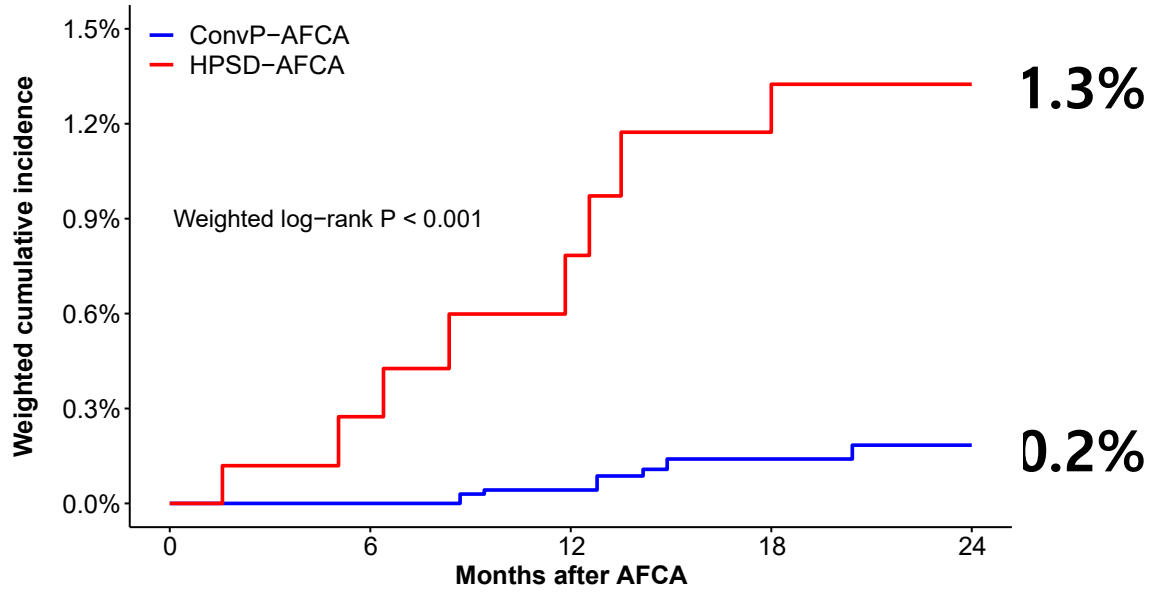
- **Cumulative incidence of PVS**
  - **Crude population**



