


# A comparison of 8-mm and open-irrigated gold-tip catheters for typical atrial flutter ablation: Data from a prospective multicenter registry

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## Abstract

**Background:** Cavotricuspid isthmus (CTI) radiofrequency (RF) catheter ablation is the standard treatment for patients suffering from CTI-dependent atrial flutter (AFL). The aim of this study was to compare the use in clinical practice of 8-mm gold-tip catheter (8mmRFC) and open-irrigated gold-tip catheter (irrRFC) for RF typical AFL ablation.

**Methods:** Patients with typical AFL were treated with 8mmRFC or irrRFC catheters according to investigator preferences. The primary endpoint was the cumulative radiofrequency time (CRFT). Fluoroscopy time, acute and 6-month success rates were secondary endpoints.

**Results:** After excluding 3 patients with left AFL, 157 of the enrolled patients (median age 71.8 [interquartile range, 64.1-76.2], 76% men, 91% in NYHA class  $\leq$ II, 65% with no structural heart disease) were analyzed: 74 (47%) subjects were treated with the 8mmRFC and 83 (53%) with the irrRFC. The median CRFT was 3 [2-6] minutes in the 8mmRFC group and 5 [3-7] minutes in the irrRFC group ( $P = .183$ ). There were no significant differences in ablation success rates, intraprocedural CTI reconnections, audible steam pops, and procedural times. In the 8mmRFC group, a significantly lower fluoroscopy time was observed as compared to the irrRFC group (8 [5-12] vs 15 [10-20] minutes,  $P < .001$ ). During the follow-up period, AFL recurrences were documented in 3 patients in the 8mmRFC group and 2 in the irrRFC group ( $P = .655$ ).

**Conclusions:** The 8mmRFC and the irrRFC performed similarly in routine practice for CTI ablation in terms of cumulative RF time, acute and 6-month success rates. Fluoroscopy time was significantly lower in the 8mmRFC group.

**KEYWORDS**

catheter ablation, cavotricuspid isthmus, gold-tip catheter, radiofrequency, typical atrial flutter

## 1 | INTRODUCTION

Radiofrequency (RF) catheter ablation is generally considered a first-line therapy for cavotricuspid isthmus (CTI)-dependent atrial flutter (AFL), due to its curative effect and low complication rate.<sup>1</sup> Bidirectional CTI conduction block is generally achieved with two main approaches, either based on cooled or large-tip (mostly 8 mm long) catheters theoretically capable of creating wider and deeper lesions as compared with conventional catheters. Procedural duration and RF time to obtain bidirectional CTI conduction block may vary considerably from one patient to another. In fact, CTI has a complex and variable anatomy, with recesses, bridges, trabeculae, and different muscle thickness. All the anatomical obstacles may potentially impede effective ablation.<sup>2</sup> In a comparison with solid large 8-mm-tip catheters, dissociation between the generated power and the local convective effect may be considered as preferential factors associated with externally cooled radiofrequency catheters. In fact, such dissociation allows the delivery of higher and more stable power.<sup>3</sup> In addition, tip materials may play a role: in-vitro studies suggested that gold-tip catheters create wider and deeper lesions, potentially improving ablation efficacy.<sup>4,5</sup> However, superiority of gold-irrigated tip catheters over gold large-tip is still needed to be shown, and in ordinary clinical practice, either of the two approaches is used depending on physician's preferences or familiarity. The aim of this study was to compare typical AFL ablation approach with 8-mm gold-tip catheter (8mmRFC) as compared to externally cooled 3.5-mm gold-tip catheter (irrRFC) in routine practice.

## 2 | METHODS

This study was a prospective and multicenter registry involving 8 Italian sites. The number of enrolments per site ranged from 9 to 30. Investigational centers were selected based on the predisposed operators' preferences for long-tip or open-irrigated catheter to balance the study arms.

