Increased procedural safety of cryoballoon pulmonary vein isolation with a double 120 seconds freeze protocol.

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Abstract

Background: recently a double 120 seconds freeze cryoballoon (CB) pulmonary vein isolation (PVI) protocol proved to be non inferior to a double 240 seconds freeze protocol in terms of atrial fibrillation recurrences. We hypothesized that this approach could also result in an increased procedure safety.

Methods: 80 consecutive patients treated with a double 120 seconds freeze protocol (Group CB120) were compared with 80 previous consecutive patients treated with a single 240 seconds freeze protocol (Group CB240). Procedures were performed with a temperature probe to monitor the luminal esophageal temperature (LET), using a cut off for cryoenergy interruption of 15°C. During ablation at the septal pulmonary veins, the phrenic nerve (PN) function was monitored by pacing.

Results: in CB120 and CB240 the rate of single shot isolation was similar in all PVs. Time to isolation was not different between the two groups. Mean minimal esophageal temperature was lower in LSPV and LIPV of the CB240 group. 4/80 patients (5%) of the CB120 group experienced a PN injury, but no persistent form was recorded; 11/80 patients (14%) of the CB240 group experienced a PN injury, 3 in a persistent form (p=0.10). A LET <15°C was recorded in 3/80 patients (4%) in the CB120 group and in 16/80 patients (20%) in the CB240 group (p<0.01). Composite rate of energy-related safety events (LET<15°C and PN injury) was significantly lower in the CB120 (34% vs 9%, p<0.01).

Conclusions: Safety of second generation CB PVI can be increased using a double 120 seconds freeze protocol.

Key words: atrial fibrillation, ablation, cryoablation.

1 - Introduction

Cryoballoon (CB) ablation for pulmonary vein isolation (PVI) has emerged as an established interventional rhythm control therapy for atrial fibrillation (AF) [1]. CB PVI efficacy has already been shown to be comparable to radiofrequency (RF) PVI in patients with paroxysmal AF [2]. The relative simplicity of this technique has the potential to improve the success rates of AF ablation, especially in centres with less experienced operators [3]. The introduction of the second generation CB (CB2) led to significant improvement of the acute and chronic success rate [4], however, the enhanced cooling of CB2 may lead to inadvertent lesion formation in contiguous anatomical structures. Phrenic nerve injury (PNI), in his transient or persistent form, and esophageal injury, most of the times represented by endoscopy detected esophageal lesions (EDEL)[5] are energy-dependent complications described in the context of CB ablation. To balance safety and efficacy of CB procedures, many clinical studies focused on the optimal cryoenergy dosing. However, nowadays a uniform consensus is lacking, being the approaches separated in three main groups: “fixed-dose” cryoablation, “no bonus” cryoablation and “time-to-isolation (TTI)” tailored cryoablation, the last based on real time visualization of pulmonary vein potentials from the intraluminal spiral catheter (SC) [6]. Recently a double 120 seconds freeze protocol was demonstrated to be non inferior to a double 240 seconds freeze protocol in terms of AF recurrences [7]. Since the involvement of extracardiac structures is “freezing-time” dependent, we hypothesized that a freeze reduction to 120 seconds could also result in an increased procedural safety.

2 - Methods

2.1 Aim of the study

The main aim of our study was to compare the procedural acute efficacy and safety profile of a double 120 seconds freeze protocol CB PVI to a standard 240 seconds freeze protocol CB PVI.

2.2 Patients

The first 80 consecutive patients with symptomatic AF treated with a double 120 seconds freeze protocol (Group "CB120") were enrolled. As a control group, the last 80 consecutive patients treated with a single 240 seconds freeze protocol were selected (Group CB240), in a 1:1 comparison. In both groups an eventual bonus freeze was deployed in case of TTI>75 seconds, as previously described [8]. All PVI procedures were performed at CCB Markus Krankenhaus, Frankfurt am Main, Germany, between august 2019 and august 2020. All patients signed informed consent for the ablation procedure. The study was approved by the institutional review board.

2.3 Cryoballoon ablation procedure, phrenic nerve monitoring and esophagus temperature recording

All procedures were performed under conscious sedation using boluses of midazolam, fentanyl, and a continuous infusion of propofol. A temperature probe with 3 thermocouples separated by 10 mm (SensiTherm, St Jude Medical, Inc,) or the Circa's S-CATH (Circa Scientific) was placed into the esophagus transorally. The position of the probe was adjusted to the fluoroscopic position of the balloon before each cryoenergy application.

