

# The use of a high-power (50 W), ablation index-guided protocol for ablation of the cavotricuspid isthmus

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## Abstract

**Background:** High-power (HP) ablation protocols are increasingly used for ablation procedures to shorten procedural times and improve short- and long-term success. The ablation index (AI) combines contact force, power settings, and ablation time. It can be used in combination with HP protocols to guide operators toward standardized lesions. The purpose of this study was to evaluate both a HP and AI-guided strategy for ablation of the cavotricuspid isthmus (CTI) in patients with typical atrial flutter (AFL).

**Methods:** In this single-center study, consecutive patients with typical AFL ( $n = 52$ , mean age  $68.7 \pm 8.3$  years, 21/52 [40.4%] female) underwent AI-guided HP radiofrequency (RF) ablation of the CTI. Ablation was performed with 50 W and AI target values of 550 with a maximum ablation duration of 25 seconds per lesion. Target interlesion distance was  $\leq 6$  mm. Ablation was performed with a 3.5 mm porous tip Smarttouch SF catheter.

**Results:** Acute CTI block was achieved in 52 of 52 patients (100%), and first-pass conduction block was achieved in 41 of 52 patients (80.4%). Spontaneous reconnection after 30 minutes waiting time occurred in 1 of 52 (1.9%) patient. Average ablation time until CTI block was  $3:51 \pm 1:40$ ;  $2:33 \pm 1:01$  minutes of bonus ablation pulses were applied after CTI block. An audible steam pop was noted in one patient (1.9%). No major complications occurred. After a mean follow-up of  $193.7 \pm 152.2$  days, no patient showed recurrence of typical AFL.

**Conclusion:** In this pilot study, AI-guided HP ablation of the CTI was fast, safe, and effective.

## KEYWORDS

ablation index, cavotricuspid isthmus, high-power ablation, typical atrial flutter

Philipp Attanasio and Martin Huemer contributed equally and thus share last authorship.

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## 1 | INTRODUCTION

Radiofrequency (RF) ablation of the cavotricuspid isthmus (CTI) is an effective and widely used treatment for typical atrial flutter (AFL). Current guidelines recommend catheter ablation already after the first episode of symptomatic typical AFL (Class of recommendation: IIa), or after symptomatic, recurrent episodes (Class of recommendation: Ia).<sup>1</sup>

For a safe and effective ablation strategy, it is crucial to achieve durable and standardized lesions. Factors influencing lesion formation include power, contact, local thermal heating, and electrode diameter.<sup>2</sup>

Contact force (CF) ablation catheters and improvements of 3D-mapping systems provide the basis for the development of standardized ablations. The ablation index (AI) (CARTO 3 V4; Biosense Webster, Inc) summarizes CF, time (t), and power (P) in a weighted formula.<sup>3</sup> Animal studies showed accurate and reproducible lesion formation using the AI.<sup>4</sup> In clinical practice, AI-guided pulmonary vein isolation (PVI) and left anterior line ablation show promising results.<sup>3,5,6</sup> One study using AI guidance for ablation of the CTI showed higher first-pass conduction block of the CTI despite fewer RF applications.<sup>7</sup>

In the pursuit of optimized lesions, another current strategy is to increase power. It is known that higher energies are forming larger lesions with smaller lesion depths.<sup>2</sup> In these *ex vivo* models, high-power (HP) short-duration was also combined with the AI as indicator of lesion metrics. These preclinical results may provide guidance for the use of a similar approach for ablation of various arrhythmias.

Data about the use of HP short-duration ablation with AI guidance in typical AFL are missing. This study was designed to investigate the safety and efficacy of such a combined protocol.

## 2 | METHODS

### 2.1 | Study population

In this prospective, single-arm, single-center study, consecutive patients with typical AFL underwent HP, AI-guided RF ablation of the CTI.

This study conforms to the guiding principles of the Declaration of Helsinki of 2014 and was approved by the local ethics committee (EAEA4/114/15).

All authors had full access to the data, and have read and agreed to the manuscript as written.