### 2.1 | Study population

The study enrolled consecutive patients established on pharmacological therapy undergoing first-time RF ablation of typical CTI-dependent AFL, with at least one documented persistent typical AFL episode over 2 hours. Subjects with any of the following criteria were excluded: (i) previous CTI ablation; (ii) acute coronary syndrome or myocardial infarction within the last 3 months; (iii) severe cardiac valvular defects, tricuspid valve replacement, atrial septum defect; (iv) cardiovascular surgery scheduled within the next 6 months; (v) New York Heart Association (NYHA) class IV; (vi) age < 18 years;

(vii) pregnant or breastfeeding women. All patients gave written informed consent. The study was approved by the competent ethics committees.

### 2.2 | Ablation protocol and follow-up

Ablation procedures were performed according to physician's standard practice including the use of a 20-pole catheter alongside the tricuspid valve annulus, the insertion of an additional multipolar catheter in the coronary sinus (CS), and/or electro-anatomic mapping. The RF ablation catheter was selected before the procedure according to physician's preference between the following:

1. 7F steerable quadripolar 8-mm gold-tip catheter (Alcath Flutter LT Gold FullCircle, Biotronik SE&Co, Berlin, Germany) equipped with an integrated thermocouple at the tip (8mmRFC). The recommended ranges of ablation parameters were maximum temperature 60-70°C, maximum output: 70 W, free maximum energy delivery duration.
2. 7F steerable quadripolar open-irrigated 3.5-mm gold-tip catheter (Alcath Flutter eXtra Gold FullCircle, Biotronik SE&Co, Berlin, Germany) equipped with an integrated thermocouple at the tip (irrRFC). Recommended ranges of ablation parameters were maximum temperature 43°C, maximum output: 35-40 W, free maximum energy delivery duration, flow rate 2 mL/minute during mapping and 30 mL/minute during RF delivery.

The ablation was performed during ongoing AFL, or during CS pacing in patients in sinus rhythm. During the procedure, the dependence of the arrhythmia on CTI was proven by positive entrainment using established criteria.<sup>6</sup> Patients with a CTI-independent AFL were ruled out. The procedural endpoint was the demonstration of bidirectional isthmus block by previously published criteria.<sup>7,8</sup> CTI bidirectional block was verified with re-induction pacing and 20 minutes of waiting time. According to the investigational plan, failure to achieve bidirectional CTI block after 30 minutes of energy application allowed procedure termination or application of an alternative catheter or approach.

A 12-lead electrocardiogram (ECG) documenting heart rhythm was obtained at hospital discharge. Patients were instructed to contact immediately the site in case of symptoms suggestive of tachycardia. A 6 month ambulatory visit was scheduled to evaluate 12-lead ECG, symptoms, recurrence of AFL and atrial fibrillation (AF), and all-cause hospitalizations.

### 2.3 | Primary objective

The principal objective of the study was to collect data from CTI-dependent AFL ablation procedures during normal practice and

a-posteriori compare the cumulative radiofrequency time (CRFT) defined as cumulative time of RF delivery required to obtain a complete CTI bidirectional block, without considering the time of RF delivery for consolidation, between two groups of procedures initiated with 8mmRFC and irrRFC.

## 2.4 | Secondary objectives

The secondary objectives included comparison of (i) catheter success rate, defined as rate of documented stable peri-procedural bidirectional CTI conduction block with a specific ablation catheter type; (ii) procedural success rate, defined as rate of procedures successfully terminated with documented stable bidirectional CTI conduction block, whatever ablation catheter type was used during the entire procedure; (iii) acute clinical success rate, defined as ECG-documented absence of AFL at patient discharge; (iv) six month clinical success rate, defined as ECG-documented absence of AFL at 6 month follow-up; and (v) six month documented AF recurrences; (vi) total fluoroscopy time.