The principles of single transseptal 28-mm CB PVI have been described previously [9, 10]. In brief, a single transseptal puncture was performed with a SL1 transseptal sheath and a BRK1 needle (St.Jude Medical) under fluoroscopy guidance and under pressure control. After transseptal puncture, intravenous heparin was administered, targeting an activated clotting time of 300 to 350 seconds (30 minute intervals). Selective PV angiograms were performed and ostial PV diameters were measured (right PVs: right anterior oblique 30°; left PVs: left anterior oblique 40°). The second-generation CB (Arctic Front Advance, Medtronic, Inc, Minneapolis, MN) was finally inserted into the left atrium guided by an endoluminal spiral mapping catheter (Achieve, 20 mm, Medtronic, Inc). After positioning the inflated CB at the PV ostium, the SC Achieve was maneuvered to ensure PV recordings. The grade of occlusion was then assessed by contrast medium injection. During the first application at each PV the time to isolation (TTI) was collected. In Group CB120 freeze time was set to 120 seconds, repeated in two consecutives applications, separated by the thawing phase (**Fig.2**). In Group CB 240 patients were treated as usual with a single 240 seconds application. Patients of both groups received an extra freeze application if TTI exceeded 75 seconds (see "energy dosing" section for more details). The ablation end point was the absence or dissociation of all PVs potentials as confirmed by the spiral mapping catheter.

For each application, the minimal luminal esophageal temperature (LET) was recorded as the temperature nadir occurring during or shortly after the cryoenergy deployment in any of the thermo-couples[11]. Application was immediately stopped and an active deflation was performed in case of LET<15°C[12]. During ablation at the septal pulmonary veins (PVs) the phrenic nerve (PN) was systematically paced with high output and monitored in its function by manual palpation and using the compound motor action potential (CMAP) modified ECG, with immediate interruption of energy application in case of perceived weakening of diaphragmatic contractions or reduction >30% of the maximal CMAP amplitude[13].

We defined PN injury as "persistent" if PN palsy was still present at hospital discharge, 48 hours after the procedure, in line with the Fire and Ice trial[2]. In case of intraprocedural PN recovery or

recovery before hospital discharge, the term "transient" PN injury was used.

PN function was checked by fluoroscopy.

Procedural data were collected, with particular focus on LET and PN injury.

2.4 Energy dosing

The flowcharts (**Figure 1**) illustrates the energy dosing options in the CB120 and CB240 group.

CB-120 group

CB PVI was guided by real-time PV signals recordings displayed by the intraluminal SC. The target duration of the freeze was 240 seconds, divided into two separated 120 seconds applications. If PVI could be obtained within 75 seconds of the first application, no additional bonus freeze was delivered. If TTI was >75 seconds or PV potentials could not be visualized, 1 bonus freeze (third application of 120 seconds) was delivered. If PVI could not be achieved after the second 120 seconds application, the operator was free to switch to the standard 240 seconds freeze protocol. In case of PV-left atrium reconnection during the rewarming phase of the first 120 seconds application (non sustained block), the operator could also switch to the 240 seconds protocol.

CB-240 group

The cryoenergy dosing option with a standard 240 seconds application TTI-guided protocol has already been illustrated[8]. CB PVI was guided by real-time PV signals recordings displayed by the intraluminal SC. The target duration of the freeze was 240 seconds; if PVI could be obtained within 75 seconds of the first application, no bonus freeze was delivered; if TTI was >75 seconds or could not be visualized, one bonus freeze (180 seconds) was delivered.

In both groups, if aforementioned safety criteria were met (PN injury and LET≤15°C), the application was prematurely terminated and no further freeze was delivered.

2.5 Study Endpoints

The rate of PNI or of LET<15° and their combination in a composite endpoint served as primary endpoints. Secondary endpoints were the comparison of procedural efficacy as well as procedural data such as procedure and fluoroscopy time.

2.6 Statistical analysis

Data were expressed as mean ± SD to describe continuous variables with normal distribution; the Student t test was conducted to calculate differences between groups. Categorical variables were compared using the Chi-squared test and the Fisher's exact test. A P value < 0.05 was considered statistically significant.

3 - Results

3.1 Population

A total of 160 consecutive patients with symptomatic AF treated with CB PVI were retrospectively analyzed (age 67,2 ± 12,1; men 58,1%; BMI 27,4 ± 4,7; persistent AF 27,5%). Group CB240 and CB120 baseline features did not differ with regard to age, left atrium anteroposterior diameter, left ventricular ejection fraction, prevalence of paroxysmal form of the arrhythmia and the other clinical features. Baseline characteristics are summarized in **Table 1**.