### 2.2 | Ablation procedures

Transesophageal echocardiography was performed in all patients prior to the ablation procedure to rule out left atrial thrombi. Oral anticoagulation with phenprocoumon was continued with a target international normalized ratio (INR) of 2-3. Bridging with low-molecular-weight heparin was performed when an INR < 2 was documented. In patients treated with novel oral anticoagulants, the medication was withheld the morning prior to the procedure and re-initiated at the evening of the same day.

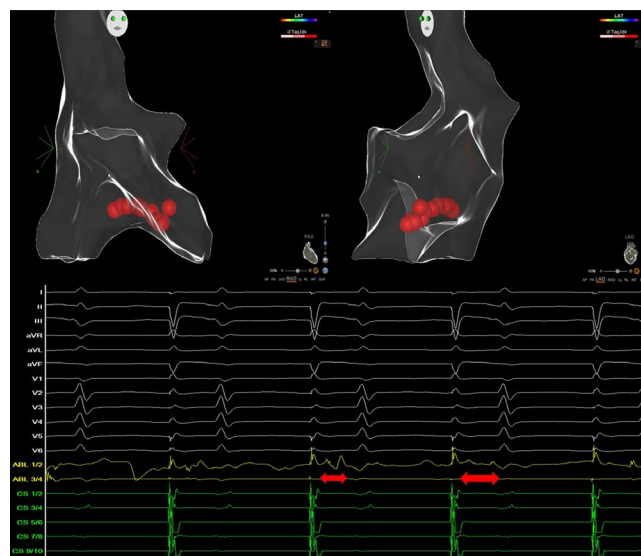
Ablation of the CTI was performed under deep sedation using propofol. No general anesthesia was performed. A decapolar diagnostic catheter was placed in the coronary sinus in all patients. Ablation was performed with a 3.5 mm “porous tip” Smarttouch SF catheter (Thermocool Smart-touch SF F-curve; Biosense Webster) guided by an Agilis™ NxT steerable introducer (Abbot). Irrigated RF energy was delivered point by point between the tricuspid annulus and the inferior vena cava ostium. Ablation energy was set at 50 W with a maximum temperature level of 43°C. All procedures were guided by AI target of 550 with a maximum ablation duration of 25 seconds, a target interlesion distance of ≤6 mm, and a minimum of 10 g of CF. These values were chosen according to the settings used in the “Close” Protocol for anterior wall of the left atrium.<sup>8</sup>

Ablation was continued until bidirectional CTI block was achieved. Once the endpoint was reached, additional bonus RF energy was delivered. First-pass block was defined as the bidirectional block just after concluding the first ablation line (see Figure 1).

About 34 patients (65%) underwent CTI in combination with PVI. Therefore, procedural time was defined as the time between RA access and exit with the ablation catheter. Waiting time after RF ablation for spontaneous reconduction was 30 minutes.

### 2.3 | Postprocedural management and follow-up

Patients were under continuous electrocardiogram (ECG) telemetric monitoring until discharge. Pericardial effusion was ruled out by transthoracic echocardiography. Major complications were noted and defined as described in the HRS/EHRA/ECAS Expert Consensus Statement.<sup>9</sup>



**FIGURE 1** Electroanatomical reconstruction of the right atrium with ablation points (red) through cavotricuspid isthmus in right anterior oblique view (top right) and left anterior oblique view (top left). At the bottom, intracardiac electrocardiogram with cavotricuspid isthmus block during ablation (red arrows)

An outpatient clinical visit was planned for each patient 3 months after the procedure. For each patient, a 24-hour Holter ECG was obtained. In case patients had rhythm monitoring devices implanted, interrogation was performed at follow-up.

Furthermore, telephonic follow-up was performed. Arrhythmia recurrence was defined as episodes of typical AFL lasting  $\geq 30$  seconds.

## 2.4 | Statistical analysis

Continuous variables are expressed as mean  $\pm$  SD; categorical variables are expressed as numbers or percentages. Statistical analysis was performed using SPSS statistics (version 23).

## 3 | RESULTS

### 3.1 | Study population

A total of 52 patients (mean age  $68.7 \pm 8.3$  years, female 21/52 [40.4%]) with typical AFL were included in this study. The mean CHA<sub>2</sub>DS<sub>2</sub>-VASc score was  $2.8 \pm 1.4$ , and the mean HAS-BLED score was  $1.5 \pm 0.9$ . At the time of ablation, 3/52 (1.6%) patients were in flutter of which two patients received additional PVI.