## 2.5 | Data and statistical analysis

Patients were divided into two groups according to the ablation catheter first selected: 8mmRFC group and irrRFC group. Primary and secondary study endpoints and procedural parameters were analyzed hierarchically. Variables were evaluated with generalized linear mixed models having variables of interest as response, catheter as fixed effect, and ablation technique and investigational sites as random effects. The Mann-Whitney test was used for baseline continuous variables, and the Pearson chi-square or the Fisher's exact test for categorical variables. Continuous variables were reported as median (interquartile range); categorical variables as percentages. The CRFT and the fluoroscopy times were dichotomized; threshold values were set at 10 minutes and 20 minutes, respectively, as they were reported as average values in the available literature.<sup>9</sup> Logistic regression was used to conduct a univariate analysis, while a step-wise process with a significant level of 0.1 for removal from the model was implemented for multivariate logistic regression model. Statistical significance was defined as  $P \leq .05$ . All statistical analyses were performed using the 11E version of STATA software (StatCorp LP, College Station, Texas).

## 3 | RESULTS

### 3.1 | Patients' characteristics

From June 2014 to September 2016, 160 patients were enrolled in the study. After excluding 3 patients with left AFL, 74 (47%) subjects were treated with 8mmRFC and 83 (53%) with irrRFC. The 6 month follow-up period was completed by 147 (92%). The complete flow chart of the enrolled subjects is shown in Figure 1.

Most of the patients were men (76%), in NYHA class I or II (91%), and had no structural heart disease (65%). The median age

was 71.8 (64.1-76.2) years. There were no significant differences between the two groups concerning baseline characteristics, except for a higher incidence of hypertension in the 8mmRFC patients (79% vs 52%,  $P < .001$ ). Baseline characteristics are reported in detail in Table 1.

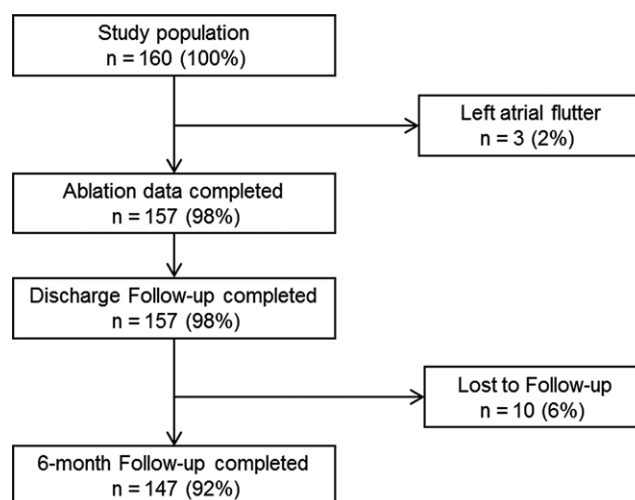
### 3.2 | Primary and secondary objectives

The median CRFT was 3 (2-6) minutes for the 8mmRFC group and 5 (3-7) minutes for the irrRFC group, excluding time of RF delivery for consolidation (Figure 2). The initially selected ablation catheter was changed during the procedure only in 3 cases; all changes recurred in procedures commenced with the open-irrigated ablator. In an intention-to-treat principle, all available cases were then included in the linear mixed model analysis to test the catheter approach as a fixed effect, with no significant results ( $P = .183$ ).

No significant differences between study groups were observed in ablation success rates; catheter, procedural and acute success rates were all higher than 94% for the overall population (Table 2). In the 8mmRFC group a significant low fluoroscopy time was observed (8 [5-12] vs 15 [10-20] minutes,  $P < .001$ ). At 6 month follow-up, the total clinical success rate of the AFL ablation resulted 97% and 11 (7%) patients reported AF episodes; no significant differences were found between the 2 groups.