3.2 Procedural Data

The single big CB PVI procedure was successfully performed in all patients (n=160; 631 PVs) without the need for focal touch-up ablation. A left common trunk was present in a total of 9 patients (CB 120 group= 4, CB 240 group= 5). Comparison of PV diameters showed slight larger right side PVs in the CB120 groups (RSPV: CB120 16,4 ± 2,4 mm, CB240 15,6 ± 2,6 mm p=0.04; RIPV: CB120 17,0 ± 2,5 mm, CB240 15,8 ± 2,3 mm p<0.01); while no difference was found in left PV diameters (LSPV: CB120 17,9 ± 3,6 mm, CB240 17,2 ± 2,5 mm p= 0.21; LIPV: CB120 16,4 ± 2,1 mm, CB240 15,8 ± 2,4 mm p= 0.11; LCPV: CB120 21,7 ± 4,5 mm, CB240 17,4 ± 1,7 mm p=0.12). Single shot PVI was obtained in 85% (538 of 631) of all PVs (CB240 274/315 PVs; CB120 264/316 PVs; p=0.22). In CB120 and CB240 groups the rate of single shot isolation was similar in all PVs (LSPV CB120 83%, CB240 89%, p=0.25; LIPV CB120 95%, CB240 96%, p=0.71; LCPV CB120 100%, CB240 100%, RSPV CB120 86%, CB240 88% p=0.81, RIPV CB120 70%, CB240 75%, p=0.48).

Real time TTI recording was similar in all PVs (LSPV CB120 87%, CB240 83%, p=0.47; LIPV CB120 91%, CB240 84%, p=0.21; LCPV CB120 75%, CB240 100%; RSPV CB120 84%, CB240 88% p=0.46, RIPV CB120 73%, CB240 69%, p=0.27).

Time to isolation was comparable between the two groups and among the different PVs, beside of LSPV isolation with a faster PVI in the CB 120 group (45,0 ± 21,0 seconds) rather than CB240 group (57,6 ± 43,3 seconds, p=0.04). No difference was found in cryoballoon temperature at the moment of PV-left atrium block in all PVs.

In the CB120 group an early PV reconnection after isolation (non sustained block) was recorded in 7/316 PVs (LSPV 4, RIPV 3) vs 1/315 PVs (RIPV) in the CB240 Group (p= 0.07); of the 8 PVs with early reconnection, 7 had a TTI> 75 seconds. Notably, veins with a non sustained isolation had a longer TTI (90,5 ± 15,9 seconds) compared to PVs that showed no acute reconnection (43,5 ± 27,9; p<0,001). In the CB120 patients with a non sustained PV isolation, the mean delta between TTI and freeze interruption was 33 seconds. In 10/316 (3%) PVs a switch to the CB240

protocol was needed (5/10 cases in the RIPV); none of these patients suffered from energy-related safety events.

As expected, mean minimal cryoballoon temperature was lower in all PVs of the CB240 group, with the exception of the LCPV (LSPV: CB120 -46,9 ± 5,8, CB240 -51,0 ± 6,2 °C, p< 0.001; LIPV: CB120 -44,4 ± 4,6, CB240 -47,6 ± 5,2 °C, p< 0.001; LCPV: CB120 -49,6 ± 5,9, CB240 -56,3 ± 8,1 °C, p=0.26; RSPV: CB120 -48,1 ± 6,1, CB240 -51,4 ± 6,5 °C, p<0.01; RIPV: CB120 -44,8 ± 5,4, CB240 -48,5 ± 5,9 °C, p< .001; **Fig.3**). The detailed procedural characteristics are summarised in **Table 2**. Procedure time (CB120 59,7±16,7, CB240 56,7±15,4 minutes, p=0.24), fluoroscopy time (CB120 9,2±4,1, CB240 8,1±3,7 minutes, p=0.08) and fluoroscopy dose (CB120 859,7±757,7; CB240 845,8±702,8 uGym^2, p=0.90) were comparable between the two groups .

3.3 Safety Data

In 4/80 patients (5%) of the CB120 group an application was prematurely stopped because of a PN injury and all showed an intraprocedural recovery, after few minutes of observation (transient PNI). 11/80 patients (14%) of the CB240 group experienced a PN injury, in 8 cases with resolution in few minutes of observation (transient PNI), in 3 cases still present after 48 hours (persistent PNI) (p=0.10). Overall, the median time to PNI was 120 seconds (min 66 seconds – max 213 seconds). In the CB120 group, 1 PNI was recorded during the first application and 3 PNIs were recorded during the second application: the median time to PNI was 118 seconds (min 79 seconds – max 120 seconds). In the CB240 group, all the PNIs were recorded during the first application: the median time to PNI was 121 seconds (min 66 seconds, max 213 seconds). Right PVs associated with PNI had a PV diameter (16,2±2,5 mm) similar to right PVs not associated to PNI (16,3±2,7 mm; p=0,96).

Of the 3 patients experiencing a persistent PN injury, one underwent a fluoroscopic control after 3 months from CB PVI procedure with evidence of a partial recovery (active contraction of the right diaphragm but weaker compared to the left diaphragm); in the other 2 patients the

fluoroscopy control is scheduled but still not performed at the moment of writing.

A LET <15°C was recorded in 3/80 patients (4%) in the CB120 group and in 16/80 patients (20%) in the CB240 group (p<0.01) (20/631 PVs: LSPV 1/20, LIPV 13/20, LCPV 0/20, RSPV 0/20, RIPV 6/20). Mean minimal esophageal temperature was significantly lower in LSPV and LIPV of the CB240 group (LSPV: CB 120 34,8 ± 2,0, CB 240 32,8 ± 4,6 °C, p<0.01; LIPV: CB 120 31,4 ± 6,3, CB 240 28,1 ± 9,0 °C, p=0.01; **Fig.3**).