In total, 34/52 (65%) patients underwent an additional PVI in the same procedure as both symptomatic atrial fibrillation and AFL were previously documented. Table 1 summarizes the clinical details of the included study subjects.

### 3.2 | Procedural characteristics

In all patients, bidirectional block was achieved. Mean ablation time to achieve bidirectional block was  $3:51 \pm 1:40$  minutes.

**TABLE 1** Baseline characteristics

Age (y), mean $\pm$ SD	$68.7 \pm 8.3$
Female, n (%)	21 (40.4)
Antiarrhythmic drugs, n (%)	11 (21.2)
Coronary artery disease	12 (23.1)
Arterial hypertension, n (%)	40 (76.9)
LVEF (%), mean $\pm$ SD	$60.37 \pm 8.02$
LA Volume (mL), mean $\pm$ SD	$54.31 \pm 15.4$
CHA <sub>2</sub> DS <sub>2</sub> -VASc-score, mean $\pm$ SD	$2.80 \pm 1.4$
HASBLED, mean $\pm$ SD	$1.49 \pm 0.85$
ICD, n (%)	1 (1.9)
Implantable loop recorders, n (%)	10 (19.2)

Abbreviations: ICD, implantable cardioverter defibrillator; LA, left atrial; LVEF, left ventricular ejection fraction.

HAS-BLED is a scoring system developed to assess 1-year risk of major bleeding in patients taking anticoagulants with atrial fibrillation.

First-pass block was achieved in 41/52 (80.4%) patients. After achieving bidirectional block,  $2:33 \pm 1:0$  minutes safety pulses were applied with a total RF time of  $6:23 \pm 2:43$  minutes. Spontaneous reconduction after 30 minutes of waiting time was seen in one (1.9%) patient. Mean AI achieved in all patients were  $530.73 \pm 33.39$ . We could not identify a difference in AI values between patients with (AI:  $529.5 \pm 35.5$ ) and without first-pass block (AI:  $530.6 \pm 14.9$ ) ( $P = .934$ ). A mean duration of  $17.32 \pm 2.93$  was noted as the average duration time per point. An average of 20 ablation points were performed per patient with fewer ablation points in patients with compared to patients without first-pass block ( $18.6 \pm 4.3$ ;  $27.4 \pm 12.8$  [ $P < .05$ ]). Complete procedural characteristics are shown in Tables 2 and 3.

An audible steam pop was noted in one patient (1.9%). In this case, the average duration time was longer ( $22.2$  seconds) compared to patients where no steam pop occurred ( $17.2s \pm 2.9$  seconds), with no difference in AI values ( $541.8$  to  $530.5 \pm 33.7$  [ $P = .741$ ]). No major complications occurred during the procedure or during follow-up.

A comparison of these results with previously published trials is shown in Figure 2. In the majority of the previously published trials, different ablation catheters were compared. For this comparison, only the more effective catheter with regard to a reduction of RF ablation time was included.

### 3.3 | Follow-up

Mean follow-up was  $193.7 \pm 152.2$  days. 24 Holter ECGs performed at 3 and 6 months showed no signs of AFL recurrence.

Eleven patients (21.2%) had rhythm monitoring devices implanted (10/52 patients [19.2%] implantable loop recorders and 1/52 patient [1.9%], a dual chamber implantable cardioverter defibrillator). Interrogation of the devices during follow-up showed no episodes of regular atrial tachycardia.

In 2/34 (5.9%) patients who underwent additional PVI, atrial fibrillation recurrence was recorded during blanking period of which 1/34 (2.9%) patient underwent re-PVI.

Additionally, 2/52 (3.8%) patients underwent ablation for left atrial tachycardia, 1/52 (1.9%) patient underwent ablation for ventricular tachycardia, and 1/52 (1.9%) patient had ablation of the AV node during our follow-up period.

During these procedures, block of the CTI was reevaluated and reconduction was identified in 1/5 patients (20%).