### 3.3 | Ablation characteristics and procedural predictors

Table 3 shows additional procedure details. Twenty-pole catheter alongside the tricuspid valve annulus catheter and additional CS catheter were used in 82% and 84% of the procedures, respectively. Diagnostic catheter on the His bundle and the sheath were mainly used in the irrRFC group (45% vs 3%,  $P < .001$ , and 34% vs 1%,  $P < .001$ ). The temperature control mode was mainly used in the 8mmRFC group, with a median power of 69 [60-70] W. The



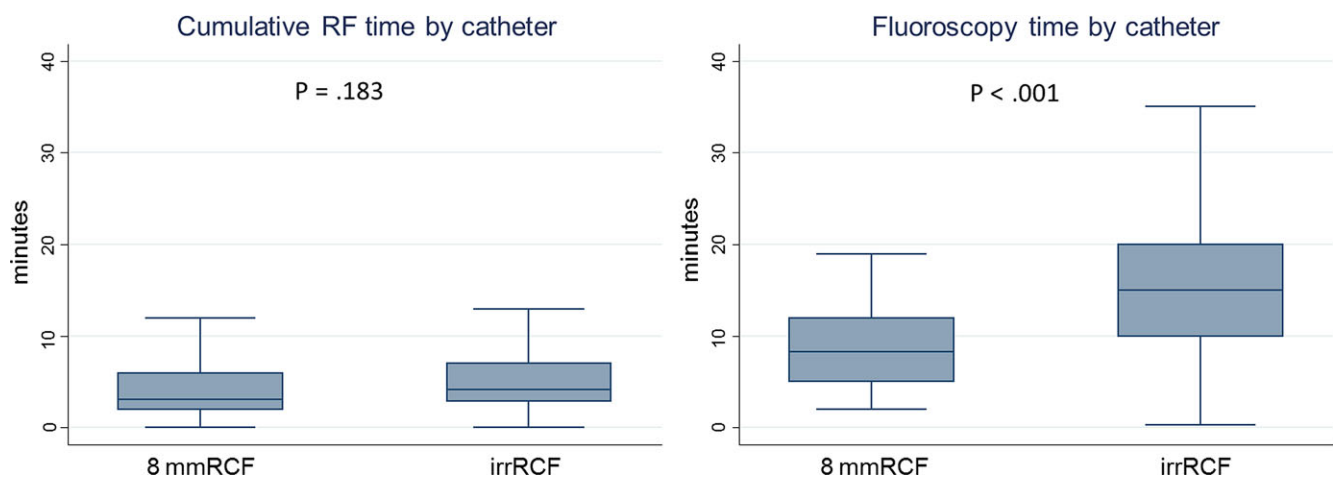
**FIGURE 1** Flow chart of enrolled patients

**TABLE 1** Baseline characteristics of the overall population and of the patients treated with 8mmRFC and irrRFC catheter

	All (n = 157)	8mmRFC (n = 74)	irrRFC (n = 83)	P value
Age	71.8 [64.1-76.2]	70.0 [63.9-77.1]	72.6 [65.0-76.6]	.485
Male	119 (76)	60 (81)	59 (72)	.181
NYHA class				
I	82 (52)	41 (55)	41 (49)	.328
II	63 (40)	28 (38)	35 (42)	.644
III	12 (8)	5 (7)	7 (9)	.677
Weight, Kg	80 [74-85]	80 [75-85]	80 [70-89]	.976
Height, cm	170 [166-175]	171 [168-176]	170 [165-175]	.349
Body Mass Index	27.2 [25.5-28.7]	27.1 [25.6-28.4]	27.3 [24.9-29.7]	.537
CHA <sub>2</sub> DS <sub>2</sub> -VASc score	3 [1-3]	2 [1-3]	3 [2-3]	.088
Structural heart disease				
None	101 (64)	44 (59)	57 (69)	.189
Left heart hypertrophy	11 (7)	6 (8)	5 (6)	.624
Dilated cardiomyopathy	8 (5)	4 (5)	4 (5)	.881
Valvular disease	14 (9)	3 (4)	11 (13)	.052
Coronary artery disease	19 (12)	10 (13)	9 (11)	.628
Hypertension	99 (63)	56 (76)	43 (52)	<.001
Prior history of AF	61 (39)	33 (45)	28 (34)	.099
LV end diastolic diameter, mm	53 [48-56]	53 [48-56]	51 [48-55]	.376
LV end systolic diameter, mm	30 [24-35]	30 [24-35]	34 [30-35]	.310
LV ejection fraction, %	56 [50-60]	57 [55-60]	55 [50-60]	.121
Antiarrhythmics	135 (86)	63 (85)	72 (87)	.923
Anticoagulants	105 (67)	52 (70)	53 (64)	.376

AF, atrial fibrillation; AFL, atrial flutter; LV, left ventricle.