Taken altogether, the rate of energy-related safety events (LET<15°C and PN injury) was statistically higher in the CB240 group (34% vs 9%, p<.001).

PV diameter didn't show any impact on TTI, mean minimal CB temperature, efficacy and safety.

A pericardial tamponade was recorded in CB120 group, managed with pericardiocentesis; one femoral hematoma and one transient mechanical complete AV block during CB manipulation at a RIPV were recorded in the CB240 group. Main safety data are summarized in **Fig. 4**.

4 - Discussion

4.1 Main findings

The main findings of this study are the following: (a) a double 120 seconds freeze protocol carries a similar procedural acute efficacy profile as a standard 240 seconds freeze protocol; (b) however, an empirical shortening of the freeze duration can lead to acute PV reconnection; (c) 120 seconds applications carry a lower risk of freeze-related complications; (d) we found no difference in procedure duration, fluoroscopy duration and fluoroscopy dose.

4.2 Cryoablation dosing

Historically, the recommended duration of cryoenergy application for PVI with the first generation CB was set to 300 seconds. This was based on the preclinical observation that longer

freezing duration produces larger lesions, but a plateau is reached in five minutes[14]. Since the introduction of the second generation CB, the application duration was reduced to 240 seconds, with the suggestion to deliver a bonus freeze after successful PVI. Used in this setting, CB was demonstrated in the Fire and Ice trial to be non-inferior to RF for patients with paroxysmal AF[2]. Preclinical and clinical studies have then tried to find the optimal cryoenergy dosing, looking for the shortest effective freeze duration for a durable PVI.

The possibility of reducing the freeze application to 120 seconds with the second generation cryoballoon was firstly investigated in a preclinical setting by Andrade et al.[15] which found that there was no difference in the achievement of complete circumferentially transmural lesions between PVs randomized to 120 and 240 seconds. This experimental finding found its clinical counterpart in the CIRCA-DOSE trial [7], that found no difference in freedom from any atrial tachyarrhythmia for one year of continuous invasive rhythm monitoring after PVI procedure between patients randomized to contact force-guided radiofrequency ablation, 4-minute cryoballoon ablation and 2-minute cryoballoon ablation.

A further shortening of the freezing duration was previously investigated in the 123 study[16]: 222 patients were randomized to short (2x1 minute), medium (2x2 minutes) and long (2x3 minutes) cryoenergy duration, demonstrating that short application time may impair the rate of sustained isolation of left side PVs.

In line with this observation, we found that an empirical reduction of freeze duration to 180 seconds may also impact the rate of durable PVI[17], and Heeger et al. described a 47% rate of PV reconnection with an ablation protocol with 120 seconds freeze on top of TTI[18].

We report now that lowering freezing time to 120 seconds and doubling the applications number carries the same acute procedural efficacy as a standard 240 seconds freeze protocol. However, it has to be acknowledged that we observed an increase in the rate of non sustained PV isolation after a single 120 seconds application: in this context, a second 120 seconds application seems to be mandatory to assure a durable PVI. In the search for the ideal freeze duration, advanced cardiac imaging may play a role in the future for a patient-tailored therapy:

studies are needed on cryoballoon ablation and the correlation to the atrial wall thickness and tissue characterization (degree of fibrosis), as well as the distance to extracardiac structures as esophagus and phrenic nerve.

4.3 Safety profile

Two recently published studies showed how the CB is more effective than antiarrhythmic drugs as a first line therapy for symptomatic AF[19,20]. If used in this context, the safety of CB ablation will become even more crucial. Cryoenergy spreads time-depently in a radial fashion[21]: a reduction of application duration should also result in a reduction in the involvement of extracardiac structures and of the related injuries.

PNI is the typical balloon ablation complication during PVI. In our recently published study[22], we found an overall incidence of PNI during CB PVI of 4,1% (71/1720 patients) between 2010 and 2018. Interestingly, a previous study[23] observed that during second generation CB PVI the mean time to PNI was 177 seconds, and that only 14% of the total PNI during first and second generation CB PVI developed in the first 120 seconds of energy application. The previously cited "123 study" also investigated the relationship between cryoenergy application duration and PNI, finding a significative reduction of this adverse event only in the short duration group (2x1 minute) compared with longer protocols (2x2 minutes and 2x3 minutes). Accordingly, our study shows no statistical difference in PNI between CB120 and CB240 group, but there is a clear numerical reduction of events in the CB120 group, that furthermore showed only transient injury forms.

Esophageal injury is a feared complication of every PVI procedure. In the majority of cases it manifests as asymptomatic thermal lesion, but rarely as an atrio-esophageal fistula (AEF).