## 4 | DISCUSSION

To the best of our knowledge, this is the first study evaluating a combined HP and AI-guided ablation strategy for RF catheter ablation of the CTI in patients with typical AFL. With this approach, a high rate of first-pass conduction block was achieved

**TABLE 2** Procedural parameters

RF duration (min), mean $\pm$ SD	6.23 $\pm$ 2.43
RF energy (J), mean $\pm$ SD	18 771 $\pm$ 7755
Combined CTI plus PVI <sup>+</sup> , n (%)	34 (65.4)
RF duration until bidirectional block (min), mean $\pm$ SD	3:51 $\pm$ 1:40
RF duration of Safety Pulses (min), mean $\pm$ SD	2.33 $\pm$ 1.01
First pass block, n (%)	41 (80.4)
Right atrial time (min), mean $\pm$ SD	11:96 $\pm$ 8:19
Spontaneous reconnection, n (%)	1 (1.9)
Failure to achieve endpoint, n (%)	0 (0)
Audible steam pops, n (%)	1 (1.9)

Abbreviations: CTI, cavotricuspid isthmus; PVI, pulmonary vein isolation; RF, radiofrequency.

**TABLE 3** Ablation characteristics

Ablation points, n mean + SD	20.47 $\pm$ 7.56
Average duration time (s) mean + SD	17.32 $\pm$ 2.93
Average force (g) mean + SD	18.65 $\pm$ 4.76
Average base impedance ( $\Omega$ ) mean + SD	151.27 $\pm$ 13.28
Average impedance drop ( $\Omega$ ) mean + SD	9.65 $\pm$ 2.82
AI average mean + SD	530.73 $\pm$ 33.39

Abbreviation: AI, ablation index.

with very short ablation time. We could not identify any relation between AI values and first-pass block. The number of ablation points, however, was lower in patients where first-pass block was achieved. No major complications occurred. It is known that the isthmus region varies interindividually with regard to the anatomy with pouches, recesses, trabeculations, irregularities, and varied muscle thickness. These were shown in different postmortem and imaging studies.<sup>10-13</sup> Several studies were published investigating

the effectiveness of various catheter technologies and energy settings for ablation of the CTI to overcome these anatomical challenges.

At first, short- and large-tip nonirrigated catheters were compared,<sup>14,15,16-18</sup> resulting in a higher effectiveness of the larger 8 mm tip catheter.

The effectiveness of irrigated vs nonirrigated catheters was analyzed in two prospective, randomized trials each demonstrating a higher efficacy for rapid achievement of CTI block with lower procedure and fluoroscopy times using the irrigated-tip catheters.<sup>19,20</sup>

To further optimize lesion depth, gold-tip catheters were developed and compared to platinum-iridium catheters in in vitro studies. Gold-tip catheters showed a significantly deeper lesion formation in porcine endomyocardium.<sup>21</sup> The same effect was shown in vivo in the prospective randomized AURUM 8 trial by Lewalter et al<sup>22</sup> with a higher primary ablation success rate and reduced incidence of char/coagulum formation of the nonirrigated gold-tip catheter compared to platinum-iridium tip catheter.

The next step to optimize lesion formation was the development of catheter technologies such as CF measurement. Venier et al<sup>23</sup> compared CF-guided vs CF-blinded catheter ablation of typical AFL in 70 patients. They found a significant reduction in total RF delivery time when CF guidance was used.

The second published study using CF-guided ablation of patients with AFL also included AI guidance. In this trial, target AI setting was 500 for each lesion at the anterior 2/3 segments of the CTI, while 400 was the target value for the posterior 1/3 segments. CF targets values were 5-40 g.<sup>7</sup> By using this setup, a very high first-pass conduction block of 93.0% was achieved, while no major complications occurred.