Missing data were not replaced. Data were presented as median (interquartile range), or percentages for binary variable.

**FIGURE 2** Box-Whiskers plots of Cumulative Radiofrequency time (CRFT) and fluoroscopy time by catheter used: 8-mm gold-tip catheter (8mmRFC) and open-irrigated 3.5-mm gold-tip catheter (irrRFC)

adopted strategy was anatomical isthmus line ablation for all the procedures with the point-by-point technique more frequently used in the irrRFC group (90% vs 36%,  $P < .001$ ) and the dragging technique in the 8mmRFC group (85% vs 37%,  $P < .001$ ). The two approaches did not lead to differences in CRFT and fluoroscopy time

in the irrRFC group, while in patients treated with 8mmRFC the point-by-point technique increased CRFT (10 [6-18] vs 3 [2-5] minutes,  $P = .0004$ ), with no effect on fluoroscopy time. There were only 3 changes of the ablation catheter; all were in procedures started with the open-irrigated ablator. No differences between

**TABLE 2** Secondary endpoints for the overall population and for the patients treated with 8mmRFC and irrRFC catheter

	All (n = 157)	8mmRFC (n = 74)	irrRFC (n = 83)	P value <sup>a</sup>
Catheter success rate	149 (95)	73 (99)	76 (92)	.247
Procedural success rate	152 (97)	73 (99)	79 (96)	.363
Acute success rate	152 (97)	73 (99)	79 (96)	.363
Six months clinical success rate <sup>b</sup>	142 (97)	70 (96)	72 (97)	.655
Six months documented AF recurrences <sup>b</sup>	11 (7)	3 (4)	8 (11)	.764

AF, atrial fibrillation.

Values are given as n (%).

<sup>a</sup>Results of generalized linear mixed model analysis with catheter as fixed effect, and ablation technique and investigational sites as random effects.

<sup>b</sup>Data 6 month follow-up available for 147 patients (92%).

groups were found in other procedural parameters. There were no major procedural complications.

At the univariate and multivariate analysis (Table 4), the only variable significantly associated with high CRFT was the dragging ablation technique, showing a reduction in the risk of CRFT higher than 10 minutes of 82% (hazard ratio 0.18, CI: 0.06-0.53,  $P = .002$ ). On the other hand, only the use of irrRFC catheter was confirmed to be an independent predictor of high fluoroscopy time, with an increased risk of 5 times (hazard ratio 5.22, CI: 1.68-16.20,  $P = .004$ ). Table 5 reports ablation details and outcome by patients with CRFT below or above 10 minutes, and fluoroscopy time below or above 20 minutes.

### 3.4 | Follow-up data

During the follow-up (median duration 186 [IQR: 181-226] days), 9 patients (6%) experienced palpitations, 5 in the 8mmRC group, and 4 in the irrRFC group. In 7 of them (78%), an atrial tachycardia episode was documented. AFL was documented in 5 of them, 3 in the 8mmRC group, and 2 in the irrRFC group ( $P = .655$ ). In all these subjects, a check of the CTI block was performed and confirmed in 4 (80%) cases. Therefore, only one case of redo CTI block ablation was reported in the 8mmRFC group. The following additional procedures were performed during the follow-up: 3 AF ablation procedures, 1 AF cardioversion, 2 non-CTI-dependent right flutter ablation procedure, and 1 implantable loop recorder implantation.