AEF is a devastating and potentially lethal complication of PVI. In a study[24] collecting 11 cases of AEF after PVI with second generation CB, the estimated incidence was <1/10000.

Interestingly, the reported median durations of the "culprit" cryoenergy applications were, in most cases, ≥ 240 seconds, and in all cases at least of 180 seconds. Fortunately, during CB PVI

the systematic measurement of the local esophageal temperature (LET) and the use of temperature cut off can lead to a reduction of EDEL [5, 11]. A very recent publication on more than 1000 consecutive CB PVI using a LET cut-off of 15°C, revealed that this cut off is reached in 19% of the patients[10]. In a previous study we reported that CB ablation without a LET cut off can lead to esophageal ulcerations in 19% of patients [5], with an higly accurate predictive value of a LET<12°C (sensitivity 100%, specificity 92%). To avoid a LET<12°C, we realized that the CB application should be stopped at a LET of 15°C[11]. Interestingly, we observed that mean "time to LET 15°C drop" was 164 seconds, and only in 3% of patients a LET<15°C was reached within the first 120 seconds of application[11]. Accordingly, our study shows lower LET in LSPV and LIPV in the CB240 group and a strong reduction of the necessity of interruption of freeze application because of LET <15°C in the CB120 group (4%).

Taking all these "safety issues" together, we found that a double 120 seconds freeze strategy seems to increase the overall safety of CB PVI, and may become the standard of care especially in centres where a LET measurement probe cannot be routinely used or in patients where the PN monitoring results technically difficult.

5 - Limitations

Our study has a number of limitations. This was a retrospective, non-randomized, single-center experience with relatively small sample size. We used a surrogate endpoint for the risk of esophageal lesions (LET<15°C), instead of performing gastroesophagoscopy in all patients. As an institutional protocol, our patients did not undergo preprocedural computer tomography assessment evaluating the anatomic characteristics of the PV antrum, that has been reported to be associated with the risk of PNI [25].

6 - Conclusion

Safety of second generation CB PVI can be increased using a double 120 seconds TTI-guided freeze protocol. This approach carries the same procedural acute efficacy, procedural time and fluoroscopy dose as a standard 240 seconds TTI-guided freeze protocol.

Data Availability Statement: The data underlying this article will be shared on reasonable request to the corresponding author.

7 – Figures

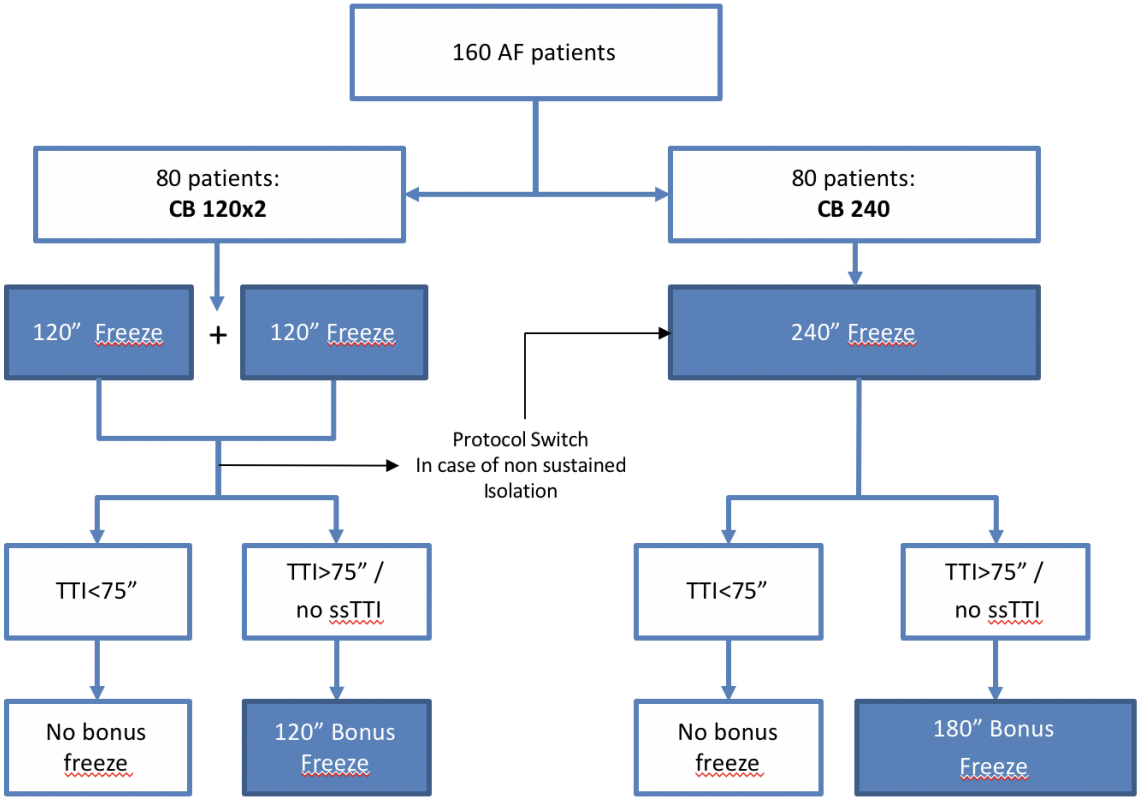

Figure 1: flowchart illustrating the energy dosing options in CB120 and CB240 group.