Number at risk

ConvP−AFCA	2832	2707	2600	2496	2359
HPSD−AFCA	1019	824	641	457	288

  - **Weighted population**

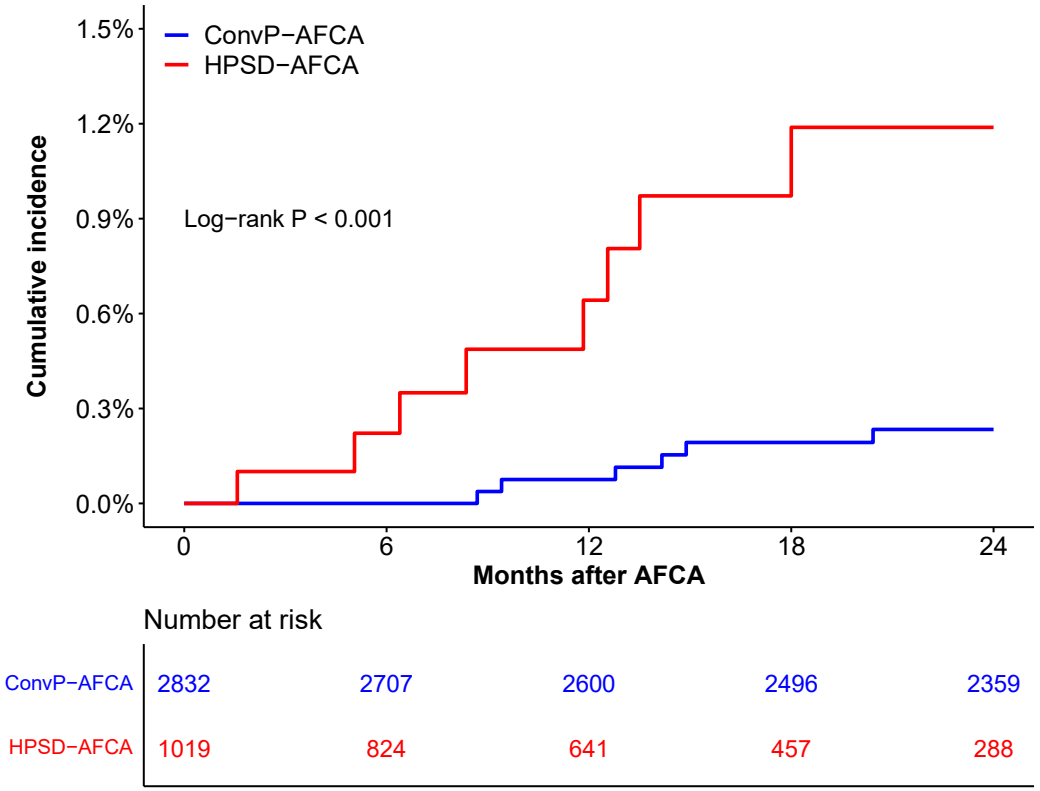


Number at risk (Weighted cumulative incidence)

ConvP−AFCA	2832 (0%)	2707 (0%)	2600 (0.04%)	2496 (0.14%)	2359 (0.18%)
HPSD−AFCA	1019 (0%)	824 (0.27%)	641 (0.78%)	457 (1.32%)	288 (1.32%)

RESULTS

- **Cumulative incidence of PVS**
  - **Crude population**



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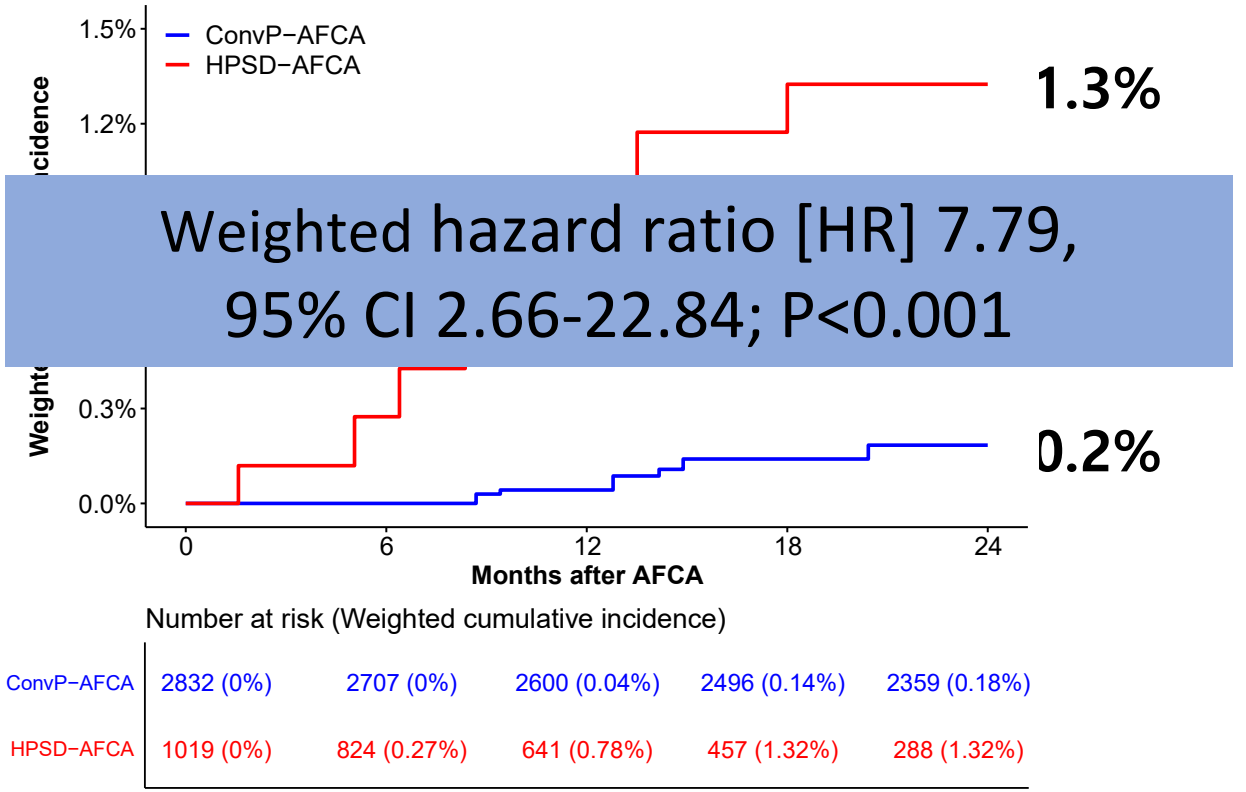