## 4 | DISCUSSION

The main findings of the present study are (i) gold-tip 8mmRFC and irrRFC performed similarly for CTI ablation in terms of cumulative RF and total procedure time, acute and 6 month success rates; (ii) fluoroscopy time was significantly lower in the 8mmRFC group; (iii) the use of the dragging ablation technique showed a reduction of 82% in the risk of procedure with CRFT > 10 minutes, while the use

**TABLE 3** Ablation characteristics and details for the overall population and for the patients treated with 8mmRFC and irrRFC catheter

	All (n = 157)	8mmRFC (n = 74)	irrRFC (n = 83)	P value <sup>a</sup>
Ablation characteristics				
Use of				
Sheath	29 (18)	1 (1)	28 (34)	<.001
20-pole diagnostic catheter	129 (82)	49 (66)	80 (96)	<.001
CS catheter	131 (84)	72 (99)	59 (71)	<.001
HIS catheter	39 (25)	2 (3)	37 (45)	<.001
Control Mode				
Temperature	81 (52)	72 (97)	9 (11)	<.001
Power	76 (48)	2 (3)	74 (89)	<.001
Ablation strategy				
Anatomical isthmus line	155 (99)	72 (97)	83 (100)	.285
Ablation technique				
Point by point	100 (65)	26 (36)	74 (90)	<.001
Dragging	91 (59)	61 (85)	30 (37)	<.001
Reverse dragging	5 (3)	4 (6)	1 (1)	.130
Change of catheter	3 (2)	0 (0)	3 (4)	.247
Ablation details				
Time from first ablation until acute bidirectional block	10 [3-19]	8 [3-18]	10 [4-20]	.239
Reconnection during waiting period	9 (6)	3 (4)	6 (7)	.602
Annulus	2 (1)	0 (0)	2 (2)	.518
Mid isthmus	6 (4)	2 (4)	4 (5)	.768
VCI	1 (1)	1 (2)	0 (0)	.397
Time to achieve bidirectional block	13 [6-22]	18 [12-30]	7 [5-14]	.260
Total number of energy deliveries	7 [4-12]	6 [4-9]	8 [5-13]	.745
Cumulative RF time until final bidirectional block (after consolidation)	5 [3-9]	5 [3-9]	6 [3-9]	.799
Total time from first ablation until final bidirectional block	15 [8-25]	10 [6-20]	19 [10-30]	.226
Fluoroscopy time	12 [7-16]	8 [5-12]	15 [10-20]	<.001
Total procedure time	50 [38-60]	45 [40-60]	52 [35-61]	.895
Occurrence of audible steam pops	3 (2)	2 (3)	1 (1)	.497

(Continues)

**TABLE 3** (Continued)

	All (n = 157)	8mmRFC (n = 74)	irrRFC (n = 83)	P value <sup>a</sup>
Sudden impedance rise	0 (0)	0 (0)	0 (0)	-
Thrombus formation at tip	0 (0)	0 (0)	0 (0)	-

Missing data were not replaced. Data were presented as median (interquartile range), or percentages for binary variable. Times are expressed in minutes.

<sup>a</sup>Results of generalized linear mixed model analysis with catheter as fixed effect, and ablation technique and investigational sites as random effects.

of a irrRFC catheter was associated to higher fluoroscopy time (>20 minutes).

### 4.1 | Impact of ablation catheter

Studies comparing cooled and 8-mm-tip catheters for CTI ablation showed contrasting and hardly comparable results for several reasons (different irrigation design,<sup>9</sup> small cohorts, and different study endpoints<sup>10</sup>). A published meta-analysis showed the equivalence between 8-mm-tip and internally cooled catheters but did not address the influence of externally cooled irrigated catheters.<sup>11</sup> This irrigation design showed shorter RF energy application and fluoroscopy durations compared to both internally cooled and 8 mm design in a randomized study.<sup>10</sup> This result might be explained by the fact that externally irrigated electrodes create larger lesions as shown in experimental studies.<sup>12</sup> However, contrasting findings were found in another randomized study where 10-mm large-tip catheter was superior to open-irrigated tip in terms of time to obtain bidirectional CTI block.<sup>13</sup>