Abbreviations: CB = cryoballoon; TTI = time to isolation; LA-PV = left atrium-pulmonary vein.

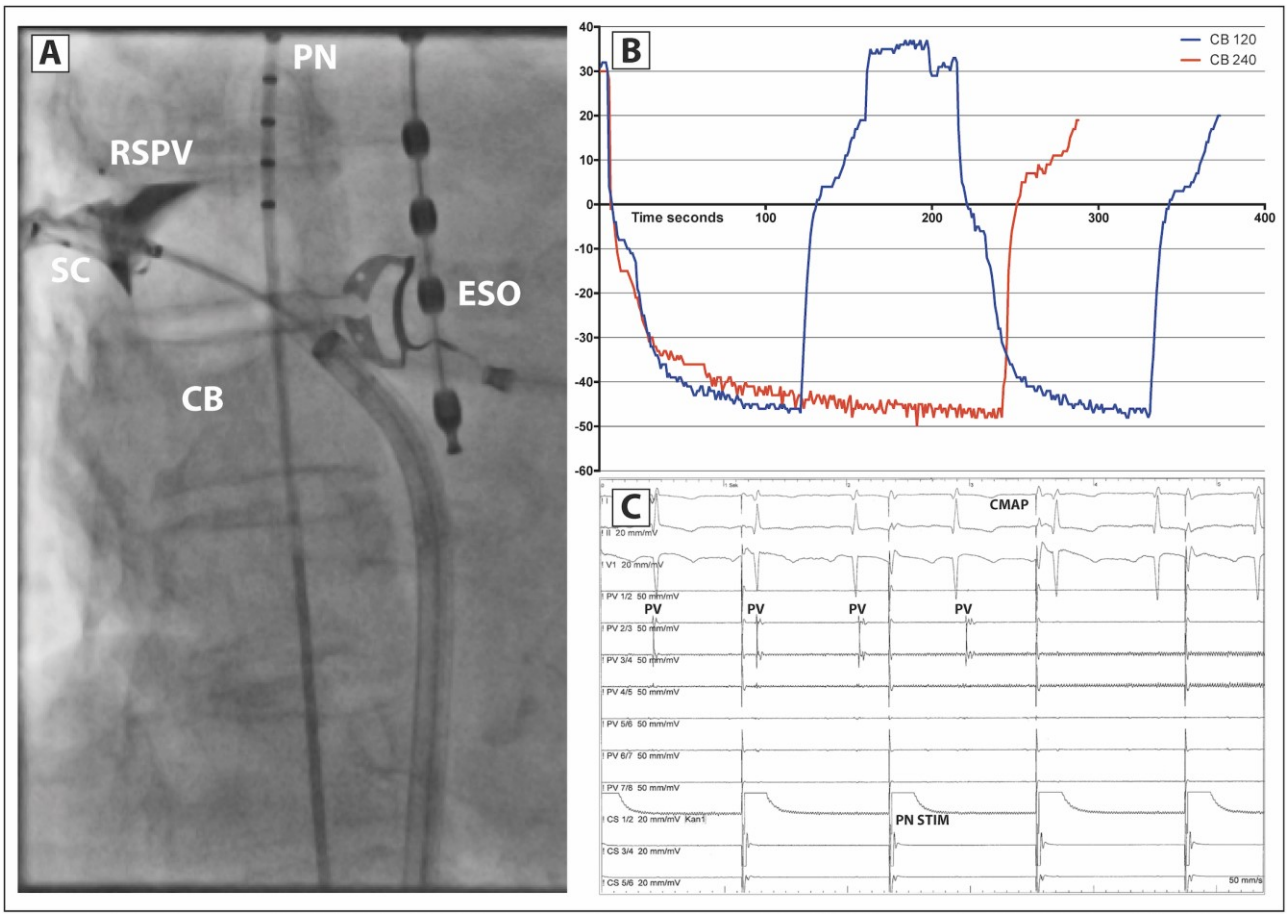

Figure 2: Panel A: Example of CB occlusion at a right superior pulmonary vein (RSPV). PN indicates the multipolar catheter advanced in the superior vena cava to stimulate the phrenic nerve; Eso indicates the temperature probe in the esophagus, CB indicates the cryoballoon, SC indicates the spiral catheter Achieve. Panel B: Plot of the balloon temperature during a single 240 seconds freeze (red line) and during a double 120 seconds freeze (blue line). Panel C: example of real time isolation recording at RSPV: CMAP indicates the recording of the compound motor action potential, PV indicates the pulmonary vein spike, PN Stim the artifact of the stimulation of the phrenic nerve.