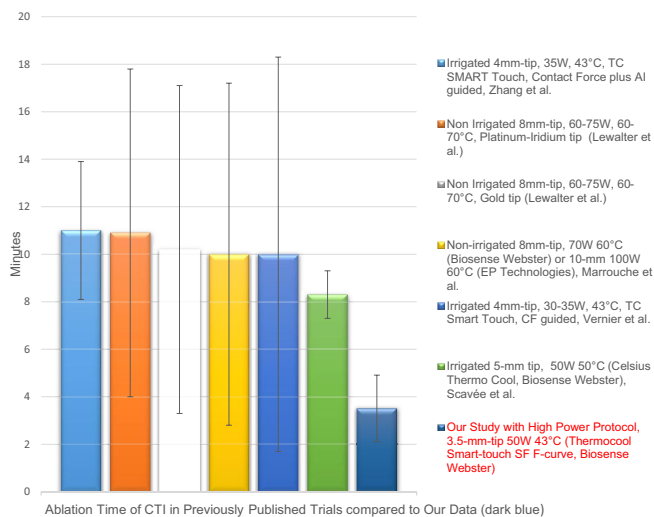
Both studies used power settings of 30-35 W with a temperature limit of 43°C.

A recently published experimental study by Bourier et al suggests 50 W, 13 seconds ablations for a HP short-duration strategy, which is similar to our power setting. The study found that by using these power settings, equivalent AI values were generated compared with conventional 30 W, 30 seconds ablations.<sup>24</sup> An earlier study also found that HP short-duration lesions became larger in diameter and smaller in depth when compared to conventional settings; therefore, potentially resulting in better contiguity between lesions.<sup>2</sup>

Aiming to find a simplified and faster approach, we used the settings originally applied in the "Close Protocol" for left atrial anterior wall ablation (50 W with AI target value of 550) for all lesions at all segments of the CTI.<sup>8</sup>

An additional finding in both previously published studies using CF catheter was that areas with lower CF were located mainly at the tricuspid valve annulus end of the CTI.<sup>7,23</sup> This led to more acute reconnections in this area. To solve this issue, a long steerable sheath (Agilis™ NxT steerable introducer; Abbot) was used in all patients in our study.

By using this combined approach, we could further reduce the total RF delivery time (additional bonus RF delivery included) to an average of 6:23  $\pm$  2:43 minutes (see Figure 2), while keeping a



**FIGURE 2** Comparison of ablation time (min) of cavotricuspid isthmus (CTI) until bidirectional block in patients with atrial flutter in previously published trials with our data

high first-pass block rate with a very low acute reconnection rate. Compared to the second fastest approach by Scavée et al<sup>20</sup> with an average total RF delivery time of  $8.3 \pm 4.5$  minutes, our approach led to a further reduction of 42% of total RF delivery time.

On the other hand, the costs of an AI-guided procedure using a CF catheter and a long steerable sheath have to be taken into account.

In procedures where only an ablation of the CTI has to be performed, an 8 mm nonirrigated gold-tip catheter is still a cheap and effective option. In case of a combination of CTI with PVI ablation, our results may help guide operators who already use these technologies for the left atrial procedure toward optimal power and AI settings for the right atrial part.

Another potential option for applying this approach is in cases using a nonirrigated catheter and a bidirectional block cannot be achieved. A crossover toward an AI-guided ablation using HP settings and a steerable sheath may be considered.

#### 4.1 | Limitations

This is a single-center study and thus it does not necessarily reflect multicenter, international data. The number of patients in this analysis is limited and larger patient populations are needed. However, this is the first study providing an ablation time-guided HP RF ablation of the CTI. Procedure time in our study does not reflect the real procedure time of a common CTI ablation. Sixty-five percent of the patients underwent a PVI in the same procedure. Therefore, the procedure time started at the moment when all catheters were in the right atrium. Therefore, a comparison with other studies was renounced because of this bias.

A short follow-up is a further limitation of this study. In our study, we did not perform imaging to analyze the anatomical characteristics of the CTI. A statement of the anatomical characteristics of CTI, where spontaneous reconnection was observed, is not possible. A further limitation of this study is a missing control group.

## 5 | CONCLUSION

This study shows that a HP, AI-guided protocol seems to be highly effective with shorter RF ablation times and a high rate of first-pass conduction block with a very low acute reconnection rate. HP, AI-guided CTI may allow a safe procedure, achieving a better lesion quality. Long-term outcome data are still missing and larger collectives are to confirm the potential advantage of this approach.

#### CONFLICT OF INTEREST

Authors declare no conflict of interests for this article.

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