Da Costa et al<sup>9</sup> recently demonstrated that the anatomy of the CTI plays an important role: they showed that 8-mm Pt tip catheters were more effective than irrigated tip catheters in straight isthmus morphology. Conversely, effectiveness of irrigated tip catheters tended to increase in concave isthmus morphologies.<sup>9</sup> Theoretically, saline irrigation of the ablation tip allows greater RF power delivery, producing larger and deeper lesions by maintaining a low electrode-tissue interface temperature and thus overcoming limitations in energy delivery. This is particularly useful in treating areas with low blood flow where nonirrigated catheters rapidly reach the maximum temperature with severe limitation in power delivery, resulting in ineffective lesions. It has been hypothesized that the adoption of a high thermal conductivity material such as gold may increase convective cooling from the electrode/tissue interface, thus reducing excessive temperature rise.<sup>6</sup> In-vitro experiments have demonstrated that this material allows higher RF power delivery and creates deeper lesions than platinum-iridium (Pt-Ir).<sup>4,14</sup> Gold tip was compared to standard Pt-Ir in 8 mm catheter for CTI ablation in two previous randomized trials.<sup>5,15</sup> Lewalter et al<sup>5</sup> concluded that gold may be preferred over Pt-Ir as the electrode material for 8-mm-tip catheters, owing to a higher primary success rate and reduced incidence of char/coagulation formation. They also did not find any differences in terms of RF duration, fluoroscopy and procedure times. Sacher et al<sup>15</sup> did not demonstrate differences in terms effectiveness, RF and fluoroscopy time among 8-mm gold-tip, externally irrigated and 8-mm Pt-Ir tip catheters. Differently from previous studies, we investigated differences using the same material (gold-tip catheters) in both arms, showing that long-tip catheter performed similarly to the open-irrigated gold-tip catheter in terms of CRFT and effectiveness. Interestingly, we found that the use of large-tip catheter was an independent predictor of low fluoroscopy procedure (<20 minutes). As we used identically designed catheters for the shaft, except

**TABLE 4** Univariate and multivariate (stepwise estimation) logistic model for risk of cumulative radiofrequency time (CRFT) above 10 minutes and fluoroscopy time above 20 minutes

Variables	Univariate analysis			Multivariate analysis*		
	HR	95% CI	P value	HR	95% CI	P value
Predictors of CRFT > 10 min						
irrRFC catheter	1.80	0.68-4.80	.238	-	-	-
Dragging ablation technique	0.18	0.06-0.53	.002	0.18	0.06-0.53	.002
Use of sheath	1.20	0.37-3.94	.756	-	-	-
Predictors of Fluoroscopy time > 20 min						
irrRFC catheter	5.65	1.83-17.5	.003	5.22	1.68-16.2	.004
Dragging ablation technique	0.59	0.24-1.43	.243	-	-	-
Use of sheath	2.92	1.10-7.77	.032	-	-	-

\*Stepwise process with significance level of 0.1 for removal from the model.



**TABLE 5** Ablation details and outcome by patients with cumulative radiofrequency time (CRFT) below or above 10 minutes, and fluoroscopy time below or above 20 minutes

	CRFT ≤ 10 (n = 137)	CRFT > 10 (n = 20)	P	Fluoroscopy time ≤20 (n = 133)	Fluoroscopy time >20 (n = 24)	P
Time from first ablation until acute bidirectional block	8 [3-15]	28 [18-41]	.002	8 [3-16]	19 [6-25]	.382
Total number of energy deliveries	6 [4-9]	23 [13-26]	<.001	6 [4-9]	16 [8-25]	.001
Cumulative RF time until final bidirectional block (after consolidation)	5 [3-8]	16 [12-25]	<.001	5 [3-8]	10 [7-15]	.004
Total time from first ablation until final bidirectional block	13 [8-20]	40 [25-49]	<.001	13 [8-21]	26 [20-37]	.009
Total procedure time	45 [36-60]	77 [62-95]	.009	45 [35-60]	60 [50-77]	.464
Six months clinical success rate <sup>a</sup>	125 (97)	17 (94)	.522	121 (96)	21 (100)	.876

Missing data were not replaced. Data were presented as median (interquartile range), or n (%). Times are expressed in minutes.