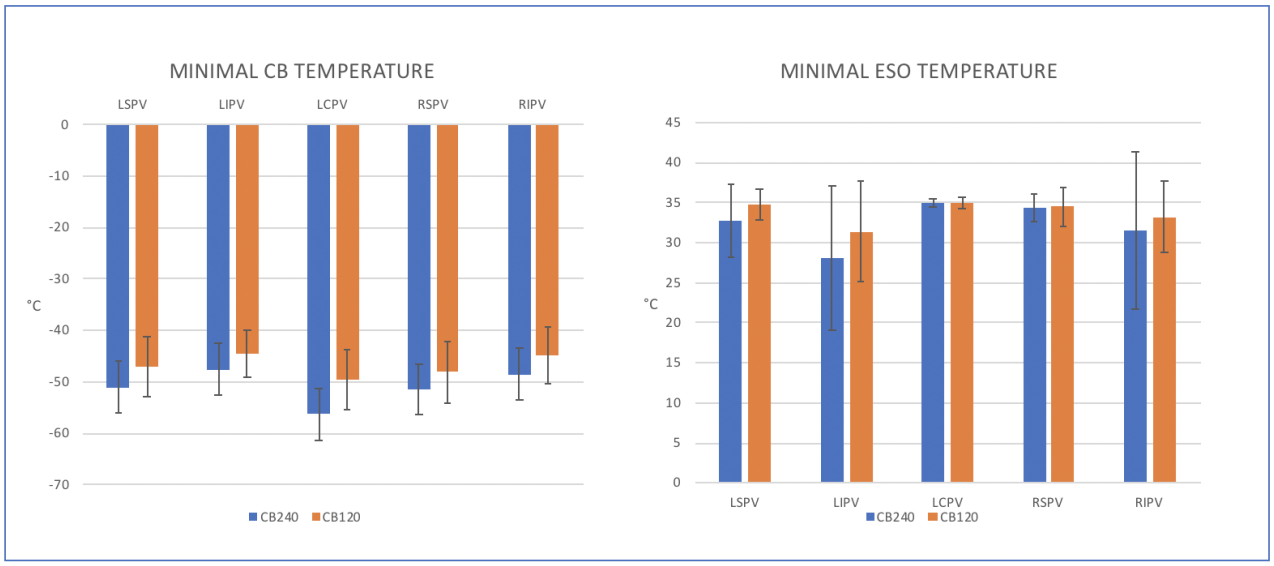

Figure 3: on the left, comparison of minimal cryoballoon temperature between the different PVs of CB240 and CB120 group. Temperature was significantly lower in all PVs of the CB240 group, with the exception of the LCPV. On the right, comparison of the minimal luminal esophageal temperature between the different PVs of the CB240 and CB120 group. Temperature was significantly lower in LSPV and LIPV of the CB240 group.

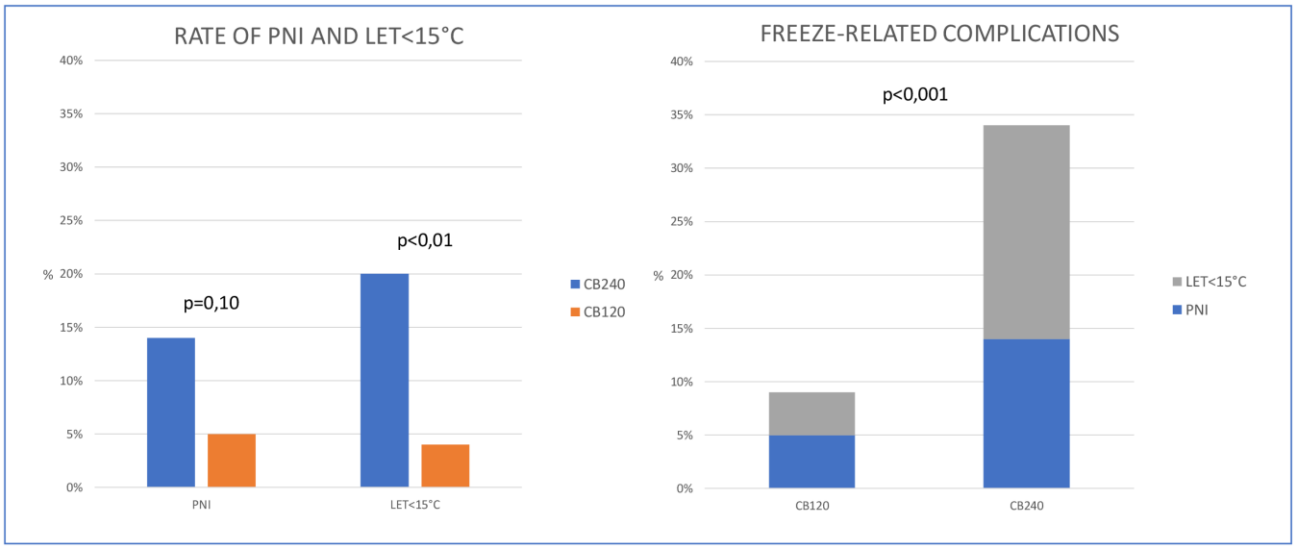

Figure 4: on the left, comparison of the incidence of PNI and LET<15°C between CB240 and CB120 group. Incidence of LET<15°C was significantly higher in CB240 group. On the right, representation of the significantly higher incidence of freeze-related complications in the CB240 group compared to the CB120 group.