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ConvP−AFCA	2832 (0%)	2707 (0%)	2600 (0.04%)	2496 (0.14%)	2359 (0.18%)
HPSD−AFCA	1019 (0%)	824 (0.27%)	641 (0.78%)	457 (1.32%)	288 (1.32%)

RESULTS

- **Association between PV stenosis and variables by Cox regression analyses**

	Univariable analysis		Multivariable analysis	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Age ≥ 65	1.72 (0.48-6.15)	0.407		
Male sex	1.24 (0.35-4.46)	0.738		
BMI, per 1 kg/m^2	0.91 (0.76-1.09)	0.308		
Paroxysmal AF	6.45 (0.84-49.28)	0.073	8.39 (1.09-64.45)	0.041
Repeated AFCA (≥ 2 times)	3.71 (1.24-11.06)	0.019	3.32 (1.11-9.98)	0.032
HPSD-AFCA (ConvP-AFCA as reference)	5.46 (1.88-15.81)	0.002	5.89 (2.02-17.22)	<0.001
LVEF, per 1% increase	1.00 (0.94-1.06)	0.941		
Small LA (LAAP < 41mm, median)	2.91 (0.91-9.28)	0.071	2.20 (0.82-51.99)	0.191
E/Em, per 1 increase	0.92 (0.78-1.09)	0.318		
Year of procedure : 2016–2022 (2009–2015 as reference)	0.71 (0.24-2.11)	0.536		
Contact force sensing catheter used*	-	-		
Comorbidity				
Heart failure	0.55 (0.07-4.18)	0.561		
Hypertension	0.44 (0.14-1.42)	0.170		
Diabetes mellitus	0.42 (0.05-3.19)	0.400		
Stroke or TIA	1.54 (0.35-6.89)	0.571		
Vascular disease*	-	-		
CHA_2DS_2-VASc score	0.77 (0.50-1.18)	0.227		

*Unable to calculate the hazard ratios since none of the patients with pulmonary vein stenosis had the comorbidity or ablated with contact force sensing.

RESULTS

- Pulmonary vein characteristics in patients with PV stenosis
  - No dominant distribution (Lt vs. Rt/ Sup vs. Inf)
  - **Smaller antral diameters and cross-sectional area**

	Overall (N=56)	Non-stenotic PV (N=36)	Stenotic PV (N=20)	P-value
Ostial longitudinal diameter, mm	16.9 ± 3.4	17.3 ± 2.7	16.1 ± 4.4	0.209
Ostial transverse diameter, mm	12.4 ± 3.0	12.9 ± 2.6	11.3 ± 3.5	0.062
Antral longitudinal diameter, mm	**17.4 ± 3.7**	**18.2 ± 3.2**	**16.1 ± 4.3**	**0.046**
Antral transverse diameter, mm	**14.2 ± 3.7**	**15.1 ± 3.3**	**12.7 ± 4.0**	**0.019**
Estimated ostial CSA, mm^2	167.3 ± 58.7	176.3 ± 49.2	151.1 ± 71.2	0.125
Estimated antral CSA, mm^2	**201.6 ± 82.6**	**219.4 ± 75.7**	**169.5 ± 86.8**	**0.029**

SUMMARY

- In our experiences, PV stenosis after RFCA seems to occur more in patients treated by **HPSD-RFCA**.
- The HPSD-RFCA has shorter procedure time than conv-RFCA's.
- The **HPSD-RFCA** & **repeated AFCA**, **PAF** were independently associated with significant PV stenosis occurrence.
- Stenotic PV after RFCA has **smaller antral diameters** and **CSA**.

CONCLUSION

- The HPSD-RFCA has advantage for reducing procedure time with similar efficacy & safety compared by conv-RFCA
- But, the HPSD can be risk factor for PV stenosis after RFCA.

- **BE cautious!** when HPSD-RFCA is planned for patient who undergo multiple-time procedure and have a **smaller PV antral diameters or cross-sectional area**.

THANKS for ATTENTION