<sup>a</sup>Data 6 month follow-up available for 147 patients (92%).

for the irrigation system, and for the tip material, this may be explained by increased electrode size which might facilitate positioning and stability on the isthmus during ablation with a consequent reduction of fluoroscopy usage.

Although there is no clear evidence that the irrigated 4 mm catheter is more effective than long-tip for the treatment of AFL, a recent survey by the European Heart Rhythm Association and Canadian Heart Rhythm Society reported that approximately 80% of the responding operators use an irrigated 4 mm catheter.<sup>16</sup> In the present study, we did not find evidence to prefer one approach to the other. From this perspective, our results might have clinical implications for the treatment of typical CTI-dependent AFL.

## 4.2 | Impact of ablation technique

In our study, two ablation techniques were mainly used to obtain bidirectional CTI block: the “dragging” and the “point-by-point” approaches. The first was used in the majority (85%) of procedures performed with the 8mmRFC catheter, while the second approach was preferably adopted (90%) using irrRFC catheter. Despite this association between ablation technique and catheter technology, dragging was an independent predictor of short procedure (CRFT <10 minutes). As compared with the point-by-point approach, the dragging technique is likely to create uninterrupted, transmural linear lesions. This may be explained by the elimination of repetitive catheter repositioning and higher RF power delivery with the dragging approach. But it has also been observed that during short point-by-point RF deliveries, a considerable amount of energy may be absorbed by the tissue surface before the development of transmural lesions.<sup>17</sup> Advantages of catheter dragging in terms of procedure shortening were reported in studies on AF ablation,<sup>18,19</sup> which also reported a potential benefit in terms of clinical outcome.<sup>19</sup> Actually, in our study on typical AFL, we did not find any difference in clinical outcome. On the other hand, no effect of the ablation technique was revealed on the fluoroscopy time. From published data on AF ablation, it seems that the dragging technique required a longer fluoroscopic exposure

time than the point-by-point technique, to confirm the stability of the catheter.<sup>18,19</sup> The movements of the catheter during ablation induce a larger use of the x-ray to check the ablator position. Our neutral data for the fluoroscopy time once again could be due to the different arrhythmia ablation procedure; the shorter duration of the AFL ablation as compared to AF ablation<sup>20</sup> and the anatomically different structures<sup>2</sup> might explain this different result.

## 4.3 | Limitations and strengths

The nonrandomized design prevented controlling for potential imbalances of patients' characteristics, techniques, and tools between study groups. Nevertheless, it is worth noting that such a design-mitigated potential biases induced by operator's preference as a randomized design would have forced operators to alternatively use the two approaches according to randomization, regardless of individual preference or familiarity. Study site selection was performed to ensure a fair balance between the prespecified groups (8mmRFC and irrRFC), and all operators were encouraged to use their most familiar approach; therefore, our results should reflect the performance of catheter technologies theoretically used in their “ideal” conditions.

Finally, during the follow-up, the atrial arrhythmia diagnosis was not based on prolonged electrocardiography monitoring possibly underestimating the incidence of recurrences.

## 5 | CONCLUSION

In this multicenter and prospective registry, the 8-mm gold-tip catheter and the externally cooled gold-tip catheters performed similarly in achieving bidirectional CTI block in terms of cumulative RF, total procedure time, acute and 6 month success rates. Fluoroscopy time was significantly lower in the 8mmRFC group. While the use of a long-tip catheter seems to predict a lower fluoroscopy time procedure, the dragging approach was significantly associated with a reduction of the RF application time.

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## CONFLICT OF INTEREST

D.G. and A.G. are employees of Biotronik Italia; the remaining authors have no major conflicts of interest to disclose.

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