8 - Tables

	Overall (n=160)	CB240 (n=80)	CB120 (n=80)	P
Age	67,2±12,1	66,9±11,8	67,6±12,5	.72
Male	93/160 (58,1%)	47/80 (58,8%)	46/80 (57,5%)	.19
BMI	27,4±4,7	27,8±4,7	27,0±4,6	.26
Pers AF	44/160 (27,5%)	27/80 (33,8%)	17/80 (21,3%)	.08
Art. HT	115/160 (71,9%)	58/80 (72,5%)	57/80 (71,3%)	.81
D. mell	18/160 (11,3%)	9/80 (11,3%)	9/80 (11,3%)	1
Stroke	8/160 (5,0%)	5/80 (6,3%)	3/80 (3,8%)	.72
NYHA	15/160 (9,4%)	5/80 (6,3%)	10/80 (12,5%)	.28
CAD	28/160 (17,5%)	10/80 (12,5%)	18/80 (22,5%)	.10
LA (mm)	40,8±5,7	40,8±5,3	40,8±6,2	.97
LV-EF(%)	60,4±10,0	61,1±9,6	59,7±10,4	.45

Table 1: Baseline characteristics. Abbreviations: BMI = body mass index; Pers AF = persistent atrial fibrillation; Art. HT = arterial hypertension; D. mell = diabetes mellitus; CAD = coronary artery disease; LA = left atrium anteroposterior diameter; LV-EF = left ventricular ejection fraction.

		Overall (n=160)	CB240 (n=80)	CB120 (n=80)	P
LSPV					
	Diam (mm)	17,5±3,1	17,2±2,5	17,9±3,6	.21
	TTI (sec)	51,3±34,5	57,6±43,3	45,0±21,0	.04
	T@PV block (°C)	-35,6±10,6	-36,8±9,0	-34,3±12,0	.20
	Min T (°C)	-48,9±6,3	-51,0±6,2	-46,9±5,8	<.001
	Esoph T (°C)	33,9±3,6	32,8±4,6	34,8±2,0	<.001
LIPV					
	Diam (mm)	16,2±2,3	15,8±2,4	16,4±2,1	.11
	TTI (sec)	36,5±21,2	37,6±22,8	35,6±19,6	.60
	T@PV block (°C)	-28,9±10,7	-29,6±11,8	-28,3±9,6	.50
	Min T (°C)	-46,0±5,2	-47,6±5,2	-44,4±4,6	<.001
	Esoph T (°C)	29,8±7,8	28,1±9,0	31,4±6,3	.01
LCPV					
	Diam (mm)	19,3±3,9	17,4±1,7	21,7±4,5	.12
	TTI (sec)	41,6±28,3	30,2±20,4	60,7±29,2	.19
	T@PV block (°C)	-34,9±10,4	-31,0±10,5	-41,3±6,2	.23
	Min T (°C)	-53,3±8,0	-56,3±8,1	-49,6±5,9	.26
	Esoph T (°C)	35,0±0,6	35,0±0,5	35,0±0,7	.96
RSPV					
	Diam (mm)	16,0±2,5	15,6±2,6	16,4±2,4	.04
	TTI (sec)	37,2±23,0	36,0±22,0	38,5±24,0	.53
	T@PV block (°C)	-30,9±12,5	-30,1±13,8	-31,6±11,0	.49
	Min T (°C)	-49,7±6,5	-51,4±6,5	-48,1±6,1	=.001
	Esoph T (°C)	34,4±2,1	34,3±1,7	34,5±2,5	.49
RIPV					
	Diam (mm)	16,5±2,5	15,8±2,3	17,0±2,5	.003
	TTI (sec)	50,5±27,9	54,4±29,4	46,7±25,7	.15
	T@PV block (°C)	-33,9±12,2	-34,3±13,7	-33,5±10,4	.76
	Min T (°C)	-46,6±5,9	-48,5±5,9	-44,8±5,4	<.001
	Esoph T (°C)	32,4±7,6	31,5±9,8	33,2±4,5	.17

Table 2: Procedural data. Abbreviations: Diam= ostial diameter; TTI = time to isolation, PV block = temperature on left atrium – pulmonary vein block; Min T = mean minimal temperature; Esoph T = esophageal temperature.

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